ALOWANCE (Agricultural Land – A National Capacity Estimator)

Report for ES0128 and Report 2 for Defra Project SP0569

December 2009

Submitted to:  
Judith Stuart  
Soils Policy  
Defra  
Room 3C, Nobel House  
17 Smith Square  
London SW1P 3JR

Prepared by:  
Fiona Nicholson, Steven Humphries and Brian Chambers  
ADAS Gleadthorpe,  
Meden Vale,  
Mansfield  
Notts  
NG20 9PF
EXECUTIVE SUMMARY

Organic materials are a valuable source of nutrients for crop growth and organic matter that can maintain and enhance soil physical conditions. There are around 9.3 million hectares of agricultural land in England and Wales potentially available for the recycling of organic materials, although not all soils or land uses are suitable. There is clearly a need to understand the size and distribution of the available landbank at both a national and local level.

ALOWANCE (Agricultural Land and Organic ‘Waste’: A National Capacity Estimator) is a GIS-based tool which estimates the available agricultural landbank based on a number of physical and practical constraints, and legislative restrictions on organic material recycling including:

- restrictions on nitrogen loading rates within Nitrate Vulnerable Zones (NVZs),
- restrictions in the Sewage Sludge Directive (i.e. soil pH and heavy metal concentrations),
- 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), and
- rules for the management of organically farmed land.

ALOWANCE has an embedded methodology for calculating: 1) the potential landbank capacity; 2) current farm manure N production; 3) the proportion of the landbank already taken up by farm manures and existing non-farm organic materials (i.e. biosolids, compost, paper crumble, digestate); and 4) the landbank remaining for ‘new’ sources of organic materials. It can be used to identify areas where there is a potential shortage or surplus of available agricultural land for recycling organic materials.

Two versions of ALOWANCE have been developed in this project based on 2004 agricultural census data. ALOWANCE-PLUS is a PC-based tool which provides the full functionality of ALOWANCE to a small number of ‘expert’ users. It incorporates scenario testing capabilities, allowing the agricultural landbank capacity to be calculated interactively. ALOWANCE-ONLINE is a web-based version of ALOWANCE which provides basic information to general users, including pre-selected map ‘layers’ (generated from ALOWANCE-PLUS) and a simple query tool. It can currently be accessed via the WRAP website: http://www.wrap.org.uk/composting/useful_tools.html.

Results from ALOWANCE-PLUS showed in 2004 that there was c.9.3 million hectares of agricultural land (the theoretical landbank). After exclusions due to physical and landuse restrictions, and after accounting for livestock N production, c.5.5 million hectares of land remained. Exclusions based on soil pH and maximum permitted metal concentrations reduced the landbank by c.150,000 ha, and after accommodating current sources of non-farm organic materials (biosolids, compost,
paper crumble and digestate), the estimated agricultural landbank for the addition of ‘new’ sources of organic materials was c.5.1 million hectares. Spatial representations showed that in some parts of the country (e.g. North-west England) the landbank was already under ‘pressure’ and transport of any future ‘new’ sources of organic materials away from these areas may be required.
1. OBJECTIVE

The overall objective of Defra project ES0128 was to develop a strategic management tool to quantify and locate, temporally and spatially, the national capacity of agricultural land to accept organic ‘waste’ streams (ALOWANCE). More specifically, the objectives of the project were to:

- Identify the existing physical and land management agreement barriers restricting the application of organic materials to agricultural land.
- Quantify the size of the available agricultural landbank to accommodate organic materials and farm generated manures.
- Calculate the size of the available landbank remaining to accommodate non-farm derived organic materials.
- Produce a software management tool for the strategic planning of organic material recycling to agricultural land, which incorporates a scenario testing capability.

In Defra project SP0569, the objective was to update the ALOWANCE software to be compatible with the new (2009) Nitrate Vulnerable Zone (NVZ) rules (Defra/EA, 2008) and to provide additional features to enhance the user interface, including the development of a web-based version of the tool.

This report presents a summary of the work undertaken in Defra projects ES0128 and SP0569 to develop and enhance the ALOWANCE software tool.

2. INTRODUCTION

There are around 9.3 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 this purpose. Organic materials provide a valuable source of nutrients for crop growth and organic matter that can help to maintain and enhance soil physical conditions. However, their application is restricted both in space and time by a number of physical and practical constraints, and legislative restrictions. These include:

- restrictions on organic material nitrogen loading rates within Nitrate NVZs,
- conditions of the EU 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), and
- 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 ALOWANCE (Agricultural Land and Organic ‘Waste’: A National Capacity Estimator) software tool was designed to address this need by calculating the agricultural landbank in England and Wales available to accommodate the application of organic materials from farm and non-farm sources, based on farm manure nitrogen (N) production and loading rates, the physical characteristics of the landscape and legislative restrictions.

Two versions of ALOWANCE have been developed (based on 2004 agricultural census data):

- ALOWANCE-PLUS is a PC-based strategic management tool which offers the full functionality of ALOWANCE to a small number of ‘expert’ users. It consists of GIS-based software and has an embedded methodology for calculating: 1) the potential agricultural 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. ALOWANCE-PLUS 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. Also, ALOWANCE-PLUS 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 and the landbank capacity to be calculated interactively within defined transport distance zones.

- ALOWANCE-ONLINE is a web-based version of ALOWANCE which provides basic information to general users, including pre-selected map ‘layers’ and a simple query tool.

3. ALOWANCE-PLUS

3.1 Land use data

The ALOWANCE software contains a 10 x 10 km spatial representation of agricultural census data (i.e. crop areas) in England and Wales from June 2004, so that the agricultural land area potentially available for the application of organic materials can be confidently quantified and located. The agricultural land area (Figure 1) was split into areas of arable land (Figure 2), grassland (Figure 3), as well as legumes and ready-to-eat crop areas so that different constraints on the spreading of organic materials could be correctly applied (Table 1).
Table 1: Summary of physical and legislative restrictions to the agricultural landbank available for spreading organic materials.

<table>
<thead>
<tr>
<th>Factor or land designation</th>
<th>Source of restriction</th>
<th>ALOWANCE constraints</th>
</tr>
</thead>
</table>
| Topography                 | Practical limitations on spreading                                                     | • No spreading if slope >16°.  
• This exclusion only applies to handled manures – excreta deposited during grazing is not affected. |
| Watercourses               | Code of Good Agricultural Practice (Defra, 2009); NVZ legislation (Defra/EA, 2008)     | • 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)                                         | • No biosolids to be applied within a SPZ Zone 1                                      |
| ESAs                       | Environmentally Sensitive Areas (ESAs)                                                | • Only farmyard manure (FYM) may be spread                                             |
| SSSIs                      | Sites of Special Scientific Interest (SSSIs)                                           | • Only FYM may be spread                                                               |
| NNRs                       | National Nature Reserves                                                               | • Only FYM may be spread                                                               |
| NVZs                       | NVZ legislation (Defra/EA, 2008)                                                      | • No organic materials in front of legumes. ALOWANCE removes the area of peas/beans from the landbank.  
• Maximum livestock manure N loading rates (i.e. from handled manures and field deposited excreta) are 170 kg/ha for arable land and grassland. |
| Organically managed farmland | UKROFS Standards (2003). Now superceded by ACOS (Advisory Committee on Organic Standards). | • Maximum livestock manure N loading rate (from handled manure and field deposited excreta) is 170 kg N/ha/yr (both inside and outside NVZs).  
• No biosolids or paper crumble may be spread. |
| Outdoor pigs               |                                                                                       | • Manure cannot be spread on land occupied by outdoor pigs                             |
| Ready to eat crops (RTE)   | Safe Sludge Matrix (http://www.adas.co.uk/Home/Publications/DocumentStore/tabid/211/Default.aspx)  
Food Standards Agency Guidelines for Farmers (FSA, 2009) | • ALOWANCE assumes that RTE crops areas have no capacity to receive slurry or biosolids/paper crumble. |
| Soil pH                    | Sludge Regulations (SI, 1989) and Code of Practice (DoE, 1996)                        | • Biosolids may not applied if soil pH<5                                               |
| Soil heavy metal concentrations | Sludge Regulations (SI, 1989) and Code of Practice (DoE, 1996)     | • Biosolids (and compost/paper crumble) may only be applied if soil heavy metal concentrations are below maximum permissible levels. |
Figure 1. Agricultural land (% of a 10 x 10 km grid square)

Figure 2. Arable land (% of a 10 x 10 km grid square)
Figure 3. Grassland (% of a 10 x 10 km grid square)

Figure 4. Livestock N loading (kg N/ha agricultural land) – sum of N from spread manure and excreta deposited during grazing
3.2 Nitrogen loadings from farm manures

Livestock numbers from the 2004 agricultural census were combined with farm manure nitrogen (N) production data (i.e. the quantity of N produced after losses during housing and storage are accounted for, expressed as of kg N/animal/year) for each livestock type as published in the NVZ Action Programme (NVZ-AP; Defra/EA, 2008). As the livestock categories in the NVZ-AP were not the same as those used in the agricultural census, it was necessary to interpolate the NVZ N production figures to convert from one format to the other, to provide N production figures by agricultural census categories (Data presented in Appendix. Tables A1-A3). These data were then used to calculate livestock N loadings to agricultural land at a 10 x 10 km grid square resolution covering England and Wales (Figure 4).

Using recent data on manure management practices from Defra project WQ0103 (MANURES-GIS; Defra, 2007), the N loading was subdivided into field deposited N (i.e. deposited directly in the field by grazing livestock) and manure N handled as FYM (straw-based farmyard manure), slurry, poultry litter or poultry manure (Tables A1-A3). In this way, different legislative and practical constraints on the handling and spreading of these materials was accommodated.

ALOWANCE assumed that all poultry litter produced within a distance of 8 grid squares (80 km radius) of a power station was burnt and the N contained did not contribute to manure N loadings to agricultural land. However, the phosphorus (P) and heavy metals it contained were accounted for in poultry ash additions. Around 38% of poultry litter is estimated to be incinerated in England and Wales at two power stations (Misselbrook et al., 2008).

Table 2. Power stations burning poultry litter in England

<table>
<thead>
<tr>
<th>Location</th>
<th>Quantity of poultry litter burnt (t/yr fresh weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thetford, Norfolk</td>
<td>420,000</td>
</tr>
<tr>
<td>Eye, Suffolk</td>
<td>160,000</td>
</tr>
<tr>
<td>Total (E&amp;W)</td>
<td>580,000</td>
</tr>
</tbody>
</table>

3.3 Nitrogen loadings from other organic materials

In addition to farm manures, ALOWANCE includes data layers on the location of sewage treatment works (i.e. biosolids production sites), composting sites, paper crumble production sites, anaerobic digestors and power plants burning poultry litter. For each site, information on the quantity of organic materials produced for land spreading (i.e. biosolids, compost, paper crumble, digestate, poultry ash) was obtained and combined with data on the ‘typical’ N content of the materials (Table A4), to calculate the N loading to agricultural land in each 10 x 10 km grid square. For biosolids, a ‘typical’ N content of 36 kg N/t dry solids (ds) was used for all biosolids types based on the mean N content of biosolids reported by the Environment Agency between 2001 and 2007 (Table A4).
The quantities of biosolids applied to agricultural land were provided by the individual Water Companies for 2005/6, compost tonnages were provided by The Composting Association for 2004/5 and paper crumble quantities were from 2003 (Gibbs et al., 2005).

To ensure that specific sources of non-farm organic materials could not be identified, the N was assumed to be distributed evenly across grid squares within a specified transport distance, which was based on industry information (Table A4). The N from non-farm materials was added to the farm manure N loading to calculate the total N loading to agricultural land for each 10 x 10 km grid square.

3.4 Phosphorus loadings
ALOWANCE also estimates phosphorus (P) loadings to agricultural land from livestock (both from handled manures and excreta deposited during grazing) and other organic materials based on N:P ratio of the materials (Tables A1-A4).

3.5. Transport of organic materials
If ALOWANCE calculates that there is an excess of N in a particular grid square (e.g. from a large poultry unit), the excess N is distributed evenly across neighbouring grid squares up to the maximum specified transport distance (Table A4). In addition, a record is kept of the quantity of N that has been transported and the distance travelled.

3.6 Exclusions and constraints
The potential landbank (prior to any organic material additions) was calculated by considering the proportion of each 10 x 10 km grid cell that was agricultural land, and within this how much was excluded by physical or legislative restrictions.

3.6.1 Physical constraints

Topography. For practical reasons, it is very unlikely that organic materials will be spread on steeply sloping land (>16°). This exclusion was only applied to handled manures; excreta deposited during grazing on sloping land is not constrained. Topographical data was obtained from the Ordnance Survey Landform Panorama (OS, 2007) and showed that c.0.5% of agricultural land was excluded from the agricultural landbank for spreading organic materials (Figure 5).

Watercourses, boreholes and Source Protection Zones. Both the Code of Good Agricultural Practice (Defra, 2009) and NVZ legislation (Defra/EA, 2008) state that organic materials should not be spread within 10m of any watercourse (including ditches) or within 50m radius of a spring, well or borehole used for human consumption or farm dairies. This exclusion was only applied to handled organic materials, as excreta deposited during grazing near to watercourses is not constrained. Watercourse (Rivers and Streams dataset at a scale of 1:50,000 for 2007 obtained from CEH) and borehole (dataset for 2007 obtained from the Environment Agency) location data showed that c.1.8% of agricultural land was
Figure 5. Areas where the slope exceeds 16°

Figure 6. Location of Source Protection Zones (SPZ1) and boreholes
within 10m of a watercourse and c.0.1% was within 50m of a borehole (Figure 6) and was therefore excluded from the agricultural landbank for spreading organic materials. Groundwater Source Protection Zone 1 (SPZ) areas were excluded from the agricultural landbank available for biosolids application (c.1.3% agricultural land).

**ESAs, SSSIs and NNRs.** In ESAs, SSSIs and NNRs only low readily available N manure (e.g. farmyard manure) may be spread to agricultural land. Hence, these areas (Figures 7-9) were excluded from the agricultural landbank available for application of high readily available N manures (i.e. slurry and poultry manure) and other organic materials (c.3.4% under agreement in ESAs; c.1.8% in SSSIs; c.0.1% in NNRs).

### 3.6.2 Other constraints

**NVZs.** NVZ areas were also defined as a GIS map layer (Figure 10). Within these areas, organic material additions were restricted in front of legumes, hence ALOWANCE removed the area of peas/beans from the landbank. In addition, a maximum N loading rate from handled manures and field deposited excreta of 170 kg ha⁻¹ per annum was applied to both arable land and grassland within NVZs. Outside an NVZ, the recommended maximum application rate for handled manures was set at 250 kg/ha (Defra, 2009).

**Organically managed farmland.** The areas of organically managed farmland comprised c.1.9% of agricultural land (Figure 11). In these areas, ALOWANCE assumed a maximum N loading rate (from handled manure and field deposited excreta) of 170 kg N/ha per annum both inside and outside NVZs. In addition, no slurry, biosolids or paper crumble was spread on organically managed farmland.

**Outdoor pigs.** Organic materials cannot be spread on land already occupied by outdoor pigs. ALOWANCE calculated the area which should be excluded in each grid cell, using the number of breeding pigs (i.e. sows, maiden gilts and boars) from the 2004 Agricultural Census, the proportion of the breeding herd reared outdoors (36% for sows and 28% for gilts/boars) (Misselbrook et al., 2008). A stocking rate of 20 breeding pigs/ha was assumed, including the land area taken up by piglets, growing pigs, farm tracks etc. Outside an NVZ, the N production from outdoor pigs was not included in the N production figures and hence was excluded from the quantity of handled manure N.

**Ready to eat crops.** The ADAS Safe Sludge Matrix (wwwadas.co.uk/matrix) and the Food Standards Agency Guidelines for Farmers on "Managing Farm Manures for Food Safety" (FSA, 2009) restrict the application of biosolids and slurries before ready to eat (RTE) crops to reduce the risks of microbiological contamination. ALOWANCE therefore assumes that RTE crop areas (from the 2004 agricultural census) have no capacity to receive slurry or non-farm organic materials. RTE crops include: lettuce, radish, onions, beans, vining/podded peas, mangetout, cabbage, cauliflower, calabrese/broccoli, courgettes, celery, red beet, carrots, herbs, asparagus, garlic, shallots, spinach, chicory, celeriac, nuts, top fruit, soft fruit, stone fruit and vines.
Figure 7. Location of Environmentally Sensitive Areas (ESAs) under agreement

Figure 8. Location of Sites of Special Scientific Interest (SSSIs)
Figure 9. Location of National Nature Reserves (NNRs)

Figure 10. Nitrate Vulnerable Zones (NVZs) in 2002 and 2009
Soil pH. The Sludge (Use in Agriculture) Regulations (SI, 1989) and the Code of Practice for Agricultural Use of Sewage Sludge (DoE, 1996) state that biosolids may not be applied to agricultural soil if the pH is <5. Data from the Representative Soil Sampling Scheme (RSSS), which measured the pH of agricultural soils in over 7000 fields between 1969 and 2003 was interpolated to 10 x 10 km grid cells (Figure 12). Note: where there was more than one RSSS data point in a 10 x 10 km grid cell, the average of the values was used. Where there was no RSSS data for a grid cell, the soil pH was assumed to be 6.5 for the purpose of assigning maximum permissible soil metal concentrations (see below).

Soil Heavy Metals. The Sludge (Use in Agriculture) Regulations (SI, 1989) and the Code of Practice for Agricultural Use of Sewage Sludge (DoE, 1996) state that biosolids may only be applied if soil heavy metal concentrations are below maximum permissible levels (Table 4). These soil metal limits have been adopted in ALOWANCE to constrain the agricultural landbank available for biosolids (and compost/paper crumble) applications based on soil metal concentrations (Zn, Cu, Ni, Cr, Cd and Pb) measured in the National Soils Inventory (NSI), 1978-1982 (McGrath and Loveland, 1992). Figures 13 and 14 show total soil Zn and Cu concentrations in England and Wales. Note: where there was more than one NSI data point in a 10 x 10 km grid cell, the average of the values was used.
Table 4. Maximum permissible concentrations of heavy metals in soils after application of sewage sludge (DoE, 1996).

<table>
<thead>
<tr>
<th>PTE</th>
<th>Soil pH</th>
<th>5.0&lt;5.5</th>
<th>5.5&lt;6.0</th>
<th>6.0-7.0</th>
<th>&gt;7.0*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zn</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>80</td>
<td>100</td>
<td>135</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Ni</td>
<td>50</td>
<td>60</td>
<td>75</td>
<td>110</td>
<td></td>
</tr>
</tbody>
</table>

For pH 5.0 and above

- Cd 3
- Pb 300
- Hg 1
- Cr 400

*These maximum permissible concentrations were only applied where the measured soil pH was above 7.5 to ensure that only calcareous soils (i.e. containing more than 5% calcium carbonate) were included.

**Soil P.** ALOWANCE contains a GIS map of soil Olsen extractable P levels (as ADAS Index values) based on data from the RSSS, to provide an indication of where organic materials additions may be restricted i.e. at soil P Index 3 and above, where the Code of Good Agricultural Practice recommends that “when the soil phosphorus index is already 3 or above and you wish to utilise the nitrogen and other nutrients in organic manures, you should not apply more total phosphorus than will be removed by the crops in the rotation” (Defra, 2009). The map (Figure 15) is provided for information only and is not presently linked to any landbank exclusions or constraints on organic material applications.

**3.7 Landbank calculations**

ALOWANCE uses a rule-based algorithm (derived from the restrictions and constraints identified in Table 1 and Section 3.5) to decide how and where organic materials should be allocated to the available agricultural landbank capacity. This is summarised in Figure 16.
Figure 12. Soil pH data (RSSS)

Figure 13. Soil Zn concentrations (mg/kg)

Source: NSI (Cranfield University)
Figure 14. Soil Cu concentrations (mg/kg)

Source: NSI (Cranfield University)

Figure 15. Soil Olsen extractable P (ADAS Index)
Figure 16. Schematic representation of ALOWANCE rules and exclusions
3.8 Software capability

ALOWANCE-PLUS 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, and Microsoft ACCESS and ESRI MapObjects for data storage and mapping, respectively. The use of Microsoft ACCESS enables rapid data update and ease of sharing of baseline data with other databases/software.

All the spatial data in ALOWANCE-PLUS is available as a series of map layers that can be selectively viewed and queried. These layers include agricultural land area/use information, livestock numbers and the landbank capacity results, all of which can be viewed directly in the map viewer. ALOWANCE-PLUS also contains a sophisticated interactive calculator and graphing tool. This allows the integrated total value of a requested parameter (e.g. the agricultural landbank) to be summed for all cells within a chosen radial distance from a selected point, which is graphed automatically. This capability enables users 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 the site? Or, what is the landbank available for recycling e.g. compost/digestate within 30km of a selected site? The tool also makes it possible to answer questions such as – what location has the most slurry production available for anaerobic digestion, within a specified transport distance.

ALOWANCE-PLUS also has scenario testing capabilities enabling predictions to be made of the future agricultural landbank in light of potential changes in farming systems, for example, as a result of changing livestock numbers or regulation changes. New sources (e.g. new composting or anaerobic digestion plants) can be added to assess the effect on the landbank remaining. Additionally, ALOWANCE-PLUS has a spatial analysis capability that allows statistical summaries of landbank areas, livestock numbers, organic material N loadings to land etc. to be produced. These data can be obtained for specific areas (e.g. counties or regions), using on-screen toolbar controls or through loading an external ESRI shapefile to specify the boundary to be selected.

3.10 Results

Results from ALOWANCE-PLUS showed in 2004 that there was c.9.3 million hectares of agricultural land (the theoretical landbank). After exclusions due to physical and landuse restrictions, and after accounting for livestock N production, c.5.5 million hectares of land remained. Exclusions based on soil pH and metal concentrations reduced the landbank by c.150,000 ha, and after accommodating current sources of non-farm organic materials (biosolids, compost, paper crumble and digestate), the estimated agricultural landbank for the addition of ‘new’ sources of organic materials was c.5.1 million hectares.

Spatial representation of the agricultural landbank (Figures 17 and 18) showed that in some parts of the country (e.g. North-west England) the landbank is already under ‘pressure’ and transport of any future ‘new’ sources of organic materials away from these areas may be required.
Figure 17. The agricultural landbank (ha)

Figure 18. The agricultural landbank available for recycling ‘new’ organic materials (% agricultural land)
4. ALOWANCE-ONLINE

ALOWANCE-ONLINE is a web-based version of ALOWANCE which provides basic information to general users (Figure 19). It includes pre-selected map 'layers' which users can view and query (but not alter), including:

- The area of agricultural land (hectares) available for 'new' organic material applications (i.e. the landbank) – default view (Figure 20)
- The area of agricultural land (hectares)
- Livestock numbers – dairy/beef cattle, sheep, pigs and poultry (4 separate maps)
- Areas of grassland and arable land (hectares)
- A map of soil pH distribution (summarised in pH bands)
- A map of soil extractable phosphorus (P) distribution (summarised as ADAS Indices)
- Nitrate Vulnerable Zone (2009) designated areas

Each map consists of a grid of 10x10 km squares that are colour coded according to value ascribed (Figure 20). Using the zoom function, a detailed OS map can be viewed which provides contextual information about a selected location.

Users will commonly want to know the total agricultural landbank available for ‘new’ organic material additions within a specified distance from a point on the map. To make this as easy as possible, a postcode recognition system has been incorporated into the software. ALOWANCE-ONLINE will find the location of the postcode and automatically calculate the agricultural landbank within a specified distance. The total agricultural landbank available in the selected area is expressed in hectares and shown in red at the top of the page. Additionally, the data can be viewed in chart format, summarising the potential landbank (hectares) versus distance from the selected point (Figure 21). The tool can also be used in a similar way for the agricultural land area and livestock numbers map layers.

A secondary tool is also available which enables users to select areas using on-screen circle, square or polygon tools. For the selected area, data properties such as the agricultural land area, livestock numbers or available landbank for recycling ‘new’ organic material layers are summarised on-screen.

Comprehensive user help and associated background and technical information are also available to users of ALOWANCE-ONLINE. In addition, a facility has been created for the website manager to review and report on site use.

ALOWANCE-ONLINE can currently be accessed via the WRAP website at: http://www.wrap.org.uk/composting/useful_tools.html
Figure 19. The ALOWANCE-ONLINE home page

Figure 20. ALOWANCE-ONLINE showing the agricultural landbank map layer, with the available landbank within 40km of a selected postcode.
5. SUMMARY

Organic materials are a valuable source of nutrients for crop growth and organic matter that can maintain and enhance soil physical conditions. There are around 9.3 million hectares of agricultural land in England and Wales potentially available for the recycling of organic materials, although not all soils or land uses are suitable. Applications are restricted both in space and time by a number of physical and practical constraints, and legislative restrictions.

There is clearly a need to understand the size and distribution of the available agricultural landbank at both a national and local level. ALOWANCE (Agricultural Land and Organic ‘Waste’: A National Capacity Estimator) is a GIS-based strategic management tool that has an embedded methodology for calculating: 1) the potential landbank capacity; 2) current farm manure N production; 3) the proportion of the landbank already taken up by farm manures and existing non-farm organic materials (i.e. biosolids, compost, paper crumble, digestate) and 4) the landbank remaining for ‘new’ sources of organic materials. ALOWANCE can be used to identify areas where there is a potential shortage or surplus of agricultural available land for recycling organic materials.

Two versions of ALOWANCE have been developed (based on 2004 census data). ALOWANCE-PLUS is a PC-based tool which offers the full functionality of ALOWANCE to a small number of ‘expert’ users. It incorporates scenario testing capabilities, which enable new organic material streams to be added and the agricultural landbank capacity to be calculated interactively. ALOWANCE-ONLINE is a web-based version of ALOWANCE which provides basic information to general
users, including pre-selected map ‘layers’ (generated from ALOWANCE-PLUS) and a simple query tool. It can currently be accessed via the WRAP website.

Results from ALOWANCE-PLUS showed in 2004 that there was c.9.3 million hectares of agricultural land (the theoretical landbank). After exclusions due to physical and landuse restrictions, and after accounting for livestock N production, c.5.5 million hectares of land remained. Exclusions based on soil pH and metal concentrations reduced the landbank by c.150,000 ha, and after accommodating current sources of non-farm organic materials (biosolids, compost, paper crumble and digestate), the estimated agricultural landbank for the addition of ‘new’ sources of organic materials was c.5.1 million hectares. Spatial representations showed that in some parts of the country (e.g. North-west England) the landbank was already under ‘pressure’ and transport of any future ‘new’ sources of organic materials away from these areas may be required.

6. FURTHER WORK

- Livestock manures occupy the largest proportion of the agricultural landbank, and farmers will always accommodate their own manures before importing other ‘non-farm’ derived organic materials. There will be a need to update ALOWANCE when more up to date data on livestock numbers become available (presently ALOWANCE is based on 2004 agricultural census data).

- Both the composting and anaerobic digestion industries are dynamically changing and expanding. There will be a need to update ALOWANCE with more up to date data on new sources of non-farm organic materials (e.g. new anaerobic digestion or composting plants); the compost data in ALOWANCE is currently from 2004/5.

- There will be a need to update ALOWANCE when livestock N (and P) standards are updated in light of new scientific information.

7. PUBLICATIONS


the Agricultural Landbank for Recycling Organic Materials. Paper presented at
the Association for Organics Recycling (AFOR) Annual Conference,

8. REFERENCES

ADAS (2001). The Safe Sludge Matrix

Defra (2007). The National Inventory and Map of Livestock Manure Loadings to
Agricultural Land (Manures-GIS) - WQ0103. Project description available at:
None&Completed=0&ProjectID=14500#Description [accessed December
2009).

leaflets a to i.

Practice for Farmers, Growers and Land Managers. The Stationery Office,
Norwich.

Defra Publication Sales Unit, 01709-891318.


Minimise the Risks of Microbiological Contamination of Ready to Eat Crops.
http://www.food.gov.uk/multimedia/pdfs/manuresguidance.pdf [accessed
October 2009].


Misselbrook, T. H., Chadwick, D. R., Chambers, B. J., Smith, K. A. & Williams, J.
contract AC0112, Inventory Submission report, October 2008.

OS (2007). Ordnance Survey Landform Panorama. Available at:
http://www.ordnancesurvey.co.uk/oswebsite/products/landformpanorama/

SI (1989) United Kingdom Statutory Instrument No 880. The Sludge (Use in

September 2008].

application strategies to conserve nitrogen within farming systems. In:
Agriculture and Waste Management for a Sustainable Future. (Eds. T.
APPENDIX

Table A1. N production, proportion of handled manure, proportion of handled manure which is solid, and manure N:P ratios for dairy and beef cattle.

<table>
<thead>
<tr>
<th>Census description</th>
<th>Census Category</th>
<th>N production* (kg/hd/yr)</th>
<th>Handled manure (%)</th>
<th>Solid manure (%)</th>
<th>P excretion (kg/hd/yr)</th>
<th>N:P ratio**</th>
</tr>
</thead>
<tbody>
<tr>
<td>All dairy cows &amp; heifers that have calved</td>
<td>K1</td>
<td>101</td>
<td>62</td>
<td>34</td>
<td>19</td>
<td>5.3</td>
</tr>
<tr>
<td>Heifers in 1st calf &gt; 2yrs/1-2yrs</td>
<td>K2, K3</td>
<td>61</td>
<td>35</td>
<td>34</td>
<td>12</td>
<td>5.1</td>
</tr>
<tr>
<td>Other females for dairy herd replacement &gt; 2yrs/1-2yrs</td>
<td>K4, K5</td>
<td>61</td>
<td>35</td>
<td>82</td>
<td>12</td>
<td>5.1</td>
</tr>
<tr>
<td>All beef cows &amp; heifers that have calved</td>
<td>K6</td>
<td>83</td>
<td>38</td>
<td>82</td>
<td>14</td>
<td>5.9</td>
</tr>
<tr>
<td>Beef heifers in 1st calf &gt; 2yrs/1 – 2yrs</td>
<td>K7, K8</td>
<td>61</td>
<td>38</td>
<td>82</td>
<td>12</td>
<td>5.1</td>
</tr>
<tr>
<td>Other females for beef herd replacement &gt; 2yrs/1-2yrs</td>
<td>K9, K10</td>
<td>50</td>
<td>38</td>
<td>82</td>
<td>8</td>
<td>6.3</td>
</tr>
<tr>
<td>Bulls for service &gt; 2yrs</td>
<td>K11</td>
<td>48</td>
<td>35</td>
<td>82</td>
<td>9.1</td>
<td>5.3</td>
</tr>
<tr>
<td>Bulls for service 1-2yrs</td>
<td>K12</td>
<td>50</td>
<td>35</td>
<td>82</td>
<td>8</td>
<td>6.3</td>
</tr>
<tr>
<td>Females intended for slaughter &gt;2yrs/1-2yrs</td>
<td>K13, K14</td>
<td>50</td>
<td>38</td>
<td>82</td>
<td>8</td>
<td>6.3</td>
</tr>
<tr>
<td>Other male cattle &gt;2yrs/1-2yrs</td>
<td>K15, K16</td>
<td>50</td>
<td>38</td>
<td>82</td>
<td>8</td>
<td>6.3</td>
</tr>
<tr>
<td>Intended for slaughter as calves</td>
<td>K17</td>
<td>8.8</td>
<td>38</td>
<td>100</td>
<td>1.2</td>
<td>7.3</td>
</tr>
<tr>
<td>Other female calves/ Other male calves</td>
<td>K18, K19</td>
<td>29</td>
<td>45</td>
<td>82</td>
<td>5.8</td>
<td>5.0</td>
</tr>
</tbody>
</table>

*N production is the quantity of N produced after losses during housing and storage are accounted for. The figures have been corrected for occupancy and can be used as direct multipliers with animal numbers from the Agricultural Census

**Ratio of N production to P excretion
Table A2. N production, proportion of handled manure, proportion of handled manure which is solid, and manure N:P ratios for pigs.

<table>
<thead>
<tr>
<th>Census description</th>
<th>Census Category</th>
<th>N production* (kg/hd/yr)</th>
<th>Handled manure (%)</th>
<th>Solid manure (%)</th>
<th>P excretion (kg/hd/yr)</th>
<th>N:P ratio**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sows in pig/Suckled or dry sows for further breeding</td>
<td>L1, L3</td>
<td>17</td>
<td>100</td>
<td>25</td>
<td>7.1</td>
<td>2.4</td>
</tr>
<tr>
<td>Gilts in pig</td>
<td>L2</td>
<td>13.9</td>
<td>100</td>
<td>25</td>
<td>4.4</td>
<td>3.2</td>
</tr>
<tr>
<td>Boars used for service</td>
<td>L4</td>
<td>17.5</td>
<td>100</td>
<td>100</td>
<td>5.2</td>
<td>3.4</td>
</tr>
<tr>
<td>Gilts – 50kg &amp; over for breeding</td>
<td>L5</td>
<td>13.9</td>
<td>100</td>
<td>65</td>
<td>4.4</td>
<td>3.2</td>
</tr>
<tr>
<td>Barren sows for fattening</td>
<td>L7</td>
<td>12.3</td>
<td>100</td>
<td>65</td>
<td>3.7</td>
<td>3.3</td>
</tr>
<tr>
<td>Growers &gt; 110kg</td>
<td>L10</td>
<td>12.3</td>
<td>100</td>
<td>65</td>
<td>3.7</td>
<td>3.3</td>
</tr>
<tr>
<td>Growers 80 – 110kg</td>
<td>L11</td>
<td>12.3</td>
<td>100</td>
<td>65</td>
<td>3.7</td>
<td>3.3</td>
</tr>
<tr>
<td>Growers 50 – 80kg</td>
<td>L12</td>
<td>8.8</td>
<td>100</td>
<td>65</td>
<td>2.6</td>
<td>3.4</td>
</tr>
<tr>
<td>Growers 20 – 50kg</td>
<td>L13</td>
<td>8.8</td>
<td>100</td>
<td>65</td>
<td>2.6</td>
<td>3.4</td>
</tr>
<tr>
<td>Weaners &lt; 20kg</td>
<td>L14</td>
<td>1.5</td>
<td>100</td>
<td>50</td>
<td>0.4</td>
<td>3.8</td>
</tr>
</tbody>
</table>

*N production is the quantity of N produced after losses during housing and storage are accounted for. The figures have been corrected for occupancy and can be used as direct multipliers with animal numbers from the Agricultural Census.

**Ratio of N production to P excretion.
Table A3. N production, proportion of handled manure, proportion of handled manure which is solid or layer manure or poultry litter (poultry only), and manure N:P ratios for poultry, sheep and other stock.

<table>
<thead>
<tr>
<th>Census description</th>
<th>Census Category</th>
<th>N production* (kg/hd/yr)</th>
<th>Handled manure (%)</th>
<th>Solid manure or poultry manure (%)</th>
<th>Poultry litter (%)</th>
<th>P excretion (kg/hd/yr)</th>
<th>N:P ratio**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birds in laying flock – caged</td>
<td>N31, N32</td>
<td>0.41</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0.196</td>
<td>2.1</td>
</tr>
<tr>
<td>Layers – free range</td>
<td>N33</td>
<td>0.55</td>
<td>80</td>
<td>100</td>
<td>0</td>
<td>0.227</td>
<td>2.4</td>
</tr>
<tr>
<td>Broilers</td>
<td>N10</td>
<td>0.39</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0.141</td>
<td>2.8</td>
</tr>
<tr>
<td>Layer/broiler breeders/cocks</td>
<td>N5, N6, N7</td>
<td>0.74</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0.295</td>
<td>2.5</td>
</tr>
<tr>
<td>Growing pullets up to point of lay</td>
<td>N2</td>
<td>0.24</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0.112</td>
<td>2.1</td>
</tr>
<tr>
<td>Turkeys</td>
<td>N15</td>
<td>1.19</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0.339</td>
<td>3.5</td>
</tr>
<tr>
<td>Ducks</td>
<td>N13</td>
<td>0.9</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0.349</td>
<td>2.6</td>
</tr>
<tr>
<td>Geese</td>
<td>N14</td>
<td>1.19</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0.339</td>
<td>3.5</td>
</tr>
<tr>
<td>All other birds</td>
<td>N16</td>
<td>0.9</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0.349</td>
<td>2.6</td>
</tr>
<tr>
<td>All sheep</td>
<td>M1, M4, M7, M9, M13, M14</td>
<td>9.8</td>
<td>5</td>
<td>100</td>
<td>1.45</td>
<td>6.8</td>
<td></td>
</tr>
<tr>
<td>Lambs under 1 yr</td>
<td>M17</td>
<td>0.6</td>
<td>0</td>
<td>100</td>
<td>0.19</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>Horses</td>
<td>P1, P2</td>
<td>21</td>
<td>25</td>
<td>100</td>
<td>6.9</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Goats – breeding females -</td>
<td>P5, P6</td>
<td>15.1</td>
<td>100</td>
<td>100</td>
<td>3.1</td>
<td>4.9</td>
<td></td>
</tr>
<tr>
<td>Other goats and kids</td>
<td>P7</td>
<td>0.6</td>
<td>100</td>
<td>100</td>
<td>0.19</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>Farmed deer</td>
<td>P10</td>
<td>13.9</td>
<td>25</td>
<td>100</td>
<td>2.25</td>
<td>6.2</td>
<td></td>
</tr>
</tbody>
</table>

*N production is the quantity of N produced after losses during housing and storage are accounted for. The figures have been corrected for occupancy and can be used as direct multipliers with animal numbers from the Agricultural Census.

**Ratio of N production to P excretion.
Table A4. N, P and dry matter content of organic materials and transport distances

<table>
<thead>
<tr>
<th>Type of material</th>
<th>N content (kg/t dry solids)</th>
<th>N content (kg/t fresh weight)</th>
<th>Dry matter (%)</th>
<th>P₂O₅ content (kg/t fresh weight)</th>
<th>P content (kg/t dry solids)</th>
<th>P content (kg/t fresh weight)</th>
<th>N:P ratio¹</th>
<th>Transport distance (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poultry manure</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>All other manures</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>Biosolids²</td>
<td>36</td>
<td>-</td>
<td>-</td>
<td>31</td>
<td>-</td>
<td>1.2</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Other organic materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green compost³</td>
<td>-</td>
<td>7.5</td>
<td>60</td>
<td>3.0</td>
<td>-</td>
<td>1.3</td>
<td>5.8</td>
<td>20</td>
</tr>
<tr>
<td>Paper crumble (biologically treated)⁴</td>
<td>-</td>
<td>7.5</td>
<td>28</td>
<td>3.8</td>
<td>-</td>
<td>1.7</td>
<td>4.5</td>
<td>60</td>
</tr>
<tr>
<td>Paper crumble (non-biologically treated)⁴</td>
<td>-</td>
<td>2.2</td>
<td>41</td>
<td>0.5</td>
<td>-</td>
<td>0.2</td>
<td>10.4</td>
<td>60</td>
</tr>
<tr>
<td>Anaerobic digestate⁵</td>
<td>-</td>
<td>8.2</td>
<td>4</td>
<td>1.0</td>
<td>-</td>
<td>0.4</td>
<td>17.7</td>
<td>30</td>
</tr>
<tr>
<td>Fibrophos⁶</td>
<td>-</td>
<td>0.01</td>
<td>-</td>
<td>240</td>
<td>-</td>
<td>105</td>
<td>0.0001</td>
<td>80</td>
</tr>
<tr>
<td>CropKare⁷</td>
<td>-</td>
<td>0.01</td>
<td>-</td>
<td>120</td>
<td>-</td>
<td>52</td>
<td>0.0002</td>
<td>80</td>
</tr>
</tbody>
</table>

¹Ratio of dry solids N and P content for biosolids and fresh weight N and P contents for other organic materials
²Mean of data for 2001 to 2007 for England and Wales supplied by the Environment Agency (M. Davies, pers. comm.). Currently, all biosolids types use the same nutrient analysis.
³Data on N and P contents from Defra "Fertiliser Manual (RB209)", in Press.
⁴Data on N and P contents from Gibbs et al. (2005)
⁵Mean of nutrient analysis data from two AD plants. Transport distance assumed to be the same as biosolids.
⁶Nutrient analysis of Traditional product in Southern and Central England/Wales. N content set to 0.01 kg/t to allow an N:P ratio to be calculated.
⁷Typical analysis. N content set to 0.01 kg/t to allow an N:P ratio to be calculated. Transport distance assumed to be the same as incinerated poultry litter.