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# The Political Ecology of Hedgerows and Their Relationship to Agroecology and Food Sovereignty in the UK

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Hedgerows can make an important contribution to agroecological transitions and to an overall contribution to multifunctional agro-ecosystems with multiple benefits for biodiversity, climate change mitigation, soil health, human health, well-being, and livelihoods. Where such agroecological transition assumes the form of political agroecology, this can underpin transformation of the farming system towards food sovereignty. Current mismanagement of hedgerows is constraining the optimum delivery of ecosystem services by these important features of the British landscape. This mismanagement is, moreover, an integral part of a (capitalist) productivist degradation of the countryside that is contributing to the delivery of ecosystem disservices and is, therefore, antithetical to the adoption of agroecological production practises. Being contrary to the requirements of political agroecology, it is similarly antithetical to the requirements of food sovereignty. In response, this paper outlines what appears to be required, in policy and political terms, for the adoption of an agroecological and food sovereignty framework enabling the sustainable management of hedgerows and maximising their potential for ecosystem services delivery.

**Keywords: political ecology, hedgerows, agroecology, food sovereignty, sustainable food system**

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## INTRODUCTION

Hedgerows are an iconic feature of the lowland British, and, particularly, lowland English landscape. Together with "wood-pasture" (see Rackham, 1986), they represent the closest approximation in Britain to "agroforestry" systems, that is, systems that functionally and symbiotically combine, on a relatively long-term and stable basis, a relationship between agricultural and woodland management. Sadly, today, with the almost universal loss of "infield" biodiversity in lowland farmed environments in Britain, hedgerows often represent the only element of natural/cultural heritage remaining on most conventional farms. Yet, these surviving elements of biodiversity and cultural heritage seem to be woefully under-appreciated, and are indeed being slowly degraded on most conventional farms through inappropriate "management" or through neglect, rather than through outright destruction. Most are subjected to annual flailing "from above" and, in livestock areas, browsing "from below." Where not grazed out, hedgerow bottom flora is commonly subjected to annual mowing and species loss through herbicide drift, eutrophication from artificial fertilisers, and consequent invasion by nutrient responsive species. This annual "management" leads to loss of hedge structure (gappiness), destruction of fruits, nuts, and berries, reduction of food and habitat for birds, mammals, and invertebrates, uses considerable quantities of $CO_2$ emitting fossil fuel, and prevents the maturation of trees in the hedgerow (Tilzey, 2000; Dover, 2019). "Appropriately" managed hedgerows, that is, hedgerows that are "laid" on an $\sim$ 10 yearly cycle, or are flailed no more frequently than once every 3 years (together with trees permitted to mature at frequent intervals in the hedge), are an increasing rarity in the lowland British landscape (Carey et al., 2009). Similarly, hedgerows that are afforded appropriate protection from livestock browsing are an increasingly rare sight.

Yet hedgerows have massive potential, with changed and/or relaxed management, to contribute to biodiversity conservation, soil conservation and enhancement, carbon sequestration (e.g., by allowing far more trees to grow to maturity), water retention and flood alleviation, climate change mitigation, shelter for crops and livestock, and cost savings (and reduced $CO_2$ emissions) for the farmer and land manager (Montgomery et al., 2020; Tilzey, 2021b). In short, hedgerows can make an important potential contribution to agroecological transitions and an overall contribution to multifunctional agro-ecosystems with multiple benefits to biodiversity, climate change mitigation, soil health, human health, well-being, and livelihoods. Where such agroecological transition assumes the form of *political* agroecology, this can underpin transformation of the farming system (encapsulating its productive, distributive, and consumption dimensions) towards food sovereignty (see below).

This paper will explore these elements of multifunctionality and assess the contribution of hedgerows to Ecosystem Services (ES), and whether this contribution may be enhanced through changes towards more permissive management as envisaged above. The paper will then explore the relationship between ES provision and the requirements of agroecology and food sovereignty, again looking at whether the adoption of more permissive hedgerow management can contribute to agroecological production practises and transitions. We will suggest that the "standard" management of hedgerows as described above is constraining the optimum delivery of ES by hedgerows and is, moreover, an integral part of a (capitalist) productivist management of the countryside that is contributing to the delivery of ecosystem *disservices* and is, therefore, antithetical to the adoption of agroecological production practises. Being contrary to the requirements of political agroecology, it is similarly antithetical to the requirements of food sovereignty. Finally, we will outline what appears to be required, in policy and political terms, for the adoption of an agroecological and food sovereignty framework enabling the sustainable management of hedgerows and maximising their potential for ES delivery. Overall, we will be analysing hedgerows through political ecology, incorporating their various and wider historical, political and economic dimensions. Through this analytical but *critical* political ecology we can develop a political ecology of *praxis*, key elements of which are political agroecology and food sovereignty (see Tilzey, 2018).

## HEDGEROWS: DEFINITION, POLITICAL ECOLOGY, AND RELATIONSHIP TO AGRARIAN CAPITALISM/PRODUCTIVISM

### Definition

Strictly speaking, "hedge" and "hedgerow" have different definitions, a "hedge" being the woody component of a field boundary, whilst a "hedgerow" comprises the herbaceous (ground floristic) component together with the usual bank and ditch that are constructed in tandem with the establishment of the hedge (Dover, 2019). In common parlance, however, the terms "hedge" and "hedgerow" are used interchangeably (Forman and Baudry, 1984) and Pollard et al. (1974, p. 24) state that "we do not feel that there is any useful distinction to be made between hedgerow and hedge." In this chapter, "hedge" is employed to refer to linear strips of managed or unmanaged woody vegetation—that is, shrubs and/or lines of trees, otherwise termed woody linear features, for example, by Maskell et al. (2008).

The primary purpose behind the establishment of hedgerows was the confining/exclusion of livestock in order to protect livestock and define their ownership, facilitate the control and rotation of grazing, and to prevent livestock from causing damage to grazing/trampling-sensitive crops, notably arable and grass crops (the latter traditionally hay meadows needed for the provision of winter fodder) (Pollard et al., 1974; Maclean, 2006). Hedgerows were also established to define boundaries, whether between individual owners of land or between administrative entities, for example parishes/manors. Over time, hedgerows came to be highly valued features of the rural landscape and economy, especially for smaller landholders and the landless, providing fuel and wood, food and medicine, and providing additional fodder for livestock, together with shelter for the latter in winter and shade in summer (Neeson, 1993; Maclean, 2006). Hedgerows, as boundaries for containing livestock, have now, however, been almost entirely superseded functionally by barbed-wire fencing (or temporary electric fencing), and this loss of contemporary functionality due to the substitution by fencing is an important factor behind the degradation and loss of hedgerows, since there is no longer an imperative for them to be stock-proof or, indeed, to exist at all (CPRE, 2021).

Forman and Baudry (1984) defined three main origins of hedgerows:

- **Planted**—deliberately created, typically using a single species, and usually planted on a bank with an associated ditch, most characteristic of Rackham's (1986) "planned countryside" [commonly associated in England with enclosure of formerly common land from the late fifteenth century and, especially, with the Parliamentary Enclosure of the eighteenth and nineteenth centuries (see below)];
- **Remnant**—typically the result of woodland clearance where a strip of trees/shrubs is retained along ownership boundaries. These are usually older hedges, especially characteristic of Rackham's (1986) "ancient countryside" and are commonly species-rich due to the fact that they have not been planted and their age has facilitated colonisation by additional species

according to "Hooper's rule" [whereby he maintained that hedges could be dated by counting the number of shrubs in 30-yard lengths on the assumption that one species was added for each hundred years of the hedgerow's existence (Hooper, 1970)];

- **Spontaneous**—trees and shrubs colonise naturally pre-existing structures such as field margins, banks, etc. through dispersal of seeds by animals (including birds) or wind. These can be of any age, but the older they are the more difficult it becomes to differentiate this category from remnant hedgerows.

## Political Ecology and Relationship to Agrarian Capitalism/Productivism

Older field boundaries tend to be curvilinear or irregularly shaped, probably mainly due to piecemeal assarting,[1] or the clearance of woodland, leaving strips of the original woodland cover—these tend to be differentially "remnant" hedgerows and are the most species-rich hedges, as noted. With the emergence of capitalist agriculture and the privatisation of land in England from the sixteenth century onwards, and especially from the mid-1700s, new field boundaries defining new private land units tended to be much more rectilinear in form. From around 1750 these resulted especially from Private or General Parliamentary Enclosure Acts which enabled the division of former commonly held land (both the arable "open fields," meadows, and permanent pasture of the manorial "waste") into discrete fields (Dover, 2019). During this period of the "Great Enclosures," from ∼1750 to 1850, hedges were planted around newly privatised (enclosed) land, and within these new holdings to demarcate fields, using generally a single species, the hawthorn or quickthorn (*Crataegus monogyna*). English elm (*Ulmus procera*) was also widely planted, however, the timber of which was needed for the Navy and for industry, especially for water wheels and lock gates due to its durability under water. So profitable was elm at this time that all landowners with an eye to profit planted it, so that the hedgerow elm became, with the hawthorn hedge, the principal defining feature of the new enclosures (Pollard et al., 1974). Rackham (1986) estimates that these new plantings amounted to some 322,000 km, thereby at least doubling the entire length of hedgerows planted over the course of the previous five hundred years. "Enclosure," as implied, was not simply the establishment of new field boundaries; it was the essential counterpart of the absolute or exclusive right to property, or privatisation (farming "in severalty"), asserted by the new capitalist farmers (yeoman farmers[2]) and their landlords (Yerby, 2016; Tilzey, 2018). This implied the extirpation of common rights previously enjoyed by smallholders (the peasantry), and signalled the latter's death-knell since the small plots allocated to them (if they were lucky to receive land at all) were no longer viable as discrete units, especially since their livestock no longer had access to the broad pastures of the "waste" and fallow open fields. All the other resources that had been part of common right, such as fuel, wild plants, herbs and medicines, were now also closed off to the smallholders (Hammond and Hammond, 1987; Neeson, 1993). Many had to supplement their income by selling their labour to the new capitalist farmers, and many more were obliged to move away altogether to the burgeoning industrial cities. The latter process, involving the extirpation of the peasantry, Marx (1972) termed "primitive accumulation," a principal foundation stone of the rise of agrarian and industrial capitalism in England (Tilzey, 2021a).

With the emergence of industrial capitalism in England and Scotland, wool gave way to cotton as the basic material for clothing. For yeoman farmers and landlords, this implied a decline in the importance of sheep in terms of wool production in the lowlands (although production for mutton gained in importance and production for wool shifted increasingly from the lowlands to the uplands, leading to the infamous "highland clearances" from the late eighteenth century until the mid-nineteenth century) (Hunter, 2010; Tilzey, 2018). The lowland "sheep rancher," whose production of wool for the export market had been the principal cause of enclosure during the Tudor and Stuart eras, now conceded to the grower of cereals and potatoes for the urban industrial worker (Pollard et al., 1974). Enclosed fields of the "wool era" of sixty, eighty, or even a hundred acres (24, 32, or 40 hectares), were now divided up into smaller units typically of around 20 acres (8 hectares) suitable for horse-dependent arable husbandry, and these were planted with new hedges (Pollard et al., 1974).

The nineteenth and early twentieth centuries could be described as the "heyday" of the hedgerow in lowland Britain, both in terms of length (abundance) and in terms of management (pre-mechanical in nature), features conducive to the encouragement of biodiversity and other multifunctional benefits (see below under Ecosystem Services). As suggested, this coincided with a shift in the balance between arable and permanent pasture after 1750, with now more lucrative arable rotations increasing in the south and east of England, especially, at the expense of purely pastoral systems (Overton, 1996). Fodder supplies did not fall, however, since the loss of permanent pasture was compensated by new fodder crops, particularly turnip and clover, in the new arable rotations, classically based on the Norfolk Four Course Rotation, developed in the mid-eighteenth century by Lord ("Turnip") Townshend. This was a rotation of a winter-sown corn (wheat), followed by roots (usually turnip), and then by barley undersown with grasses and clover, the latter producing a ley in the fourth year. Thus, four "large" fields were needed, each being about 20 acres (8 hectares), together with a few smaller fields to facilitate stock management (Pollard et al., 1974). This was subject to regional variations, with more rotations often being employed, this in turn implying smaller fields and more hedgerows.

Not only did these new crops result in increased fodder yields, which meant more livestock manure for the land, they were also instrumental in the "improvement" of much former manorial "waste" in the lowlands, and its conversion from rough pasture

[1] "Assarting" was the term used in medieval times to denote piecemeal woodland clearance, and the strips of woodland left as boundary markers were/are termed "assart hedges."

[2] "Yeoman farmer" was the term given to former members of the "upper peasantry" who became capitalist family farmers, either tenants of landlords or independent freeholders. Their agricultural produce was sold on the market for profit.

to "productive" mixed farms. This was achieved by the same means, that is, as a fodder crop for livestock, the manure from which then raised the fertility of the "improved" land (Tilzey, 2018). The "enclosure" and "improvement" of formerly common "waste" implied the appearance of new hedgerows in these areas, in addition to those of the previously "open fields." Until the introduction of artificial nitrogen, this "improved" system of farming, together with its dense network of hedgerows, was, ecologically, relatively sustainable, and could be said to conform to many of the key principles of agroecology (see below) in its biophysical, if not in its political, dimension. Output of food was thus increased dramatically and without central reliance on fossil fuels, synthetic fertilisers, or inputs imported from overseas. However, the increased demand for nitrogen was a function of the huge export of nutrients from the land to the cities (the so-called "metabolic rift"), contingent upon the termination of locally circulated nutrients characteristic of self-subsistence economies, and the need to remove all straw from the arable fields for livestock use. Moreover, this system was set on a trajectory of ever-expanding output desired by capitalism. Accordingly, from 1830, even this ostensibly ecologically sustainable "first" agricultural revolution began to unravel, as it was replaced by a farming system dependent increasingly on energy-intensive inputs derived from fossil fuels, and upon the importation of both fertiliser and food, particularly cereals, from abroad (Tilzey, 2018). Socially and politically, moreover, this system failed to meet agroecological criteria in many respects. Access to food, especially on the part of the new urban working classes, was dependent on the ability to purchase it, and, therefore, on the ability to find waged employment. Food security for the majority was not assured, therefore, as long as food access was determined by the market. Moreover, access to fresh and nutritious food (fresh vegetables, milk, eggs, meat, etc.) was extremely limited for the urban working classes and, indeed, for many of the new rural proletariat who now spent the bulk of their meagre wages on the purchase of bread flour, having been deprived of access to all but the tiniest parcels of land (Hammond and Hammond, 1987).

British agriculture became increasingly unsustainable from a biophysical perspective (let alone a social and political one) as the nineteenth century progressed, therefore. With the abolition of the Corn Laws in 1846 (which had protected domestic production from overseas competition), British grain producers attempted for the next quarter century or so to remain competitive with overseas producers by means of the increased importation of nitrates and phosphates (particularly in the form of guano) to sustain grain production in the face of falling soil nutrient levels. There was also some degree of mechanisation with the invention and adoption of the reaping machine from the mid-century, for example, and therefore a small degree of pressure to increase field size (and remove hedgerows) again from this time (Pollard et al., 1974). However, this machinery was not widely adopted, and manual harvesting remained prevalent at least until the 1870s. The hedgerow system remained basically intact, therefore, throughout the nineteenth century. Nonetheless, agroecologically, British farming was on an increasingly unsustainable trajectory. The 1830s and 1840s were characterised by an increasing soil fertility crisis due to lack of fertilisers to replace nutrients, as the "metabolic rift" took the form of the burgeoning movement of food (and nutrients) from the countryside to the city. These developments implied that grain production, under pressure from domestic economic growth and exacerbated by competition from abroad, had reached the limits of the "organic" four-course rotation system that had before formed the bedrock of wheat and barley output for the national market. While this system might have been sustainable in the context of a steady state economy, it was incompatible with the continuous demand to increase profit, particularly in the face of competition. The only way for capitalist producers to respond to these pressures was to augment the rotational system with artificial fertilisers and imported manures. This constituted an "unsustainable" overlay of intensive energy inputs on the four-course rotation, representing a shift to the "second" agricultural revolution, or the period of so-called "high farming" (Overton, 1996). This involved a shift to what has been termed the "high feeding" of livestock, particularly cattle, to produce more meat and milk, but also to produce more dung as a vital input into the arable rotation system (Overton, 1996). There was a significant move away from grain and towards pastoralism during the third quarter of the nineteenth century (Tilzey, 2018). This shift, however, remained compatible with the retention of the dense network of hedgerows that still characterised lowland Britain.

Following the abolition of the Corn Laws in 1846, however, Britain progressively lost food self-sufficiency as the century wore on (self-sufficiency being a key criterion of agroecology) and this was implicit in the increased emphasis on meat and dairy at the expense of grain production and the progressive decline of more sustainable mixed farming systems typified by the four-course rotation system (Foster, 2016). The advent of refrigeration in the late nineteenth century meant, however, that even domestic meat production was now subject to competition from cheap overseas imports given Britain's commitment to free trade. The result was that Britain sank "into lasting food dependence" and agricultural depression (Mazoyer et al., 2006, p. 370), a situation that was to persist, excepting the brief interlude of the First World War, until at least the beginnings of state support for agriculture in the 1930s. During this period, there was little incentive to change field sizes and, indeed, a great deal of land went temporarily out of cultivation, with hedges spreading unmanaged into the fields (Pollard et al., 1974). Such land abandonment at home was the counterpart, however, of a "frontier" of largely unsustainable "extractivist" export agriculture overseas, providing Britain with "cheap" food staples premised on the externalisation of ecological and social costs, the antithesis of agroecology (Tilzey, 2018) (a scenario that, in some respects, anticipates the trend towards domestic "rewilding" today, to the extent that its advocates fail to appreciate that the corollary of land abandonment at home is the export of productivist agriculture overseas).

1950 may be taken as the time when the densely hedged landscape of lowland Britain, largely intact since the parliamentary enclosures and, in the "ancient countryside" (Rackham, 1986) since the late mediaeval period, was poised on the brink of profound change that would adversely affect not only hedgerows but also the biodiversity status of all agriculturally managed ecosystems (Pollard et al., 1974). The post-Second World War period was one in which Britain, along with other countries in western Europe, attempted, following the severe food insecurity of the war and the disruptions to food imports, to become self-sufficient in the production of principal food staples. This brought home to Britain the ecological contradictions of productivist agriculture that had previously been externalised onto the spaces of export agriculture abroad. Far from sustaining the biodiversity and landscape resource as before (through organic rotational systems or as an inadvertent result of economic depression), agriculture now became the central factor in its loss and decline (Tilzey, 2000). A massive acceleration in the rate of biodiversity loss and decline followed, attributable structurally to the impacts of a particular model of capitalist development termed "national developmentalism" (Tilzey, 2020). As applied to the agriculture sector, we may refer to this model as "political productivism," a state-managed policy framework to which an acceleration of the processes of "appropriationism" and "substitutionism"[3] are central. "Political productivism," embodied in UK post-war policy and subsequently in the Common Agricultural Policy (CAP) of the European Union, was implemented by employing the instruments of guaranteed prices, investment grants, input subsidies, state regulation of major commodity markets, and their insulation from overseas competition (Tilzey, 2000). The result was to "hothouse" agrarian capitalism through a policy framework in which higher net farm income could be secured only by means of productivity (increased output per unit of labour) and production (increased output per unit area) increases. This acted as a massive incentive to cut costs through the substitution of machinery for labour, enlarging holdings, and borrowing money for land purchase and capital projects. This, in turn, created indebtedness, further reinforcing the imperative to cut costs and increase output. The environmental impacts of such productivist policies can be enumerated as series of generic issues, affecting the whole of the agricultural landscape but, especially, the lowlands, the site of most intensive production and where machinery could be deployed without constraint (see Tilzey, 2000, p. 280–281). The generic issues of relevance to hedgerows are as follows:

- Loss or mismanagement of "interstitial" habitats (hedgerows, field margins, ditches, etc.) due to field enlargement and mechanical management, especially the mechanical, and usually annual, flailing of hedgerows and hedge-bottom vegetation, severely reducing their biodiversity value;
- Loss of crop rotations and arable-pasture mosaics, with arable specialisation in the south and east and pastoral specialisation in the north and west, leading to the loss of functionality of hedgerows, especially in the former;
- Universal application of artificial fertiliser leading to the loss or degradation of characteristic hedgerow bottom vegetation;
- Increased grazing pressure within the pastoral zone, leading to increased browsing of hedgerows "from below," combined with the virtual cessation of non-mechanical management of hedgerows, resulting in severe "gappiness" in the hedgerow bottom and grazing out of herbaceous hedge-bottom flora;
- Strong trend towards contractualisation of hedgerow management, leading to the "simplification" of management, typically entailing annual mechanical flailing of the whole hedgerow irrespective of the presence of potential trees;
- Massive increase in the use of fossil fuels to manage hedgerows (together with all farm management, exacerbated by application of synthetic fertilisers, a major source of greenhouse gas), contributing to the climate crisis.

## CURRENT STATUS OF HEDGEROWS IN LOWLAND BRITAIN

Pollard et al. (1974) estimated the stock of hedges in Britain (that is, England, Scotland and Wales) to be about 804,672 km at the end of the 1950s. Dowdeswell (1987) calculated that 230,000 km of hedgerow had been removed between 1946 and 1974, a calculation most likely based on the estimated annual loss of 8,047 km cited in Pollard et al. (1974). Estimates of hedgerow loss and length have increased considerably in accuracy with the advent of the UK Countryside Survey, based on random stratified sampling of land-use in Britain and Northern Ireland. Employing the rough estimate of the length of hedgerows from Pollard et al. (1974) and the stock of hedgerows from the latest Countryside Survey (Carey et al., 2009), and accepting that the different methodologies applied generate uncertainties, it is nonetheless possible to suggest that, since the late 1950s, Britain has lost about 41% of its net stock of managed hedgerows (that is, after the balance between losses of existing and planting of new hedges has been taken into account) (Dover, 2019). Between 1984 and 2007, the length of lines of trees has skyrocketed from 32,000 to 114,000 km (+256%), reflecting the cessation of management of many hedgerows, such that they are now considered to be lines of trees or relict hedges (Carey et al., 2009; Dover, 2019). This also reflects the predominant dichotomy emerging between mechanically managed hedgerows, on the one hand (often "over-managed," that is non-selective annual flailing along entire lengths), and complete neglect on the other, with only a miniscule percentage subject to manual management by traditional "laying." The herbaceous vegetation of hedgerows has also undergone drastic change under agricultural productivism, with significant decreases in species richness between 1978 and 1998, although no subsequent change was detected by the Countryside Survey in 2007, suggesting perhaps that the damage had effectively been done between those earlier dates [species characteristic of "unimproved" habitats, that is, low nutrient substrates, are highly vulnerable to increases in nutrients and will disappear very soon after first exposure to synthetic fertilisers—once nutrient levels are elevated, these species will not return (Grime, 1979)]. This is indeed reflected in changes in species composition, with the proportion of more competitive species (of which there are very few compared to the large numbers of

[3]Appropriationism and substitutionism refer to the undermining of discrete elements of the agricultural production process, their transformation into industrial activities, and their re-incorporation into agriculture as inputs, e.g., human labour by machinery, animal traction by the tractor, manure by synthetic fertilizers (Goodman et al., 1987).

low-nutrient adapted species) and those characteristic of fertile, shaded, or less acidic soil conditions increasing during the same period. The increase in shade-tolerant species, a trend that continued to increase through to 2007, is considered to reflect the continuing increase in unmanaged hedgerows as these mature (Carey et al., 2009).

## VALUING HEDGEROWS AS ECOSYSTEMS THROUGH AGROECOLOGY AND FOOD SOVEREIGNTY

Since the 1980s, the regime of "political productivism" (Tilzey, 2019) has conceded gradually to a more neoliberal regime of accumulation within the CAP, with commodity support giving way to direct payments, supplemented by discretionary budgets for agri-environmental measures (Tilzey and Potter, 2007). This has led to a modest "greening" of the CAP, although such "greening" falls far short of measures required to stop continued decline in biodiversity and deterioration of the biophysical resource base (water, soil, atmosphere), let alone to undo to the damage wrought by productivism over a period of some 70 years (Tilzey and Potter, 2016). The demise of "political productivism" has coincided with the rise of more holistic visions of land management, integrating low input agriculture with resource and biodiversity conservation, thus moving attention away from the previous preoccupation with the "reserve sequestration" (in effect, "land-sparing") model of nature conservation towards a problematisation of policy frameworks underlying ecological decline in the "wider countryside" (Tilzey, 2000, 2011). Within this new "sustainability phase" (see Tilzey, 2011), the advocacy of an integrated "whole countryside" approach (Tilzey, 2000) has emerged that explicitly challenges the view that nature can be conserved effectively on an isolated or fragmented basis, whether spatially or in terms of individual species (Tilzey, 2000; Perfecto et al., 2009). This view has problematised the sustainability of productivist agriculture itself, whether overtly state-supported or neoliberal ("market productivist"). A change is required, it is argued, towards ecological (and social) sustainability in the character of mainstream agriculture itself, seeking to generate both food security and biodiversity/resource conservation ("land-sharing") through a shift to agroecologically-based production, in which food and biodiversity/resource conservation are *joint products*, that is, are *co-produced*, rather than being seen as antithetical objectives (Wach, 2021). Key elements of this new holistic sustainability paradigm are agroecology itself and the ES approach.

ES theory (United Nations, 2005) recognises that human well-being is, ultimately, wholly dependent on the services afforded by ecosystems. These services are often described as provisioning services: providing food, fresh water, wood, fibre, and fuel; regulating services: climate, flood, disease, water purification; cultural: aesthetic educational, recreational; and supporting: nutrient cycling, soil formation, primary production. To these may be added biodiversity services. Combined, all these beneficial services may be considered to be preventative and curative "medicines" for ourselves and the landscape. The ES provided by hedgerows are presented in **Table 1**. It is important to emphasise that these ecosystem benefits represent more than the sum of their parts, since they act in synergy—it is the *relationship* between hedgerows and intervening agricultural habitats that is of overriding significance, such that we may regard this relation as a form of agroforestry in which each component, agriculture and woodland, benefits from the other (see Poux and Schiavo, 2021, for example). Productivist agriculture places no value on this synergy and therefore actively undermines it through its industrial management of both agriculture and hedgerows.

Sadly, the full potential of ES is being actively subverted through co-optation into hegemonic neoliberal theory (particularly neoclassical economic theory) and policy, with the rationale principally being to reduce costs for capital and the state by substituting natural processes ("natural capital") for substituted ("non-natural") processes (for example water purification and regulation by peatlands rather than by water purification and artificial flood prevention engineering) where feasible, but without reducing the overall impulse towards ecological degradation in the search for economic growth (Tilzey, 2018). Within this neoclassical/neoliberal framework, there is, then, an active struggle (cost-benefit analysis) around which "bits" of nature can be usefully retained to reduce "costs" for capital/state, and which "bits" are expendable in the process of transforming nature into commodities (Tilzey, 2011). In attempting to derive spuriously "objective" valuations of ES arising from "cost-benefit" analysis, neoclassical economists generate often meaningless quantitative valuations (for example, "willingness to pay"), thereby transmuting the irreducible qualitative dimension of ecological services (use values) into a reductive calculus of monetary "value" (exchange value) (see, for example, Foster, 1997 for further discussion).

Agroecology (Altieri, 1995, 1998), for its part, is the science of applying ecological concepts and principles to the design, development, and management of sustainable agricultural systems. It is a whole systems approach to agriculture that embraces environmental health and social equity, using their synergy, rather than economic growth and capital accumulation, as the basis for defining economic well-being. The goal is long-term sustainability for all living organisms, not merely humans. The concept of agroecology has been incorporated into the work of the UN Food and Agriculture Organisation (FAO, 2018) and comprises an important element of the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD, 2009). Agroecology's emergence from the 1960s was largely in response to productivism in the form of agro-chemical inputs, mechanisation, and intensification/specialisation, since these were found to deplete soils, reduce agro- and wider biodiversity, impair water quality and quantity, and generate wider adverse environmental impacts (Pimentel, 2006; Gomiero et al., 2011). A more holistic food system lens in agroecology emerged in the early 2000s, incorporating the social/political dimension of food and agriculture, including dietary diversity and nutrition for consumers, equity in food distribution, control over resources and other key means or production required to establish

**TABLE 1 |** Ecosystem services delivered by hedgerows (adapted from Dover, 2019).

| Type of service | Specific service | Function/example of service |
|---|---|---|
| Supporting Services | Soil formation | Soil formation |
| | Photosynthesis | Production of oxygen |
| | Primary production | Chemical energy as organic matter |
| | Nutrient cycling | Essential element recycling such as carbon, phosphorus, nitrogen |
| | Water cycling | Recycling of water |
| Regulating services | Air quality regulation | Air pollution control (removal of particulates and nitrogen dioxide); reducing agro-chemical drift |
| | Climate regulation | Carbon sequestration (above and below ground), renewable energy, temperature and humidity moderation, shelter for livestock and crops |
| | Water regulation | Run-off and flood control, increasing infiltration |
| | Erosion regulation | Soil retention, reduction of wind erosion |
| | Water quality/purification | Removal of sediments and pollutants, prevention of agro-chemical drift into watercourses |
| | Pest control | Source of predators and parasites of crop and livestock pests |
| | Pollination | Nectar, pollen, and nesting sites for pollinators |
| | Ecological resilience | Habitat diversity increasing ecological resilience |
| | Agricultural management | Containment of livestock |
| | Sense of well-being | Benefits for human mental and physical health |
| Provisioning services | Food | Human: fruit, nuts, foraged salad and vegetables, "wildflower" and berry wine, flavourings (sloe gin). Stock: fodder (most species, ash, elm especially palatable) |
| | Fibre | Timber, fenceposts, wood for turnery, tools |
| | Fuel | Wood (from trees, coppicing, pollarding) |
| | Biochemicals and pharmaceuticals | Dyes, medicinal plants |
| | Genetic resources | Seeds for production of plants of local provenance |
| Biodiversity services | Corridors, stepping stones | Facilitating movement through landscape |
| | Habitat and refuges | Nesting, feeding, hibernation, aestivation, shelter from predators |
| | Habitat and landscape diversity | Overall landscape diversity, juxtaposing agricultural and woodland ecosystems (agroforestry) |
| Cultural services | Recreation and ecotourism | Walking, enjoying nature |
| | Cultural heritage values | Cultural and historical artefacts |
| | Education | Outdoor classroom (nature, history, etc.) |
| | Aesthetics, sense of place | Appreciation of landscape, regional identity, inspiration |

agroecological food systems (Wach, 2021), bringing agroecology into close alignment with food sovereignty (Tilzey, 2018). Like ES, however, agroecology has become a contested concept as it has gained in importance, reflecting different understandings of the root causes of ecological unsustainability and social inequity in food systems (Wach, 2021).

First, the concept has suffered co-optation by certain state agriculture departments, notably in France, where, as official policy, agroecology is divested of its holism and social dimension, and deployed in an entirely instrumental fashion (see Levidow et al., 2014), much as ES above, to reduce input costs through "ecological modernisation," or "sustainable intensification," to boost the competitiveness of otherwise conventional farms. Second, agroecology has been invoked by those advocating economic diversification, local markets, "ecologisation" of inputs to reduce costs and dependence on upstream suppliers, and a shift to "post-productivist" "economies of scope" rather than "economies of scale" (Tilzey and Potter, 2016). Such producers generally supply the high-end market demand created by "reflexive" middle-class consumers, and such "niche" "post-productivist" trends have been supported by CAP Pillar 2 funding. While theorists such as Van der Ploeg (2008) have described such producers as the "new peasantry," opposed to capitalism, the reality is that these are (on the downstream side) market-dependent petty commodity producers embroiled in "relentless micro-capitalism" (Bernstein, 2014). This trend comprises a form of market segmentation, involving the co-optation of selected agroecological principles into capitalism, failing to generate the transformations required to ensure that food systems are *both* ecologically sustainable and fulfil human dietary, social, and cultural needs on an equitable basis (Wach, 2021).

Increasingly, proponents of a "political" approach to agroecology, aligning with "radical" food sovereignty (Tilzey, 2018), recognise the potential of, and need for, this theory and practice to address the ecological precarity and social inequity of capitalist food systems (Wach, 2021). Agroecological production can meet humanity's food needs, they argue, on condition that production is determined by societal food needs, not capitalist imperatives. An understanding of the concept of "market dependency" is key here (Wood, 2002; Tilzey, 2017, 2018; Wach, 2021). This concept not only considers the commodification of agricultural *inputs* to be defining of capitalist or market-dependent agriculture, but also the compulsion to sell *outputs* into markets in order to secure economic reproduction of the producer. This approach has a strong focus on *what* is produced by farmers and, therefore, a stronger food system lens, arguing that when producers are dependent on selling their outputs into markets, even where local and small-scale, market imperatives affect not only how foods are produced but also *which* foods are produced and how they are distributed (Wach, 2021). In other words, market dependency means that the focus is upon generating exchange value (maximising monetary return) and not upon meeting social need and ecological sustainability.

As we have indicated, however, the strong sustainability (ecological and social/political) embodied in ES and agroecology has been co-opted and subverted by the much weaker interpretations of sustainability by the state/capital nexus [the "state-capital nexus" understands the "state" and "capital" to be co-determining, rather than dichotomous, entities (see Tilzey, 2019)]. The "greening" of the CAP is largely an exercise in "greenwashing" and the discretionary budgets for agri-environmental Pillar 2 measures continue to be dwarfed, and essentially cancelled out, by the largesse that continues to support productivism in Pillar 1[4] (Tilzey and Potter, 2016). The counterpart of this is a continuing emphasis on the sequestration of special habitats and on the preparation of action plans to address the decline in individual species (Tilzey, 2011). Necessary as such initiatives might be as short-term "fire-fighting" measures given the drastic decline in many formerly characteristic farmland species and habitats, they continue to fail to address the basic causes of loss and decline as a result of capitalist, productivist land use throughout much of the countryside. For these reasons, productivism, and especially "political productivism" in the form of the CAP, has long been the environmental *bête noire* of the mainstream conservation movement. For these same reasons, however, the latter has tended to be beguiled by neoliberal arguments for the freer play of "market forces" as putatively the best means to assure greater environmental sustainability, a position long-held by the UK government. The CAP has thus been a relatively easy target for the mainstream conservation movement, precisely because such critiques sit comfortably with the new neoliberal economic agenda and its calls for the dismantling of market/direct support structures (Tilzey, 2011). Such is, indeed, now coming to pass with Brexit and the proposed phasing out in the UK of inherited CAP supports through Pillar 1 over a period of 7 years.

[4] Pillar 1 of the CAP, funded wholly by the EU, was designed to support and regulate supply of the major agricultural commodities, although payments are now largely decoupled from production. Pillar 2, co-financed by the EU and member states, with the latter having considerable discretion over form, funding, and content, was designed to support rural development and agri-environmental initiatives and programmes.

## CURRENT AND ANTICIPATED AGRI-ENVIRONMENTAL POLICY FRAMEWORK FOR HEDGEROW CONSERVATION

### Current Policy

In the face of prevailing productivist farm management, hedgerows currently are afforded a modicum of protection through the following means. First, through statutory protection under the Hedgerow Regulations 1997: these regulations prohibit the removal of any hedgerow over a stipulated length that is over 30 years old and meets an additional listed criterion (for example, contains certain woody species) (Natural England, 2014). While these regulations in theory protect most hedgerows from outright removal, they do very little to protect hedgerows from inappropriate management as described earlier in this paper, management that remains the norm rather than the exception. Second, through cross-compliance requirements placed on the receipt of Basic Payment Scheme monies (direct payments), received by all eligible farmers (the great majority), and requiring farmers inter alia to desist from hedge trimming between the end of March and the end of August (Rural Payments Agency, 2020). These requirements are minimalistic and do little to discourage inappropriate management outside these dates. Moreover, the cross-compliance requirements will discontinue with the cessation of direct payments, scheduled for 2027. Third, there are hedgerow conservation/renovation and establishment options available within the agri-environment schemes (the various tiers of the Environmental Stewardship scheme) (Rural Payments Agency, 2015). These schemes, however, are voluntary and competitive due to constrained agri-environment budgets, so that they are not, in practice, even available to all farmers who might wish to take them up. Moreover, being non-mandatory, there is no obligation for farmers outside these schemes to follow their management guidelines, for example, for rotational rather than annual trimming, hedge-laying, etc. Thus, within the current policy context, appropriate hedgerow management, one that maximises the ES delineated above and minimises ecosystem disservices (perhaps notably the emission of huge quantities of greenhouse gas in the course of hedgerow "over"-management), remains the exception rather than the rule.

### Anticipated Policy

The UK government wishes to replace, through phased withdrawal, the inherited support structures of the CAP with a system that affords no direct economic support to farmers, and confines public subvention to "public goods" payments—that is, to "goods and services" (many of the ES listed above) that productivism cannot effectively commoditise, and which are therefore destroyed, degraded, or neglected. It should be noted, however, that the neoclassical economic theory on which "public goods" arguments are made is deeply flawed, since it is assumed that it is the non-commodification of "public goods" that causes their loss and degradation, when it is evident that commoditisation itself is equally subversive of ecological and social use values in the farmed environment through the pressures of market dependency, leading to appropriationism and substitutionism. In this way, it is proposed to effectively confine public subvention to Environmental Land Management Schemes (ELMs) of which there will be three main components: The Sustainable Farming Initiative (SFI) (to support "environmentally sustainable farming" across the landscape), Local Nature and Recovery (to support local environmental priorities and recovery), and Landscape Recovery (to support longer-term land use change projects, including "rewilding") (DEFRA, 2021). These are to be "supported" by a set of regulatory standards, the configuration of which remains as yet unclear. ELMs, however, will remain voluntary and discretionary (competitive), so whether they will differ in any significant way from the current Environmental Stewardship scheme, and its inadequacies, remains to be seen. The fundamental problem is that they will be competing against adverse pressures flowing, not now from "political productivism," but rather from the "market productivism" embodied in the "free trade agreements" (FTAs) that the UK government is committed to concluding with countries that often have significantly lower environmental and social standards than the UK, and which will therefore exert further downward pressure on prices, forcing farmers to further externalise ecological and social costs [the outline FTA signed recently with Australia is symptomatic of this trend, a country where cattle and sheep are produced "cheaply" at huge environmental cost, including severe loss of biodiversity (biodiversity which is much higher than that of Britain), soil degradation, erosion, and salinization, and drastic deterioration in water quantity and quality, both surface and groundwater (see Tilzey, 2006; Tilzey and Potter, 2016; Kim et al., 2020)].

Under the UK government's post-Brexit "global Britain" scenario, therefore, enhanced competitive pressures will oblige farmers to accelerate "market productivism" in an attempt to supply the most lucrative markets, including the externalisation of fossil-fuel dependent transportation costs entailed in meeting distant demand. We can, therefore, anticipate a perpetuation of productivism, driven now by market imperatives rather than by the overtly political objectives of the CAP (Tilzey, 2000). In the resulting competitive "race to the bottom" the high opportunity costs of diverting land, investment, and management to conservation use or agroecology mean that agri-environmental "policy reach" will be limited. This will be the case particularly in respect of those farms described by DEFRA as "very large" (the top 25% of farms) and those in the "general cropping,"[5] cereals, horticulture, and dairy sectors in which agricultural business activities are currently profitable and enterprises are not predominantly reliant on state subsidy (as direct payments and/or agri-environment payments) (DEFRA, 2019, 2020a,b). The new ELM incentive scheme, unless endowed with very generous budgets, will struggle to meet such opportunity costs on the ∼50% of farmed area occupied by such farms and will, therefore, tend to "cherry pick" those areas/sites considered to be of the highest conservation value, leaving approximately half of the UK countryside to the tender mercies of cost-externalising productivism. Throughout much of this area, therefore, in which farmers will be preoccupied with securing further economies of scale in the face of the discontinuation of direct payments and enhanced exposure to overseas competition, the only means of securing compliance with environmental objectives will be by means of tighter regulation—as noted, however, these regulations are currently the subject of intense contestation for precisely this reason. These same pressures will also lead to further farm amalgamation (loss of the few remaining small and medium farms in those areas dominated by arable, horticulture, and dairy) and the further substitution of machinery for human labour. Absent stronger regulation and enhanced agri-environmental incentives, the future of hedgerows under this scenario and in these areas does not look bright.

Alternatively, in those zones dominated by farms described by DEFRA (2019, 2020a,b) as "mixed," "lowland grazing livestock," and "grazing livestock LFA,"[6] predominantly in the west and north of the UK and characterised by the majority "small" and "medium" farms, enterprises will struggle to survive with the demise of direct payments. The commercial activities of all farms in these categories are, on average, currently loss-making (primarily sheep and beef cattle) and they remain solvent due only to receipt of state subsidy as direct payments and agri-environment monies (DEFRA, 2019, 2020a,b). Direct payments comprise the bulk of these payments (up to 100% of income in the case of many LFA farms), and their phasing out spells the demise of many of these farms unless new ELMs disbursements can make up the deficit. As things stand currently, such an outcome appears very unlikely since ELMs budgets are likely to be both constrained and competitive, with farmers therefore having no automatic entitlement to subvention in contrast to current direct payments. Moreover, disbursements will be calibrated to generate certain environmental outcomes, not to secure the solvency of farm income. How environmental outcomes will be secured if the farmers are no longer there to deliver them, however, appears to be a question of little concern to the current UK government. In the absence of ELMs funding of sufficient magnitude to secure landscape-scale support for farmers to transition to agroecological (including agroforestry) production systems in these areas (see below for policy detail), the pressures for smaller farms to sell up and for larger farms to absorb them will be overwhelming. The latter will attempt to compete with overseas producers through economies of scale realised through the absorption of bankrupt farms, leading to a "ranching-style" landscape of derelict/over-managed hedgerows and degraded, low-biodiversity pasture. Some farms may simply be abandoned and revert to scrubland, while others may well be the fortunate recipients of agri-environment support, including for "re-wilding" projects. Farms in this situation will become primarily producers of "public goods" rather than food. Certainly, given the lack of opportunity cost to produce agricultural produce competitively, "policy reach" in these pastoral lowland and upland zones will be considerable, with demand to join ELMs, as the only subsidy system available after 2027, considerably outpacing supply absent a considerable

[5]"General cropping" refers to farms which produce both cereals and horticulture in approximately equal proportion.

[6]LFA refers to "less-favoured areas," generally meaning the uplands.

expansion in available budgets and their reconfiguration from competitive to entitlement schemes [as, for example, with the now defunct Environmentally Sensitive Areas schemes (see Tilzey, 2000)]. The uptake of ELMs in these zones is, therefore, likely to be high and over-subscribed by contrast to farms in the arable, general cropping, and dairying sectors.

The result, overall, will be a dichotomous countryside, with the agriculturally competitive (arable, general cropping, dairy, together with poultry and pig) farms in the lowlands dominated by "de-natured" market productivism, and the (sheep, beef cattle) pastoral zones of the west, north and the uplands reverting to "de-socialised" "wilderness" (Tilzey, 2011), converting to managed "re-wilding," or pursuing "ranching-style" scale-economies. Taken together, this represents a "land-sparing," not a "land-sharing," approach, and represents the antithesis of agroecology and food sovereignty. Questions of the co-production of food and biodiversity, without recourse to fossil fuels, and of the supply of, and access to, locally grown and nutritious food for all are wholly neglected in this neoliberal scenario espoused by the UK government. Rather, the realisation of ES, the elimination of ecosystem disservices, and the adoption of "political" agroecology, all imperatives for real sustainability, require the elimination of capitalist market dependency and the adoption of an entirely new post-capitalist mode of production. This mode would comprise a farming and food policy, integrating environmental policy, premised on the concept of Sustainability through Agroecology and Food Sovereignty.

## THE NEED FOR A HOLISTIC PERSPECTIVE: SUSTAINABILITY THROUGH "POLITICAL" AGROECOLOGY AND FOOD SOVEREIGNTY

There is an urgent need for a policy framework that strongly integrates and coordinates agriculture, food, environment, health and social equity. Essentially, this means producing nutritious food from our own resources (importing, as a general rule of thumb, only "non-indigenous" foods), on an ecologically sustainable basis (conserving soils and biodiversity, cutting and ideally eliminating net GHG emissions, and sequestering carbon), with production, distribution, and consumption undertaken on a democratically defined basis that ensures the equitable and secure provision of healthy diets. In other words, we need to achieve food security and equity whilst also conserving biodiversity and soils, cutting/eliminating, while at the same time sequestering, GHGs. The basic parameters of this system would comprise the elimination of grain-based meat production, the elimination of synthetic fertilisers and pesticides, the transition away from fossil-fuel-based production, the elimination of imports of "indigenous" produce and of livestock feed as part of a focus on food security through national self-sufficiency, a shift towards vegetarianism, a massive decrease in carbon emissions in tandem with a commensurate increase in carbon sequestration [secured in the main through livestock production reduction and extensification (especially of sheep, currently numbering 15 million in the UK), releasing currently lost opportunities for woodland, sylvo-pastoral, and peatland conservation, expansion, and creation], and the profound democratisation of the food system, including land redistribution (see, for example Poux and Schiavo, 2021 for an agroecological scenario for the UK in 2050).[7]

An agroecological policy framework, in addressing ecological sustainability, would be designed in such a way as to achieve conservation of, and sustainable food production in, the broader fabric of the countryside whilst, simultaneously, delivering "additionality" on special sites (such as Sites of Special Scientific Interest). This might take a tiered form, with basic tiers for wider countryside management and agroecological food production with higher tiers to deliver more demanding wildlife, resource, and landscape objectives, including measures for carbon sequestration such as peatland and woodland recreation. Farm management options would address, then, three basic situations, from higher to lower tiers: first, sensitive sites (e.g., maintenance and enhancement of semi-natural habitats); second, diversion/reversion (semi-natural habitat expansion and creation); third, agroecological production focused on most fertile land. All farms delivering these benefits would receive an area payment, graduated according to tier, and subject to degressivity in the lowest tier for farms over a certain hectarage. A strong regulatory baseline would prescribe statutory standards of land management and farming, including proscription of agri-chemicals and artificial fertilisers, strong protection for hedgerows including a proscription of annual flailing except for health and safety purposes. Generally, such regulations would enforce an internalisation of costs currently externalised in productivist farming, including fossil fuel usage, which would no longer be subsidised (currently "red diesel" used in agriculture is not subject to taxation). This would provide the needed stimulus to farmers to move from conventional to organic and thence to agroecological production.

In addition to these agri-environmental area payments, supporting the ecological (including climate change mitigation) dimension of agroecology, farmers would receive, in furtherance

[7]More orthodox economists will, of course, point to the supposed impracticalities and "costs" of such a transition. Here, it needs to be borne centrally in mind, however, that we are now living in an era of existential threat to our very future existence as a result of the climate and ecological emergencies. The current capitalist system and its supporting ideology of neoclassical economics is predicated on a model of accounting that almost wholly externalises the real costs of fossil-fuel and agro-chemically powered growth in the agri-food sector. These unaccounted costs are now coming home to roost in the form of global heating, collapse of ecosystems, exhaustion of soils, pollution and overuse of surface and groundwaters, and the loss of livelihood opportunities for people in farming as mechanisation substitutes for skilled labour. Moreover, on the current trajectory of global heating, we face the prospect, amongst many other dire impacts, of rising sea levels [melting of the Greenland ice cap will lead to 7 m rise in global sea level, loss of Antarctic ice cap will lead to a rise of over 60 m in global sea level (NASA, 2021)], levels which would lead to the calamitous submersion of the bulk of lowland Britain beneath the sea. These urgent and existential threats to our future demand the internalisation and elimination of current externalities through both the cessation of GHG emissions *and* through a programme of carbon sequestration. Within the agriculture sector, this, together with the need to address biodiversity loss, soil exhaustion, and water quality/quantity issues, can be achieved only by means of the adoption of agroecological and food sovereign systems of production and consumption.

of its "political" or food sovereignty dimension, guaranteed prices for food produced agroecologically (at least initially as a production stimulus and pending the introduction of environmental/social tariffs on imported food failing to meet stipulated socio-ecological standards).[8] Such food would be purchased by local/regional public authorities, effectively severing market dependency and competition, being distributed equitably through stipulated price mechanisms, with free food available to the unemployed and those on lowest incomes. This measure is deemed necessary since food poverty is now a very serious issue in the UK. The country now has some 2,000 food banks run by charities supplying free food to people in need, a symptom of the retreat of the welfare state and inadequate social security payments under the austerity policies pursued by the Conservative UK government. Nearly 50% of families with three or more children are now below the poverty line, while the cut in Universal Credit (introduced in October 2021) is anticipated to push a further 500,000 people into poverty and take the child poverty rate to one in every three children (Child Poverty Action Group, 2021; Department of Work and Pensions, 2021). These statistics call for drastic and concerted action. The UK social security system needs to include provision of free, healthy, and nutritious food as a basic part of the welfare package. Naturally, elimination of such need and poverty should be the aim of policy undertaken by a responsible government, and this could be secured as part of a comprehensive national plan for a "green transition" or "green new deal," including transition to agroecological production. Pending the provision of decent and rewarding livelihoods for all citizens as part of this transition, the alleviation of food poverty could, and should, be secured by means of public food provision.

Given the increased labour intensity of agroecological production and conservation management (see, Poux and Schiavo, 2021), there would need to be a policy of rural re-population and diminution in the size of landholdings to encourage new entrants to farming.[9] This might (and ideally should) entail a policy of land reform, proscribing ownership of land above certain size limits, and redistributing the resulting surplus land to new entrants to farming. This would entail an attempt, for the first time in British history, to address the grossly inequitable distribution of land in the UK and to redress the profound injustice perpetrated on the English, Scottish, and Irish peasantries through the political act of "primitive accumulation" (Hammond and Hammond, 1987; Perelman, 2000; Tilzey, 2021a). Of course, the current legal framework of private property and land access only through sale (or inheritance) as a commodity render non-market-based redistribution a virtual impossibility at the present time [at least in England and Wales—Scotland has made some significant strides towards community land rights and land reform (see Wach, 2021)]. Land ownership, as noted, is highly skewed in the UK towards proprietorship by a small number of landowners, a legacy largely of unjust and undemocratic processes of "primitive accumulation" undertaken by landlords and larger landholders between the sixteenth and nineteenth centuries (see above) (Shrubsole, 2019). This inequality in land distribution needs to be redressed not merely for reasons of social justice, but, more particularly and urgently, for reasons of facilitating the agroecological transition, one that depends crucially upon a re-peopled countryside (Poux and Schiavo, 2021; Tilzey, 2021a).

What might agroecological production look like and what would be the role of hedgerows in this radically transformed production? The UK government currently pursues an agricultural and food policy that is (or will be when direct payments are phased out) entirely market-dependent (export and import-dependency to maximise exchange value), making it extremely vulnerable to politico-economic and environmental disruption, whilst itself contributing to those very ecological and food supply insecurities through its agro-chemical and market productivist orientation. UK agriculture achieves very high productivity (the ratio of labour input to output), but only with massive quantities of fossil fuel, synthetic fertiliser and agro-chemicals, together with extraordinarily expensive equipment and infrastructure, also dependent on fossil fuel. Agro-chemicals derive, of course, from oil, while immense amounts of fuel and electricity are required to synthesise artificial fertilisers from natural gas. Their production and use release huge quantities of carbon dioxide and (much more potent) nitrous oxide into the atmosphere for every kilogramme of food commodity that is produced, making industrially-produced bread baked with conventional flour, for example, one of the most climate-destroying plant-based foods available (Rogosa, 2016; Letts, 2020).[10,11] Even this pales into insignificance,

[8]Such a policy is likely to be time limited pending general adoption of agroecological production, and would, in any case, not encounter the problems of overproduction experienced by conventional productivism due to the inherent output constraints characteristic of agroecological production, especially when predicated upon CGC arable production (see below).

[9]There is an increasing body of young people being trained in agroecological and conservation management through further and higher education, and/or through practical experience on farms. Moreover, millions of people, especially younger people, currently work unwillingly in insecure, poorly paid, unrewarding, and meaningless jobs in the so-called gig economy and related sectors, jobs that, to add insult to injury, contribute significantly to the climate and ecological crisis. These people are crying out for meaningful and rewarding livelihoods related to building the "green and solidarity economy" of the future, livelihoods that will include working on the land with nature to produce healthy and nutritious food (not as an exploited workforce but as empowered landholders). Any such transition will, of course, require concerted effort and support (including appropriate funding and training) from central government, local government, and communities.

[10]This refers to the production process, and by comparison to conventionally grown, longer-stemmed cereal crops. All conventionally grown (fossil-fuel dependent production of) crops are damaging to the climate for the above reasons, but wheat especially so. One of the most important reasons why modern wheat varieties are more demanding of synthetic fertilisers, and hence damaging to the climate, is that they have been developed with short stems, or straw, to prevent "lodging" or falling over, a real problem with the development of larger grains (Rogosa, 2016). In the 1920s, genes were identified in experimental varieties that controlled straw height. Varieties containing dwarfing genes were crossed into tall stemmed strains forcing plants to redirect surplus energy into producing more grain rather than straw. *Much more fertiliser could now be applied to crops* in order to maximise yield and gluten content without lodging. Dwarfing genes were incorporated into commercial cereals throughout the world in the 1950-60s, and the first such variety was released in the UK in the mid-1970s. All modern wheat varieties now contain dwarfing genes and have been developed for conventional production systems (Rogosa, 2016; Letts, 2020).

[11]Although the work of John Letts as an academic archaeobotanist has been widely published in peer-reviewed journals, his experimental fieldwork with "heritage" grains and CGC has, so far as I can ascertain, not yet been published similarly

however, by comparison to the ecological inefficiencies of raising livestock fed with these grains (beef, pork, and chicken, fed also with imported soya)—overall, 60% of the grain grown in the UK is fed to animals (AHDB, 2019), while some 85% of agricultural land is devoted, directly or indirectly, to livestock production (de Ruiter et al., 2017; Poore and Nemecek, 2018). As much land overseas is used to support UK grain-based livestock production system as is used in the UK itself (National Food Strategy, 2021).

We urgently need, therefore, both for food security and for ecological sustainability, to, firstly, eliminate all grain-based livestock rearing, and to confine livestock farming to pastureland free of artificial fertilisers and agro-chemicals. Secondly, neither productivist nor "rotational" organic production systems can generate the quantity of grain needed to supply UK consumption in a secure and ecologically sustainable way. This is true also of agroecological production where grain production is reliant of animal manures. This means essentially that arable and pasture must be rotated, implying inter alia that the potential for carbon sequestration on what would otherwise be permanent and extensive pasture (plus potentially new hedgerows and woodland) is rather compromised[12] (see Letts, 2020; National Food Strategy, 2021; Poux and Schiavo, 2021). Part of Poux and Schiavo's solution is to reduce UK consumption of cereals by some 45%. Inter alia this would then permit some 11% of UK to be devoted largely to carbon sequestration, adequate to meet the UK's commitments to GHG emissions.

Reducing grain consumption by this magnitude could prove very challenging, however. A potential solution is to grow cereals in a way that does not rely on animal manures as does the modelling of Poux and Schiavo (2021). Grain can be grown in an agroecologically-based way, however, that increases output whilst minimising fossil fuel usage, enhancing biodiversity, *and* sequestering greenhouse gases on a greater scale than envisaged by Poux and Schiavo (2021), for example. This addresses the two main contradictions of "rotational" organic production—the need for high soil fertility levels, requiring rotation with livestock systems to achieve these, and the use of modern grain varieties, most especially wheat, that require these high nutrient levels and have short stems, needing frequent rotation and tillage to control weeds. These modern wheat varieties, bred to respond to synthetic fertilisers, do not grow well in low input, agroecological systems. One of the main contradictions of "rotational" organic systems, then, is the need for tillage. However, "heavy and frequent tillage negatively affects a soil's physical and biological properties and is probably the most important reason for decreases in soil structural quality... Tillage may also decrease soil organic matter, which may be further reduced by rising temperatures" (Ostergard et al., 2009, p. 1440). Moreover, "minimum tillage can improve soil structure and stability, resulting in better drainage and water-holding capacity, as well as enhancing microbial activity... These practises also reduce losses of soil organic matter and thus carbon losses, while improving soil structure and water retention and enabling a more permanent soil cover. There is much potential for reduced tillage to mitigate GHG emissions..." (Ostergard et al., 2009, p. 1440). The implication here is also that carbon can be sequestered, in addition to reducing/eliminating emissions.

Currently, then, there is often a need for tillage to control weeds in organic farming. Many biotic problems could, however, be resolved by means of diversification strategies such as cultivar and species mixtures to reduce infection and spread of diseases, and by means of plant traits that confer a high level of crop competitive ability against weeds (Mason and Spaner, 2006; Ostergard et al., 2009). In addition to disease, insect, and weed control, and consequently reduced pesticide inputs, nutrient conservation, soil fertility building and enhanced yield stability are some of the ecosystem services that can be secured by crop diversification. The introduction of crop variation over time and space stabilises these systems and includes growing heterogeneous varieties that can adapt to local and changing environments, extending from the landscape to the field scale (the latter using populations or mixtures of varieties within a field). Perennial energy crops, fruit trees, and hedges are of great importance here, since they add more structural diversity to the agricultural landscape while further reducing soil tillage needs (Ostergard et al., 2009). "In systems with more variable climate and reduced external inputs, crops will need to be able to cope with spatially and temporally more heterogeneous environmental conditions. Plant breeding will have to provide varieties that are adapted to these new needs in diversified agricultural systems, which will need innovative approaches. The requirements for such varieties are enormous, as they have to combine high yield with high levels of resistance and tolerance to pests and diseases, competitiveness with weeds and an improved stand establishment with efficient use of nutrients, water, and light. *As new characteristics are needed, breeding will have to rely on*

(although it has been published in non-peer reviewed publications as per the "Land" citation). However, the agroecological foundations for his fieldwork, and conclusions from it, are supported by peer-reviewed research (see below) and his work has been funded through the EU Horizon 2020 Research and Innovation Programme under Grant Agreement No. 727848 and is summarised in the following link entitled "Low input and organic heritage cereal production in South East England." http://cerere2020.eu/wp-content/uploads/2020/03/17_EN.pdf Similar experimental fieldwork and findings have been undertaken in the USA by Rogosa (funded by the USDA Sustainable Agriculture Research and Education Program) where einkorn, emmer, and other landrace wheats outperform modern wheats under organic conditions (that is, where synthetic fertilisers and pesticides are not applied) (see Rogosa, 2016, p. 4).

[12]On average, each of the UK's 66 million citizens consumes about 60 kg of (mostly white) wheat flour a year comprising about 15% of the calories needed to maintain a healthy diet. This is about 4.55 million tons of wheat for the entire country, which in theory could be grown on 91,000 ha of good quality organic land, less than one sixth of the area currently used for arable and ley (Letts, 2020). However, the wheat crop for human consumption would be only one year out of five in the rotation, so more than 4.5 million hectares of arable land would be required to grow all the necessary wheat, an average annual yield (averaged over the 5-year rotation) of about one tonne of wheat per hectare. A fifth of this area would be down to wheat at any one time: three fifths would be producing fodder from the three years of clover ley; and the other arable crop might be barley, oats, roots or beans, either for human food or livestock feed. Even highly productive leys dedicated to organic milk production supply far fewer calories per hectare than a decent crop of organic wheat. There can be no doubt that *a great deal more land would have to ploughed up* (and therefore lose its carbon sequestration potential) in order to feed the UK on the basis of organic mixed farming. According to Letts (2020), even if the UK were to stop feeding wheat to animals, and halved the use of other cereals for animal feeds, it would still need some eight million hectares of temporary clover-grass ley—a third of the entire country—to fertilise the land needed to grow enough food for everyone.

*the intensive use of genetic resources (landraces, exotic and wild resources)*" (Murphy et al., 2005; Wolfe et al., 2008, emphasis added; Ostergard et al., 2009, p. 1441). Many of these required traits are based on a range of genes (polygenic inheritance) rather than single genes (monogenic inheritance) and are thus greatly influenced by the environment, requiring phenotypic selection.

One strategy to produce this required polygenic inheritance has been through creating diversity through breeding selected varieties of modern wheat for the above desired characteristics, a technique pioneered by Martin Wolfe (for example, Wolfe et al., 2008). An alternative is to use landraces, or "heritage" grains, drawing on the thousands of different wheat, and other cereal, varieties that used to characterise the British landscape, each adapted to local soil and climatic conditions. These have the advantage of having tall stems (straw) to outcompete weeds, have higher nutritional value and, because of the need to avoid lodging, have lower nutrient demands than modern varieties (Rogosa, 2016; Letts, 2020).

A potential solution here, then, is to grow genetically-diverse populations of landraces, or "heritage" grains, in the same fields, continuously, without animal manure or tillage, following a low-input approach known as Continuous Grain Cropping (CGC) (see Rogosa, 2016; Letts, 2020). These cereals can be grown in this way so long as the crops are genetically diverse, have tall stems (like traditional wheat) to help suppress weeds, and all the straw is left in the field post-harvest. The nitrogen removed with the grain each year is replaced by nitrogen fallout from the atmosphere, by the mineralisation of plant tissues above and below ground, and by the fixation of nitrogen by an under-sown layer of clover. Moreover, "compared to modern cultivars, wheat landraces have higher biomass; invest more root growth into deeper soil profiles; have increased ability to extract moisture from soil depths; have far greater association with mycorrhizal fungi, which enables a vastly greater capacity to scavenge nutrients in lower-fertility soils... Tall height that towers above most weeds combines with allelopathic root exudates that suppress weeds... Landraces are a treasure trove of traits for higher nutrient and water uptake under the stresses of weather extremes" (Rogosa, 2016, p. 25).

CGC production yields about 2.5–3.0 t/ha even on fairly poor soils (Rogosa, 2016; Letts, 2020). It should be noted that, since these results have not yet been published in a peer-reviewed journal, additional work is needed to quantify yields and confirm the long-term viability of the CGC system, before large-scale implementation[11]. These preliminary results do suggest, however, that current national demand could be met from ∼2 million hectares of land [current field crop hectarage in the UK (mostly cereals) is over 6 million, but a large percentage goes to feed animals and the crop land also needs to be rotated]. If diets were to become increasingly vegetarian/vegan, this area would need to expand further, but would still be less than the current field crop hectarage. If, on a reasonable assumption, we could supply increased national demand, on the basis of increasingly vegetarian diets, from around 5 million hectares of land, this would still leave some 12 million hectares for alternative production [total farmed area in the UK is 17.6 million hectares (National Food Strategy, 2021)], including the production of extensively and agroecologically reared livestock, poultry, and greatly expanded provision for carbon sequestration. In this way, then, the remaining area of non-cultivated land could be devoted to grass-based agroecological livestock/dairy and other multifunctional uses such as carbon sequestration, "re-wilding," public recreation etc.

The above parameters could, or should, shape the basic agricultural land use configuration under agroecology in which hedgerows could thrive and realise their full potential in the provision of ES. With lower soil fertility requirements and greater genetic diversity of cereals, grain production could be decentralised (re-territorialised) to all lowland areas, and likewise, livestock production. This would lead to much more mixed production landscapes in which hedgerows would regain their original functionality, separating livestock from arable crops. New hedgerows would also be planted to create, once more, smaller fields to facilitate both the rotational grazing of livestock and the cultivation of CGC arable crops (see Letts, 2020). More extensive production would enable hedgerows to be managed more permissively, with a re-peopled rural landscape and incentives for traditional management enabling hedges to be tended again by skilled human labour. Permissive management would enable hedgerows to realise their huge carbon sequestration potential [conservatively estimated at 40 million new trees, with no planting required, together with the "bulking up" of shrub and small tree species (Tilzey, 2021b based on Carey et al., 2009)], whilst providing shelter for crops and livestock, biodiversity benefits such as the recovery of many now threatened farmland bird species such as the turtle dove (*Streptopelia turtur*), and a wealth of wild produce for human consumption and for medicinal use. Meanwhile, the UK Climate Change Committee has recommended an expansion of British hedgerows by some 40% in order to help meet the UK government's statutory target of net zero carbon emissions by 2050, recognition of the important role of hedgerows, both above and below ground, in sequestering $CO_2$ (CPRE, 2021). Additionally, more marginal areas, for example the large areas of the lower slopes in upland areas dominated by bracken (*Pteridium aquilinum*), represent ideal zones for the establishment of agroforestry as contour hedgerows/woodland strips and/or as "wood-pasture." This would be especially feasible with the significant reduction in sheep numbers envisaged in our livestock extensification proposal under the agroecological transition described above [sheep, through their grazing and browsing, currently prevent natural regeneration of woodland throughout much of the upland zone and, therefore, carry a very high "carbon opportunity cost" (National Food Strategy, 2021)]. This would be a "win-win" scenario, since current low biodiversity and low value grazing land dominated by bracken could be transformed into higher diversity grassland/woodland mosaics, millions of new trees would constitute an additional and huge carbon sequestration sink, while extensive grassland would be expanded with the reduction of bracken through shading under new trees and by livestock grazing where undertaken principally by cattle (sheep, unlike cattle, are unable to suppress bracken, this fact accounting for this invasive species' huge expansion since the demise of cattle and the expansion of sheep numbers in the uplands in recent decades).

## CONCLUSION

This paper has explored the political ecology of hedgerows in the British landscape. While an earlier phase of capitalist agriculture helped to establish and sustain the majority of hedgerows, later, productivist, phases, including the current neoliberal phase, have entailed their progressive loss and degradation. This is little short of tragic since hedgerows, iconic features of the British lowlands, can make an important contribution to agroecological and food sovereignty transitions and an overall contribution to multifunctional agro-ecosystems with multiple benefits to biodiversity, climate change mitigation, soil health, human health, wellbeing, and livelihoods. In response both to this mismanagement of hedgerows and to the unsustainability of the UK food system as a whole (of which this mismanagement is an integral part), this paper has outlined what appears to be required, in policy and political terms, for the adoption of an agroecological and food sovereignty framework enabling the sustainable management of hedgerows and maximising their potential for ecosystem services delivery. The moral of this tale is that, if only we can throw off the yoke of productivism and market-dependency, we can reclaim, through agroecology and with the help of hedgerows, a landscape that affords us with all that we *really* need—healthy and nutritious food, uncontaminated water, air, and soil, wildlife-rich countryside, fulfilling livelihoods, healing and inspiring environments—all the while helping to save our planet, our only home.

## AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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