Organic farming in Europe: A potential major contribution to food security in a scenario of climate change and fossil fuel depletion

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Summary

Prevailing evidence indicates that the combustion of coal, oil and natural gas contributes to global greenhouse gas (GHG) emissions and associated climate change, including increased instability of weather, (extreme weather events -EWEs) such as temperature fluctuations and adverse distributions of rainfall. 'Peak' models for the availability of oil and natural gas indicate that shortages are likely in the near future and, combined with EWEs, may threaten the productivity of European agricultural systems. The production of mineral fertilizer and pesticides, and fuel for agricultural machinery will be affected as will the transport of agricultural commodities from producer to processor to consumer. This will put food security in highly populated towns and cities at risk. It is concluded that food production and consumption in Europe, post peak oil, will depend upon more localised farming that is relatively resilient to EWEs, can operate effectively with reduced inputs and is adaptable to likely increases in weed, pest and disease problems. to It is proposed here that organic farming can best satisfy these needs. In terms of sustainable food production policies in Europe, it is suggested that there needs to be a greater emphasis upon regional, resource-based organic production, and with a special focus upon greater energy and water use efficiency. It is therefore recommended that urgent action is required to investigate the further development of organic farming in post peak oil Europe, and before the security of current food production and distribution systems is compromised.

Keywords: food security, fossil fuels, depletion, organic farming

Zusammenfassung

Die Verbrennung von Kohle, Öl und Erdgas trägt zur Freisetzung von klimarelevanten Treibhausgasen und einem anthropogen verursachten Klimawandel bei, welcher sich unter anderem in extremen Witterungsbedingungen niederschlägt. Sogenannte Peak-Modelle zeigen, dass die Ölreserven in unmittelbarer Zukunft knapp werden. Zusammen mit extremen Witterungsbedingungen gefährdet dies die Produktivität landwirtschaftlicher Betriebe in Europa. Besonders die energieaufwendige Produktion von Mineraldünger und Pestiziden, aber auch die Bereitstellung von Treibstoff für die Landmaschinen wäre davon betroffen. Der Transport landwirtschaftlicher Erzeugnisse von Produzenten zu Verarbeitern und Verbrauchern wäre insofern eingeschränkt als erdölabhängiger Transport nur bedingt stattfinden könnte, so dass die ausreichende Versorgung der Bevölkerung mit Nahrungsmitteln in großen Städten und Metropolen gefährdet wäre. Somit ergibt sich zukünftig die Notwendigkeit zur räumlichen Nähe von Nahrungsmittelerzeugung und -verbrauch, wobei Anbausysteme nicht nur robust gegenüber extremen Witterungsereignissen (Trockenheit, Hochwasser, ungünstige Niederschlagsverteilung sowie veränderten Umweltbedingungen (Unkrautdruck, neue Krankheiten und Schädlinge) sein sollten, sondern auch mit einem reduzierten Input an Ressourcen wirtschaften und die Nahrungsmittelsicherheit der angrenzenden Bevölkerung sicherstellen müssen. Die Ökologische Landwirtschaft versucht, diesem Anspruch gerecht zu werden. Hierzu muss sich der Ökologische Landbau eine höhere Effizienz und Stabilität entwickeln. Zunächst ist es notwendig, das Leistungsvermögen der Ökologischen Landwirtschaft unter limitierten fossilen Rohstoffreserven zu analysieren, bevor Nahrungsmittelproduktion und Versorgungssysteme in Europa gefährdet sind.

Schlüsselworte: Nahrungsmittelsicherheit, fossile Brennstoffe, Erschöpfung von Reserven, Ökologische Landwirtschaft

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Introduction

European nations depend upon the consumption of large quantities of fossil energy, accounting for approximately three quarters of the total carbon dioxide (CO_2) released into the atmosphere (Hammons, 2006). Fossil fuel consumption by European farming is known to be associated with the release of CO_2, though this accounts for only about 5 % of total fossil energy use (Pinstrup-Andersen, 1999 cited in Dalgaard et al*.,* 2001). However, farms can also lead to other emissions of GHGs, such as nitrous oxide and methane from the land and/or livestock (Olesen & Bindi, 2002). Gaseous emissions from farmland and ruminants are and always have been a natural part of biological processes: it is emissions from fossil fuels that are considered in this paper.

In 2005, German agriculture contributed approximately 6.3 % to anthropogenic GHG emissions (133 mt equivalent) (Smith et al., 2007). However, organic farming has been demonstrated to contribute less to GHG emissions than comparable non-organic farming systems (Rahmann et al., 2008).

Paradoxically, though the use of fossil energy by our society has increased rapidly in recent years and contributed to an ongoing process of climate change, the probable future scenario is one of depletion of reserves (Guseo et al., 2007) and reduced availability, including that for agriculture.

The focus of this paper is therefore on how agriculture in the 21st century can adapt to a legacy of climate change due to prior combustion of fossil fuels but within a likely future scenario of reduced supplies of those same fuels.

Climate change, fossil fuel depletion and the implications for farming in Europe

Climate change

Climate change is now widely accepted as a real phenomenon (e.g. Dietz et al., 2007), involving increased temperatures and summer droughts (Fuhrer, 2003). There are also increasing references to the negative effects of climate change, including extreme weather events (EWEs), on agriculture (IAASTD, 2008). Olesen & Bindi (2002) conclude that:

> "The possible increase in water shortage and (EWEs) may cause lower harvestable yields, higher yield variability and a reduction in suitable areas for traditional crops." (Olesen & Bindi, 2002, p. 257)

Extremes of temperature can be a problem but variations in rainfall have been shown to be more critical, such as results from the Broadbalk long term cereal experiment, Rothamsted (UK), where a clear negative correlation has been demonstrated between cereal grain yields and rainfall (Chmielewskia & Potts, 1995). A recent review by Motha (2007) concludes that the implications of climatic variation are severe. For future planning, this researcher states that:

> "It is imperative that proactive mitigation measures and adaptation strategies be developed based on sound scientific knowledge about the hazards (of EWEs) so that preparedness measures can be implemented to counter their effects." (Motha, 2007, p. 307)

Fossil fuels

The concept of 'peak oil' is now well documented (Greene et al*.,* 2006; Brandt, 2007; Guseo et al*.,* 2007) and the consensus is that supplies may become limited before 2010, as the peak is passed and world production declines (Campbell, 2006). A similar depletion protocol has also been predicted for natural gas (Bentley, 2002). What are the likely effects for agriculture in Europe? Currently, the relatively high yields of European farming require matching inputs of mineral fertilisers and synthetic pesticides (Struik & Bonciarelli, 1997), the production of which is in turn dependent upon the use of fossil energy (Ramírez & Worrell, 2006) and especially natural gas (Ahlgren et al*.,* 2008). Therefore as fossil fuel supplies decline, fertilizer and pesticide inputs may become less available, or at least much more expensive, leading to reduced applications and a potentially negative impact upon crop yields. Oil restrictions are also likely to specifically affect the transportation of goods:

> "As conventional oil supplies run down…rising prices… could put transport in conflict…with other energy demands…" (Woodcock et al., 2007, p. 1083)

Thus, the transportation of food over more than a few kilometres may become much more expensive and therefore unviable.

Proactive adaptation strategies: the potential resilience of organic farming systems to climate change and fossil fuel depletion

Adaptations to climate change

An important aspect of the development of non-organic farming systems has been a gradual decline of soil organic matter (SOM), especially for arable cropping. This is illustrated by a study of changes in SOM for southern Belgium between 1955 and 2005 (Goidts & Wesemael, 2007):

> "For units under cropland, an average decrease of 5.8 t C·ha^{-1} was measured in the plough layer (from an initial equivalent SOC (soil organic carbon] stock of 46.4 t C ha^{-1})…" (Goidts & Wesemael, 2007, p.341)

By contrast, organic farms seem to be associated with relatively higher and increasing SOMs, demonstrated in a paired farm study by Armstrong-Brown et al. (2000). Higher SOMs are known to facilitate better soil water retention in droughts (Siegrist et al., 1998) and enhanced infiltration capacities (Schnug et al., 2006). Thus, organically farmed soils seem more likely to be resilient to very low or high rainfall EWEs. The latter is especially important, since studies in Germany have shown that watersheds dominated by organic farms contain soils that are better at absorbing sudden precipitation, reducing the risk of soil erosion on-farms, and mitigating against flooding further down the watershed (Schnug et al., 2004; Schnug et al., 2006).

Energy dynamics

Whilst nutrient dynamics have been widely studied for organic and other farming systems, investigations of energy dynamics have been more limited. Consideration of fossil energy use in agro-ecological systems was pioneered by Odum (see 1971, 1996 and Odum et al., 2000). Clearly, it is insufficient to merely consider fossil energy consumed unless it is compared with the energy value of the food produced. Loake (2001) has reviewed this and a summary is shown in Table 1. This indicates that energy ratios for organic farming are far superior to those for non-organic. More recent studies are also supportive, though the differences are more modest (e.g. crop production in Italy (Sartori et al., 2005); smallholder apricot production in Turkey (Gündoğmuş, 2006); general farming in Australia (Wood et al., 2006); and agricultural commodity production in the UK (Williams et al., 2006)). It is however important to understand the boundaries defined by and limitations of such studies before direct comparisons are made with other farming systems: this paper is not suggesting that all organic farming is more energy efficient than non-organic but that it is a potentially important factor that needs further investigation. Of the organic production examples reviewed in this paper, favourable energy ratios can largely be attributed to lower indirect fossil energy needs, since manufactured fertilizers and synthetic pesticides are omitted. This is not simply because they are prohibited as part of organic certification, but also because organic systems are largely based upon a pro-active rather than reactive management regime for weeds, pests and diseases. This organic approach is also important for maximising the availability of soil nutrients for crops at the optimum point in the rotation (e.g. phosphorous: Walker et al., 2006; Stockdale et al., 2006).

As global fossil fuel reserves become depleted and therefore more expensive, the increasing cost of agrochemicals and fertilisers will encourage farmers to look towards alternative, lower-input agriculture, including the principles and techniques developed from organic research and its practice.

Table 1:

Energy ratios in UK farming[a]

Ratio	Conventional system	Organic system	Components of ratio
Gross energy[b]	0.0002	0.0025	Energy out/energy in. Energy = net yield. Energy in = solar inputs, processing inputs, energy in, home related energy, fertilisers, fuels, electricity, machinery and feed purchased. (GJ).
Net energy	0.14	4.09	Energy out/energy in. Energy = net yield. Energy in = processing inputs, energy in, home related energy, fertilisers, fuels, electricity, machinery and feed purchased. (GJ).
Farm gate	0.34	4.29	Energy out/energy in. Energy = net yield. Energy in = fertilisers, fuels, electricity, machinery and feed purchased. (GJ).
Direct Human	30-35	4.3	Food energy output per man-hour of farm labour (MJ/man-hour).

[a] All ratios and definitions taken from Leach (1976).

[b] Gross energy includes solar inputs that despite being an important energy input are usually omitted because they dominate inputs, swamping the ratio and making it of little policy value (Leach, 1976).

Source: Loake (2001)

It is therefore suggested that studies by Loake (2001) and others need to be revisited to: (i) accurately audit direct and indirect fossil energy use for organic and non-organic farms and; (ii) strive for improved organic systems which maximise energy capture, minimise direct and indirect fossil energy inputs and optimise internal energy recycling without sacrificing yields. A reassessment of the relative efficacy of energy audit methods is also needed, as considered by Wilson & Brigstocke (1980) and Pervanchon et al. (2002).

Could a wider adoption of organic farming help improve food security in Europe?

IAASTD (2008) indicates that food security is a key future policy imperative and can be achieved by measures including a greater emphasis on agroecological systems such as

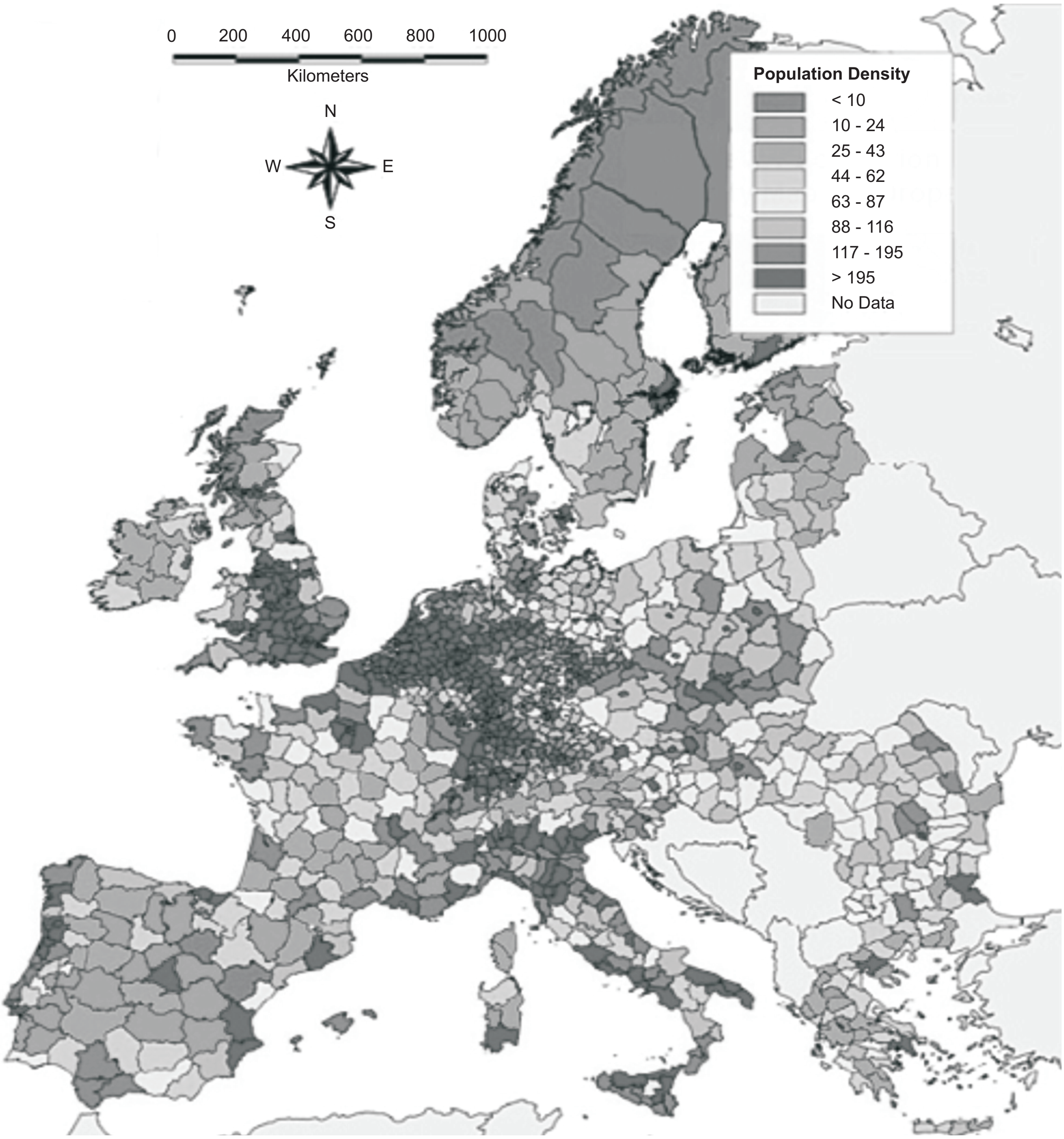

Figure 1:
Population density map of Europe (adapted from Anon 2007)

organic farming. The potential of organic farming to feed the global population has been debated for many years, but a recent, extensive and authoritative review (Badgley et al., 2007) clearly indicates that it is possible. This study considers Europe and suggests that it could feed itself by means of organic farming.

Currently, how food-secure is Europe? Data are sparse, but recent assessments in Britain (UK Agriculture, 2005) suggest that non-organic domestic production continues to decline and currently feeds no more than 60 - 73 % of that population.

Thus, total food production in Europe, post peak oil and natural gas, may be much reduced and commodities might

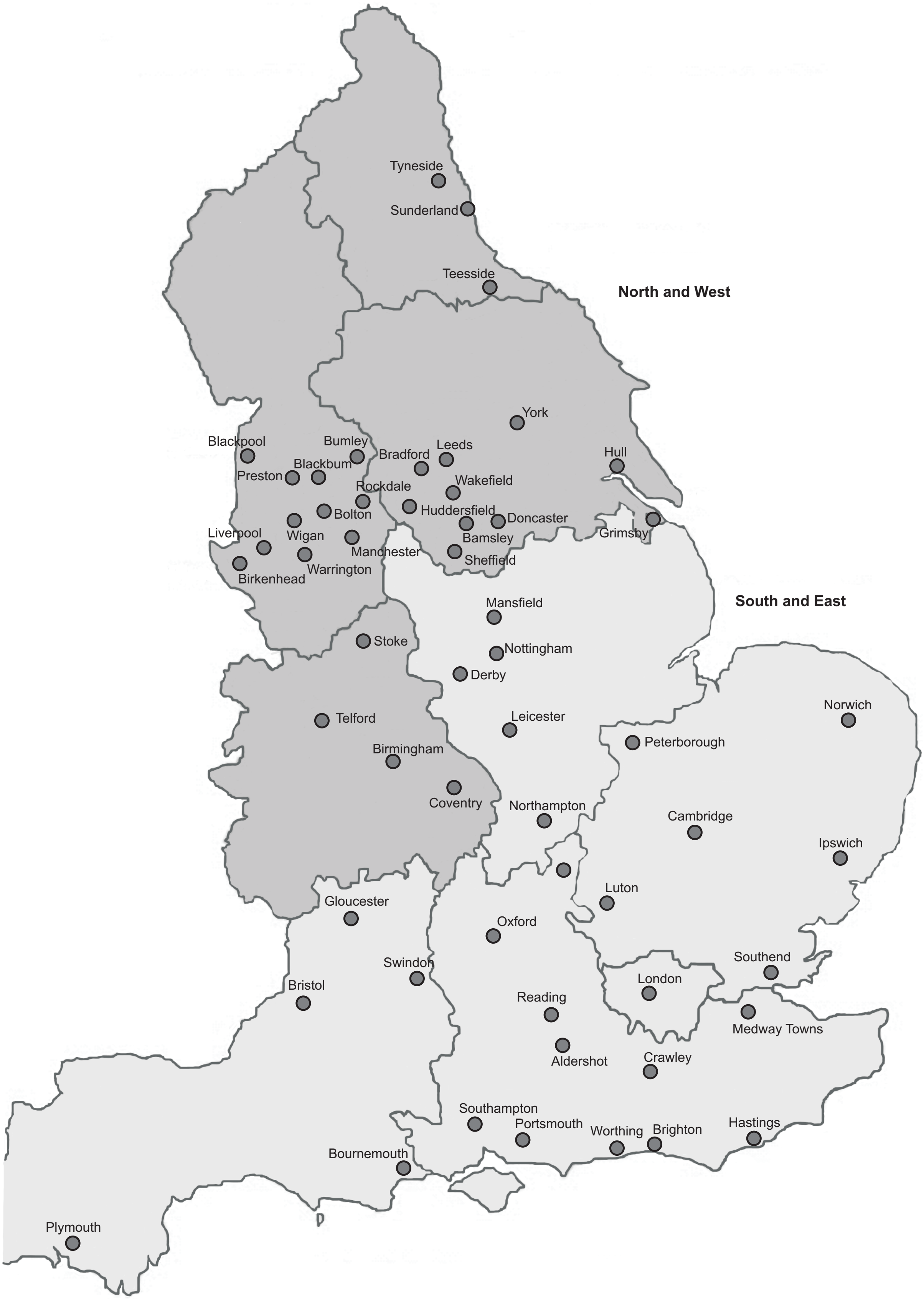

Figure 2:

England : primary urban areas with a population greater than 125,000. (adapted from Defra (2006)) only be able to be transported relatively short distances to the consumer. It follows that food production and consumption will become more regionalised and quite probably localised. If we consider the population distribution of European nations (Figure 1), it can be seen that the spread is heterogeneous. For example, in England (Figure 2), most people live close to urban centres of population.

Rural and urban issues

In a post peak oil scenario, the problem of access to food in rural areas seems likely to be less challenging, due to lower population pressures. Rather, the key issue may be how it will be possible to feed higher densities of people in urban centres. The Food and Agriculture Organisation has undertaken a review of European urban and peri-urban food production, but the emphasis is upon the health benefits of a vegetable-focussed diet rather than food security (FAO 2001). However, much can be learned from experiences of urban and peri-urban organic food production in Cuba, where yields as high as 2.5 kg vegetables per square metre *per month* have been achieved (Viljoen & Howe, 2005), though within a more favourable climate than that likely to be seen across Europe.

The hypotheses of this paper

It is suggested that organic farm management might be identified with: (i) increased resilience to EWEs, (ii) relatively lower consumption of fossil fuels per unit of yield, and; (iii) enhanced future food security for Europe, especially in urban centres.

Proposed actions: pilot demonstration farms

To test these hypotheses, it is proposed that a study be instituted across Europe, involving a comparison of watersheds that are primarily farmed organically with those that are farmed non-organically. This is not as potentially expensive as it might seem: watersheds dominated by organic farms already exist in parts of Germany (Schnug et al., 2004) and also in Britain, as indicated in Figure 3. Such a comparison will need to involve at least several years of audits of randomly chosen farms within each watershed for: fossil energy consumption (direct and indirect) and efficiency of use, soil characteristics, crop yields, and water dynamics.

It is also suggested that the potential of organic production to feed urban areas needs to be explored. Test sites need to be established in and around European cities, to establish maximum sustainable yields using the Cuban model as a bench mark but also benefiting from existing project experience in Europe as documented by FAO.

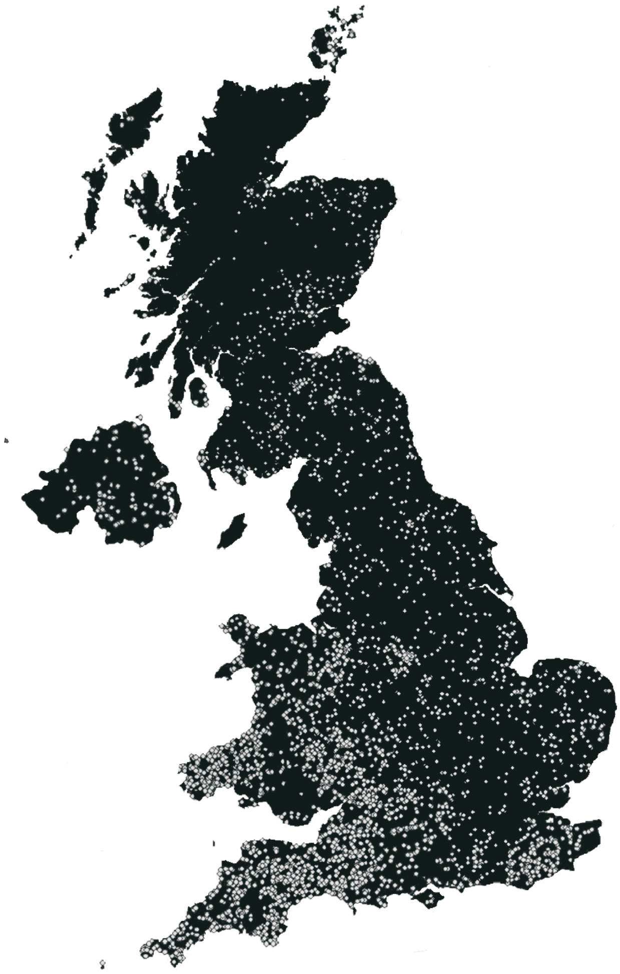

Figure 3:
UK map of organic holdings 2004 (adapted from Defra (2006))

Conclusions

Further urgent research is needed to answer the following questions: can organic farming systems really lead the way in adapting agriculture to the hazards of a more unstable climate? Can organic farms be developed, which use minimal or even no fossil energy inputs (including engine fossil fuels) and yet sustain yields? Do urban and peri-urban organic production systems hold the key to secure and sustainable food supplies in European cities? It is suggested that a base of knowledge and experience needs to be generated as an utmost priority, before the full effects of peak oil and natural gas are felt and shortages of food become a reality in 21st Century Europe.

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