

A software tool for determining the agricultural landbank for recycling organic materials (ALLOWANCE)

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Introduction

There are around 9.1 million hectares of agricultural land in England and Wales potentially available for the application of organic materials (of which approximately 50% is arable land and 50% lowland [improved] grassland), but clearly not all soils or land uses are suitable for the recycling of organic materials. Organic materials provide a valuable source of nutrients for crop growth and organic matter that can maintain and enhance soil physical conditions. However, their application is restricted both in time and space by a number of physical and practical constraints, and policy measures. These include:

- restrictions on total nitrogen loading rates within Nitrate Vulnerable Zones (NVZs),
- conditions of the EU Sewage Sludge Directive (i.e. soil pH and heavy metal concentration restrictions),
- topography and proximity to water courses (surface and ground),
- risks of pathogen transfer to food crops and water bodies,
- crop nutrient requirements,
- land management agreements in Environmentally Sensitive Areas (ESAs) etc.,
- restrictions on manure use in Sites of Special Scientific Interest (SSSIs), National Nature Reserves (NNRs)
- rules for the management of organically farmed land.

With around 90 million tonnes of farm manures (Williams et al., 2000), 3-4 million tonnes of biosolids (treated sewage sludge) and 6-7 million tonnes of industrial 'wastes' applied (on a fresh weight basis) annually to agricultural land in the UK, there is clearly a need to understand the size and distribution of the available landbank at both a national and local level. The ALLOWANCE (Agricultural Land and Organic 'Waste': A National Capacity Estimator) software tool has been designed to address this need by calculating the England and Wales landbank available to accommodate the application of organic materials from farm and non-farm sources, based on nitrogen (N) production and loading rates, the physical characteristics of the landscape and legislative limitations. ALLOWANCE is a GIS-based strategic management tool that has an embedded methodology for calculating 1) the landbank capacity 2) current farm manure N production 3) the proportion of the landbank already taken up by farm manure N loadings and 4) the landbank remaining for non-farm derived organic materials (i.e. biosolids, green compost, paper crumble). ALLOWANCE can be used to identify areas in England and Wales where there is a potential shortage or surplus of available land for recycling organic materials. ALLOWANCE incorporates scenario testing capabilities enabling the calculation of future landbank capacity in light of changes in land use and legislation, for example, as a result of changes in NVZ regulations and areas, or changes in livestock numbers. The tool allows new organic material streams to be added as point sources and the landbank capacity to be calculated interactively within defined transport distance zones.

Approach

The ALLOWANCE software contains a 10km² spatial representation of the Agricultural Census data (i.e. crop areas) in England and Wales from June 2000 (Lord and Anthony,

2000), so that the agricultural land area potentially available for the application of organic materials can be confidently quantified and located.

Livestock numbers (from the 2004 Census) are combined with N production data (expressed in terms of kg N/animal/year) for each livestock type, to calculate a total N loading from farm manures at a 10km² grid square resolution covering England and Wales. This N loading is subdivided into field deposited N (i.e. deposited directly to the field by grazing livestock) and manure N handled as FYM (straw-based farmyard manure), slurry, poultry litter or poultry manure. In this way, different legislative and practical constraints on the handling and spreading of these materials can be accommodated.

In addition, ALLOWANCE includes data layers for the location of sewage treatment works (i.e. biosolids production sites), composting sites and paper crumble production sites. For each site, information on the quantity of organic material produced for land spreading (i.e. biosolids, green compost and paper crumble) was obtained and combined with data on the N content of the materials, to calculate the N loadings in each 10km² grid square. All these sources have an associated organic material transport distance (which is largely determined by economics). This distance represents the average radial distance from the production site to the spreading location and is based on industry information. This N production is assumed to be evenly distributed to neighbouring grid squares within the specified transport zone and is added to the farm manure N loading to calculate the total N loading for each 10km² grid square.

The potential landbank (prior to any organic material additions) was calculated by considering the proportion of each 10km² grid cell that was agricultural land and within this how much was excluded by legislative or physical considerations. Different constraints were considered for slurry, FYM, poultry litter/manure and non-farm organic materials (Table 1). The spatial location of areas affected by legislation that 'restricts' the application of organic materials (i.e. NVZs, SSSIs, NNRs, ESAs, organic farming agreements, watercourses, groundwater protection zones and boreholes, steeply sloping land) were all mapped and can be queried through the ALLOWANCE interface.

ALLOWANCE uses a rules-based algorithm (derived from the constraints identified in Table 1) for deciding how and where organic materials should be allocated to the available landbank capacity. Grid squares with a surplus in any of the N streams are assumed to transport this material to neighbouring grid squares.

Software capability

The ALLOWANCE tool has been developed as a stand-alone software programme, incorporating a map interface (GIS) to visualise and query the data. The software uses Microsoft Visual Basic 6, using Microsoft ACCESS and ESRI MapObjects for data storage and mapping, respectively. The use of Microsoft ACCESS permits rapid data update and ease of sharing of baseline data with other databases/software.

ALLOWANCE makes all of its spatial data available as a series of map layers that can be selectively viewed and queried. These layers include all of the land area/use information, the distribution of livestock and the landbank capacity results, all of which can be viewed directly in the map viewer. ALLOWANCE contains a distance/value dialog that allows the integrated total value of a requested parameter (e.g. hectares of agricultural land available for applying organic materials) to be summed for all cells within a series of radial distances from a point that can be selected onscreen and for this to be graphed automatically. The distance/value function in ALLOWANCE provides a valuable tool which allows the user to ask questions such as – if I were to build an energy recovery facility at point X, how much feedstock (e.g. poultry litter) is currently produced within 50km of my position? Or what is

the landbank available for recycling e.g. compost/paper crumble within 30km of a selected position? The spatial analysis dialog function also makes it possible to answer questions such as - what location has the most slurry production available for bio-digestion, assuming a maximum transport distance of 50km?

Table 1. Summary of physical and legislative restrictions to the landbank available for spreading organic materials

Factor or land designation	Source of restriction	ALLOWANCE constraints
Topography	Practical limitations of spreading	<ul style="list-style-type: none"> • No spreading if slope >16°. • This exclusion only applies to handled manures – excreta deposited during grazing is not affected.
Watercourses	The Water Code (MAFF, 1998) NVZ legislation (Defra, 2002)	<ul style="list-style-type: none"> • No spreading within 10m of any watercourse (including ditches). • No spreading within 50m radius of a spring, well or borehole used for human consumption or farm dairies. • This exclusion only applies to handled manures – excreta deposited during grazing is not affected.
SPZs	EA Groundwater Source Protection Zones (SPZs)	<ul style="list-style-type: none"> • No biosolids to be applied within a SPZ Zone 1
ESAs	Environmentally Sensitive Areas (ESAs)	<ul style="list-style-type: none"> • Only FYM may be spread
SSSIs	Sites of Special Scientific Interest (SSSIs)	<ul style="list-style-type: none"> • Only FYM may be spread
NNRs	National Nature Reserves	<ul style="list-style-type: none"> • Only FYM may be spread
NVZs	NVZ legislation (Defra, 2002)	<ul style="list-style-type: none"> • No organic material in front of legumes. ALLOWANCE removes the area of peas/beans from the landbank. • Maximum N loading rates (i.e. from handled manure and field deposited excreta) are 170 kg ha⁻¹ for arable land and 250 kg ha⁻¹ for grassland.
Organically managed farmland	UKROFS Standards (2003)	<ul style="list-style-type: none"> • Maximum N loading rate (from handled manure and field deposited excreta) is 170 kg N ha⁻¹ yr⁻¹ (both inside and outside NVZs). • No slurry, biosolids or paper crumble may be spread
Outdoor pigs		<ul style="list-style-type: none"> • Manure cannot be spread on land occupied by outdoor pigs
Ready to eat crops (RTE)	Safe Sludge Matrix (www.adas.co.uk/matrix) Food Standards Agency Food Standards Agency Guidelines for Farmers (FSA, 2005)	<ul style="list-style-type: none"> • ALLOWANCE assumes that RTE crops areas have no capacity to receive slurry or non-farm organic materials.
Soil pH	Sludge Regulations (SI, 1990) Code of Practice (DoE, 1996)	<ul style="list-style-type: none"> • Biosolids may not applied if soil pH<5
Soil heavy metal content	Sludge Regulations (SI, 1990) Code of Practice (DoE, 1996)	<ul style="list-style-type: none"> • Biosolids (and compost/paper crumble) may only applied if soil heavy metal concentrations are below the permitted maximum

ALLOWANCE has scenario testing capabilities enabling predictions of the future agricultural landbank in the light of potential changes in farming systems, for example, as a result of changing livestock numbers or changes in regulations. New sources (e.g. a new composting or anaerobic digestion plant) can be added to assess the effect on

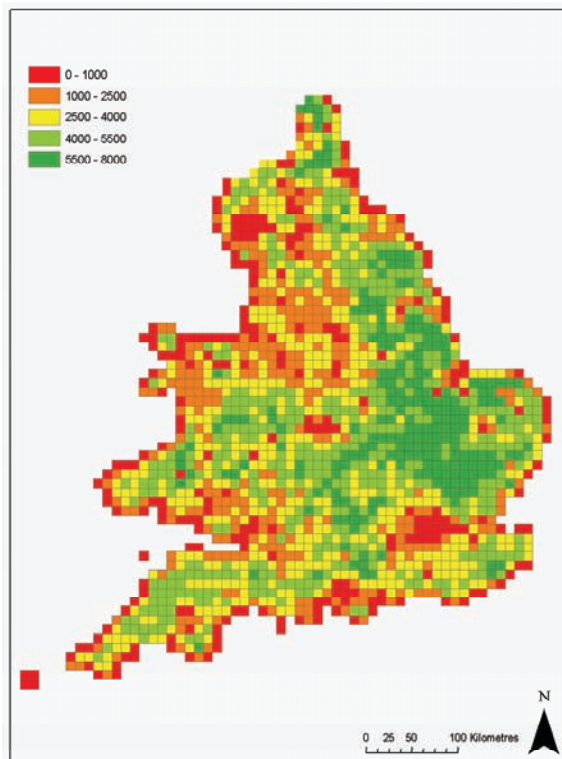
the landbank remaining. Also, ALLOWANCE has a spatial analysis capability that allows statistical summaries of landbank areas, livestock numbers, N loadings to land etc. to be produced. Such data can be obtained for specific areas (e.g. counties or regions) using onscreen toolbar controls or through loading an external ESRI shapefile to specify the boundary to be selected.

Results

Results from ALLOWANCE indicate that the agricultural landbank theoretically available for recycling organic materials in England and Wales is c. 9.1 million hectares. Taking into account land excluded by virtue of topography (steep slopes), proximity to water courses, springs and boreholes, occupation by outdoor pigs and areas of peas/beans (inside an NVZ), this area reduces to c. 8.6 million hectares for spreading FYM. Note: the area available for spreading slurry, poultry manure and other non-farm organic materials will be less than this because of the more stringent spreading restrictions for these materials in certain areas e.g. ESAs, SSSIs (see Table 1).

The area remaining after next accounting for current livestock N production reduced the landbank to c.5.9 million hectares, and after accommodating non-farm organic materials (i.e. biosolids, green compost and paper crumble) the area remaining was estimated to be further reduced to c.5.7 million hectares (Figure 1). Note: these estimates of the available landbank do not currently include restrictions on biosolids/compost/paper crumble applications due to soil pH or existing soil heavy metal concentrations.

Figure 1. Landbank theoretically available for additional organic materials in England and Wales (ha of agricultural land)



Conclusion

The ALLOWANCE software tool was designed to estimate the size and distribution of the available agricultural landbank to accommodate farm and non-farm organic materials at both a national and local level. ALLOWANCE can be used to identify areas in England and Wales where there is a potential shortage or surplus of available agricultural land for recycling organic materials. Scenario testing capabilities enable calculations of future landbank capacity in light of changes in land use, legislation (e.g. NVZ), livestock numbers and new sources of non-farm organic materials. Initial outputs from ALLOWANCE indicate that overall England and Wales there are c.5.7 million hectares of agricultural land still available to accommodate organic materials. However, in some parts of the country (e.g. North-west England) the landbank is already under some 'pressure' and transport of any new sources of organic materials away from these areas may be required.

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