ENHANCING AND VISUALISING DATA ON SOILS, LAND USE AND THE ENVIRONMENT

END OF PROJECT REPORT

ARMIS 4104

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SUMMARY

A computer based system was developed to produce new information, charts and map data on soils, environment and land use for environmental decision support. The process involved manipulation of data in tabular and electronic map form by combining features from digitised maps and tables to develop an information system of linked and harmonised data. This report reviews and illustrates the findings with outputs in the form of maps and tables.

Maps presenting sheep census information for the years 1970-1991 show greatly increased livestock densities, in the latter years. These changes mainly occurred in the (i) traditional drystock areas of the midlands (ii) south east arable areas and (iii) south east Connacht dry stock/sheep areas and reflect economic and structural changes arising out of Government policy and membership of the EU. Maps depicting the temporal changes in dairy livestock densities were not so dramatic; however the structural change is particularly reflected in the reduction of dairying in the Connacht/Midlands regions. The introduction of milk quotas in the 1980's accelerated the changes which had been taking place since the early 1970's.

In comparison to dairy cows, the increased concentration of drystock seems to be more widely spread. High concentrations of drystock occurred in the east midlands in 1970. By 1980, the high concentration of dry cattle had spread to North and South Midlands. The density of cattle increased further in Leinster and Munster areas by 1991. In Connaught, where sheep numbers had increased markedly between 1970 and 1991, cattle numbers remained relatively static.

The digitisation of detailed soil survey maps was undertaken in this project and a new soil survey map of the Lough Derg Catchment was produced using Great Soil Groups as the mapping unit. This map is included in the report.

INTRODUCTION

The National Soil Survey of Ireland was set up in 1959 in order to classify the soils of Ireland and to publish and make available soils information which would be of value to agronomy, land use planning and environmental studies. The USDA soil taxonomy classification system was uses with emphasis placed in the reports on the interpretation of the results for agricultural development and land use planning. The classification systems of FAO were not felt to be appropriate for Ireland and were not used then or since

In the main, the basic soil survey programme was operated at two levels of organisation: (1) detailed studies leading to soils maps and reports of individual counties where the soil series was the unit of mapping and (2) a combination of detailed and general reconnaissance to produce the General Soil Map of Ireland, on a single sheet with the soil association as the unit of mapping.

In 1989, as part of a major reorganisation at Johnstown Castle, there was a Teagasc policy decision to discontinue Soil Survey. At that stage, only 44% of the country had been surveyed in detail and some maps and reports remained unpublished. It was decided to undertake a GIS programme to capture and harmonise all existing data and to add value to the existing soil survey information. It would also enable maps to be generated by combining data from many other sources.

Project 4104 was set up to develop computer based system to view, manipulate and store data on soils, environment and land use in electronic map form for environmental decision support. It was designed to produce new information, charts and maps by combining features from the captured data, and to develop networking systems to allow exchange of data with other Teagasc centres, local and national government and the EU.

The first task in developing a computer based system was to review the sources of information, both maps and tables, that would be used to develop an information system of linked digital and tabular data. This report reviews and illustrates the findings and outputs under the headings:

- Map Presentation of National Census Information,
- Capturing Digital Soil Information,
- Visualisation of Soil Fertility Information and
- Thematic Maps derived from Soil Survey Information.

MAP PRESENTATION OF ANIMAL CENSUS DATA

The Central Statistics Office kindly made the 1970, 1980 and 1991 Irish Agricultural Census data on crops and animals available as a text file (Central Statistics Office, 1994). The data were converted to dBase compatible form both for database checking and processing and for compatibility with the ArcInfo geographic information system.

Each record or row of data represented the agricultural information within a distinct area called a 'district electoral division' or DED of which there are approximately 3300 in the Republic of Ireland with an average area of approximately 11 km^2. They are called DEDs because their most frequent use within the country is as the management unit for national and local elections. They are also the smallest administrative unit for which demographic data is available from official sources. The names and boundaries of district electoral divisions (and other larger administrative units) have been published in map form by the Irish Ordnance Survey Office (1935, revised 1961) with several revisions of DED code numbers since then with a major change in codes and changes in some boundaries in 1991 (Central Statistics Office,1994).

A digital map of the county and coastal boundaries and town locations was undertaken by digitising the set of 25 topographic maps of Ireland at a scale of 1:126,720 and combining the 25 'coverages'. Digitisation of the boundaries of all the DED areas in the country was undertaken from a set of four paper maps, which were published at a scale of 1:250,000. This was done county by county and the county boundaries from the DED maps were fitted to the boundaries of the more accurate topographic maps in order that the internals of the DED map would have the greatest accuracy possible.

Each DED in the electronic maps was labelled with an identification label and these labels were then linked with the DED codes used with the table of census data. This process allowed geographical relationships to be established between the boundaries of each DED in the maps and the agricultural census records in the database. The records were processed to produce a number of land use determinants for each of the three years. These included the total calculated livestock units of sheep, dairy animals, beef animals and the total area of land under

tillage. The stocking rates for sheep, dairy and beef animals were calculated by dividing the number of livestock units in each DED by the total area of the DED. While this does not reflect the stocking rate from a grazing point of view, it does allow accurate comparisons across years for the different livestock enterprises.

The formulae used to compute the stocking density for each of the enterprises is given in equations ❶ - ❸ and maps showing the livestock densities for each year and enterprise are given in figures 1-9.

Sheep Stocking Density:

$$LU_S = (a \times .23 + b \times .21 + c \times .17) / \text{area} \quad ❶$$

where a = number of rams, b = ewes and c = other sheep.

Dairy Stocking Rate

$$LU_D = [a+b+c+ (d+fa+fb) \times .7] / \text{area} \quad ❷$$

where a = number of dairy cows, b = other cows, c = bulls for breeding, d = dairy heifers in calf, e = other heifers in calf,

Beef stocking Density

$$LU_B = (a + b \times .7 + c \times .4) / \text{area} \quad ❸$$

where a = cattle > 2 years old, b = cattle 1-2 years and c = cattle < 1 year. Horner et al (1984) used similar coefficients to account for the national herd of 7.1 million cattle livestock equivalents in 1980. This broke down as 39.5% breeding cattle, 40.6% dry cattle, 9.3% cattle under 1 year old and 9.4% sheep.

Sheep Livestock Densities

Figures 1-3 show that the density of sheep in many areas increased dramatically over the years 1970-1991. The maps provide a geographic perspective into the enormous expansion in sheep production which has taken place, and they highlight the importance of the Galway-Roscommon and Carlow-Wicklow-Wexford areas in sheep production. The establishment of a common market in sheep meat and introduction of ewe premiums in 1980 had a profound effect. A comparison of Figs 2 and 3 illustrate the expansion which occurred in the (i) traditional drystock areas of the midlands (ii) south east arable areas and (iii) south east Connaught dry stock/sheep areas. The 1991 concentration in the latter areas are noteworthy. A comparison of Figs 1 and 3 also illustrates the expansion which occurred in (i) Some of the traditional dairying areas of Munster and (ii) the drystock/arable area of East Donegal.

Fig 1: SHEEP : 1970 DED STOCKING DENSITY

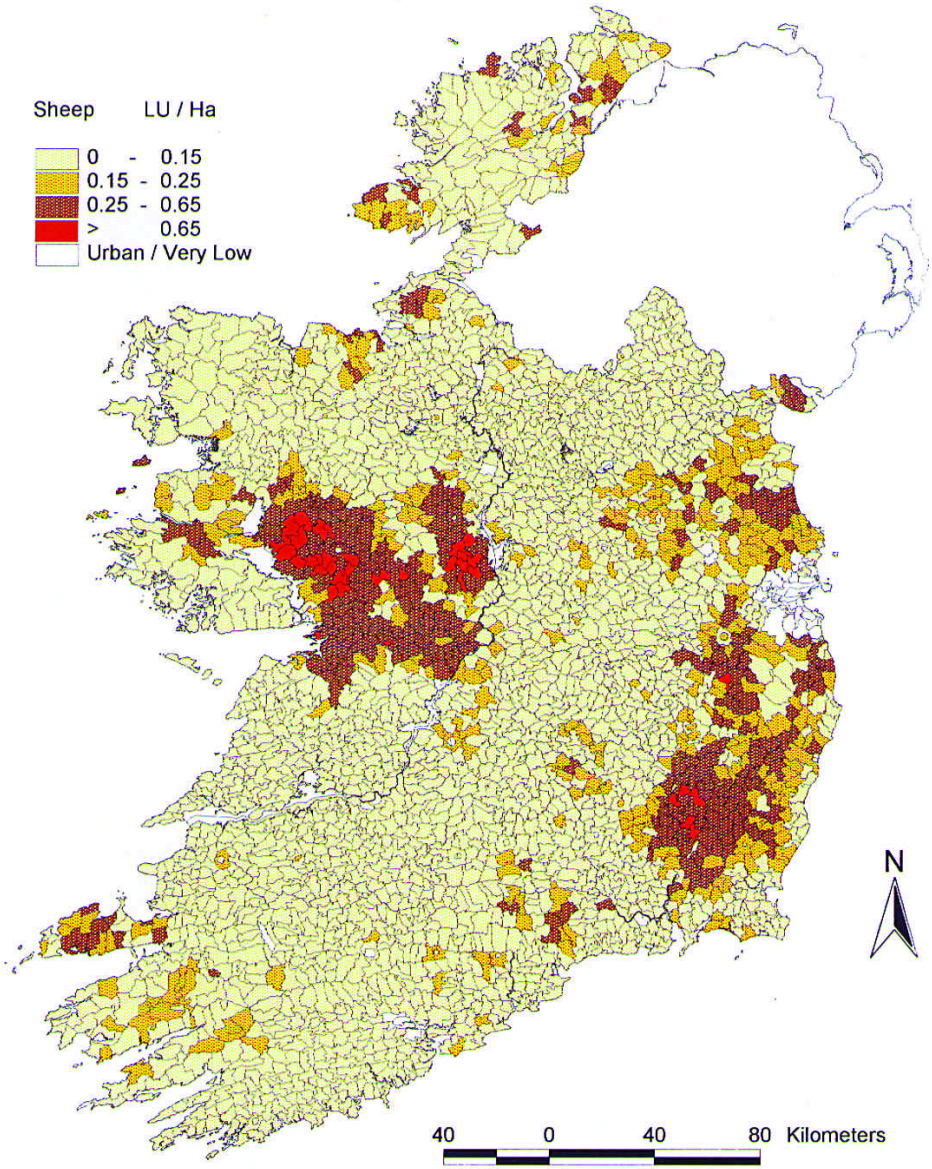

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Fig 2: SHEEP : 1980 DED STOCKING DENSITY

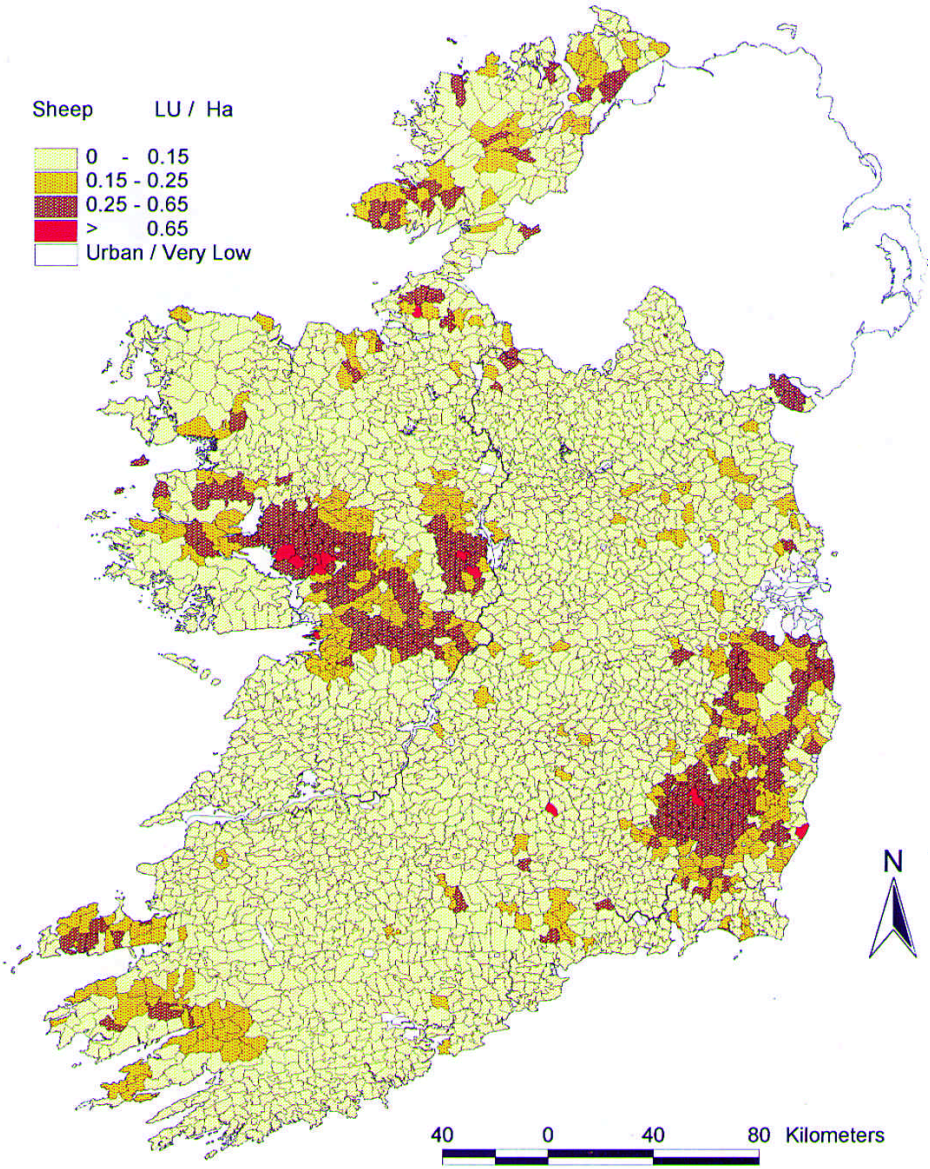

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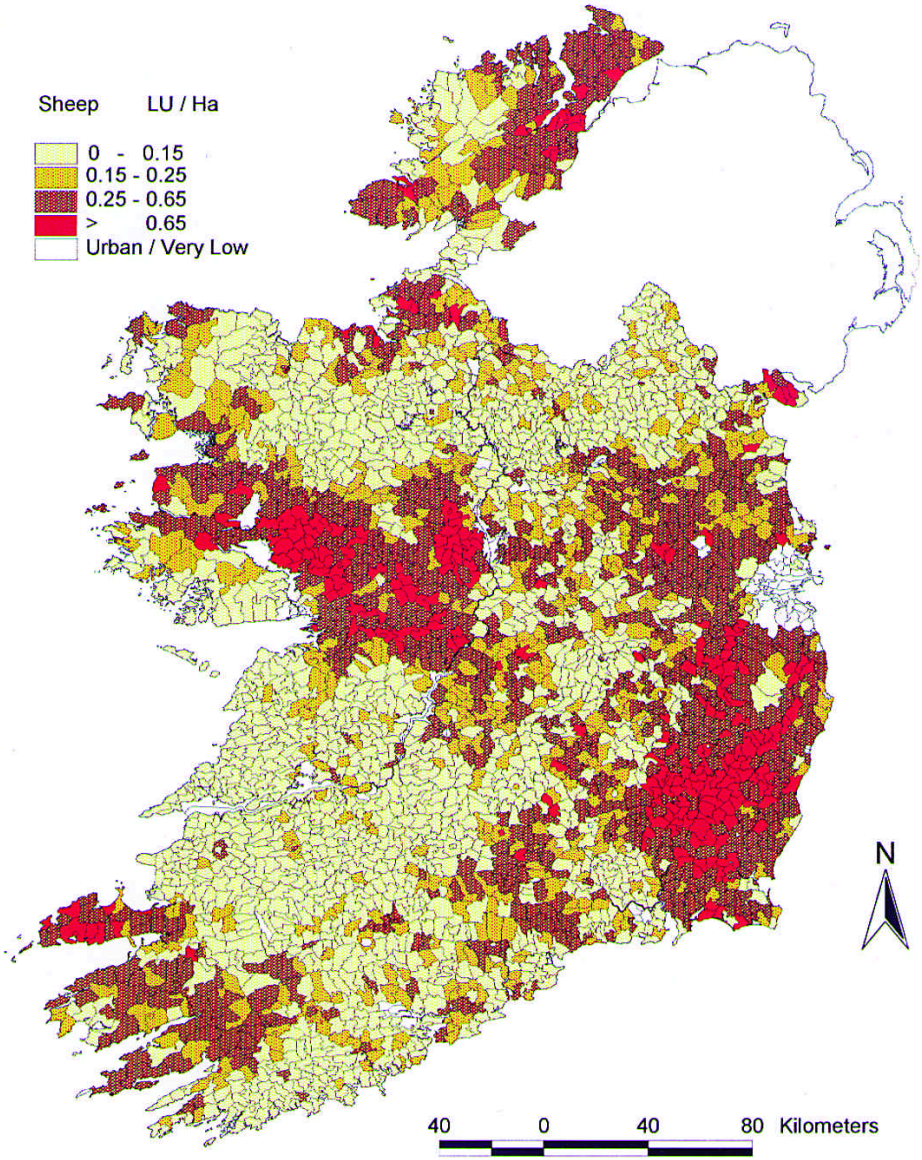
Fig 3: SHEEP : 1991 DED STOCKING DENSITY



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The expansion which occurred in the upland/hill areas of the Western Seaboard is also evident and noteworthy in the Dingle Peninsula and in the Wicklow uplands in the East. The significant expansion which occurred in the South Kerry, Mayo and Donegal uplands is also notable. From some points of view, this is undesirable, as the soils of these areas are largely characterised as peaty podzols and such soils are highly susceptible to degradation and erosion under excessive grazing pressure.

The stocking density of sheep in a DED is largely dependent on the number of breeding ewes and the following observations are based on patterns of change in this index of population size. An analysis of data published by Central Statistics Office for the years 1960-1970 and unpublished breed survey data collected by the Department of Agriculture, Fisheries and Food has shown that in the mid 1960's, ewe numbers were at an historic high. However, they then declined steadily up to the beginning of the 1980's. At this point, the EU market support for sheep meat was introduced (1981). However, this overall decline marked a divergence between hill and lowland regions. For this purpose, hill regions are defined as counties with a significant proportion of hill sheep (based on breed composition surveys). The usual definition of "hill" counties is where the proportion of hill breed ewes (Scottish Blackface or Cheviot) exceeds 0.5. This definition includes the counties Dublin, Leitrim, Louth, Sligo and Waterford in which sheep numbers are not very high and Cork, Donegal, Kerry, Mayo and Wicklow which have large numbers of ewes.

Examination of county data (J Hanrahan, 1998) shows that between 1970 and 1981 the number of ewes in the hill counties increased by 29% whereas the numbers in the non-hill counties decreased by 31%. The increases, which are clearly apparent on the maps, were particularly marked in Donegal, Kerry and Mayo; which have a very high proportion of S. Blackface ewes (>70%). In these counties the increases were 63%, 78% and 32%, respectively.

Between 1981 and 1985 the increases in ewe numbers were more marked in the non-hill counties (+48%) than in the hill counties (+15%). Between 1981 and 1992 there were major increases in all counties +80% for hill counties and +97% for the non-hill counties. Compared with 1970, the numbers in hill counties showed an increase of 167% compared with 102% in the non-hill counties.

The divergent trends between hill and lowland regions in the 1970's is probably attributable to existence of the Mountain Sheep Subsidy Scheme (initiated in 1966) and the fact that there was no EU support for lowland sheep production during the first 8 years of EU membership. On the other hand, other livestock enterprises were benefiting from the price increases that followed EU membership.

Inspection of the maps clearly shows the increased density of sheep in 1981 in areas associated with hill sheep (Donegal, north Galway, Mayo, Wicklow region, Kerry & west-Cork and Waterford). According to Gillmor and Walsh (1993) the number of sheep more than doubled in every county between 1980 and 1991; in some counties the number more than quadrupled. The 1991 map (Fig 3) shows this widespread growth in sheep numbers in all regions of the country and reflects the relative impetus to profitability of sheep consequent upon the introduction of EU support for sheep production (via ewe premium) in 1981.

Dairy Livestock Densities

The distribution of dairy animals for the census years 1970-1991 is shown in figures 4-6. The maps illustrate the geographic adjustment which has occurred in respect to dairying. This structural change is particularly reflected in the reduction of dairying in the Connacht/Midlands regions. The introduction of milk quotas in the 1980's accelerated the structural change which had been taking place since the early 1970's. This is evident in comparing Figs 4 and 5. A decline in dairying concentration in the Cavan/Monaghan "small faming area" is also evident and similarly in the West Clare traditional dairying area. This was also found by Gillmor and Walsh (1993) who stated that the greatest declines occurred in the south western half of the country with an overall drop of 16% between 1980 and 1991.

Fig 4: DAIRY : 1970 DED STOCKING DENSITY

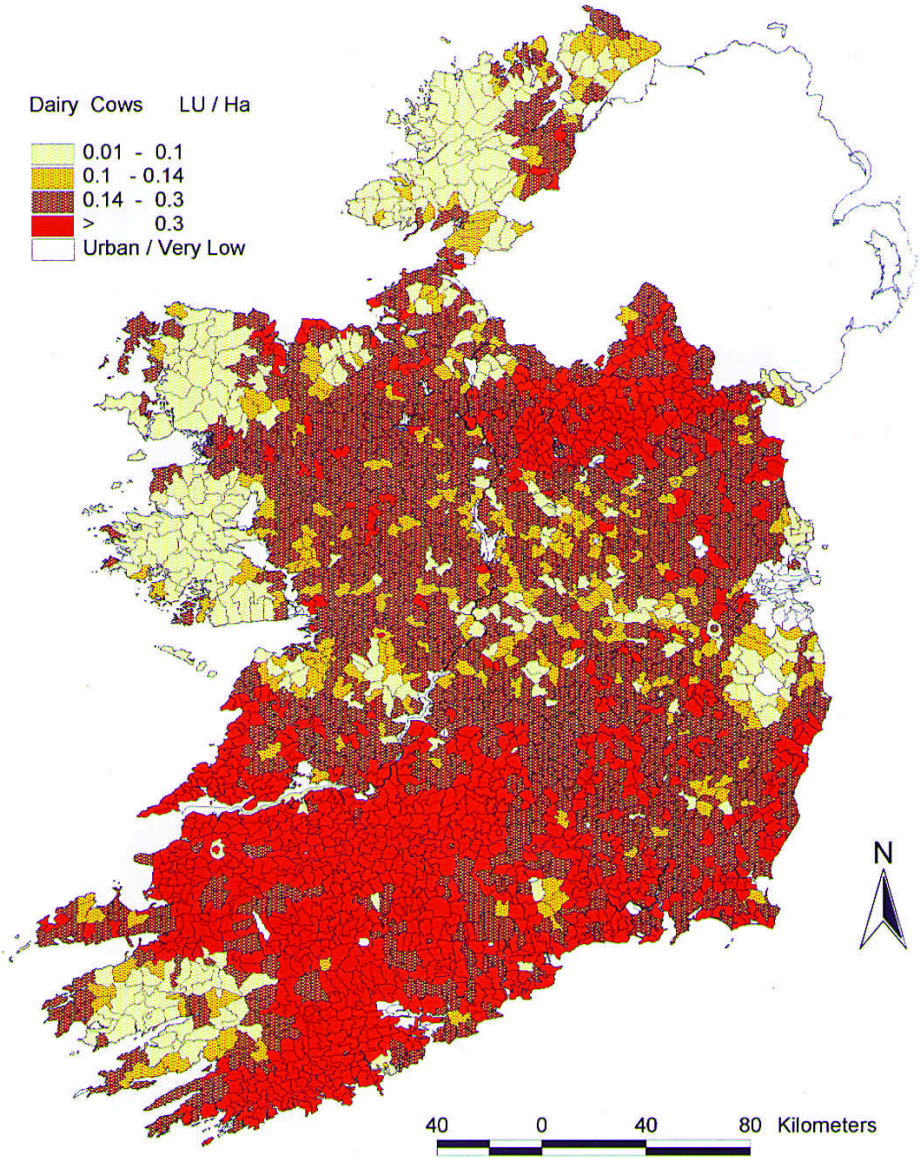

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Fig 5: DAIRY : 1980 DED STOCKING DENSITY

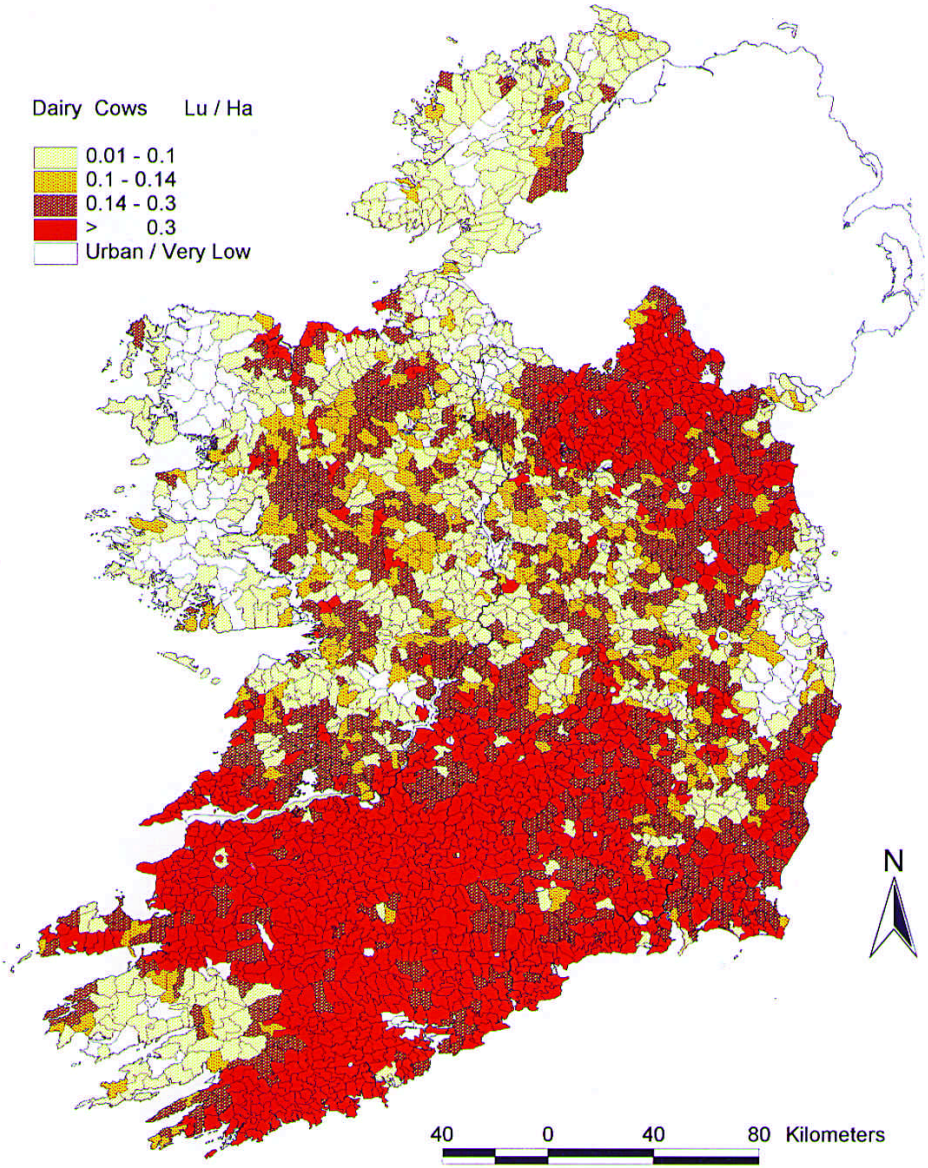

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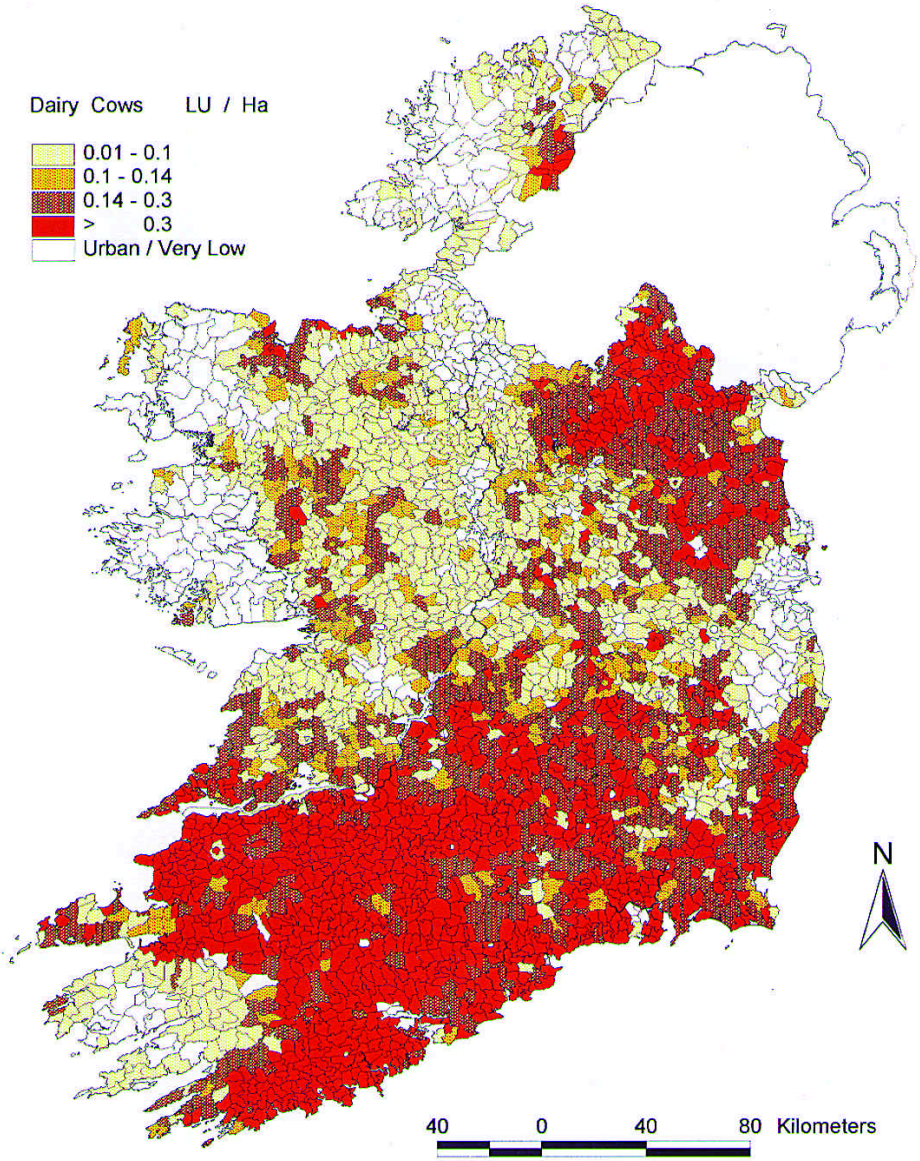
Fig 6: DAIRY : 1991 DED STOCKING DENSITY



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The declines have appear to have occurred mainly in these geographic areas where the smallest herds are disproportionately concentrated (A. Leavy 1998). Many smaller farms were unable to provide an adequate income because of restrictions on expansion or the farmer's inability to expend the investments required to produce milk to increasing quality levels.

Dairy cow numbers increased from 1.1m to 1.5m in the period 1970 to 1984, when the quota was introduced, . At present they number about 1.3m. It is clear from the maps that there has also been a concentration of dairy cow numbers in Munster apart from south Kerry and Clare. The east Cavan, north Meath and Louth area has maintained its dairy cow population. The extent of this area has, however, contracted. In south Leinster, both Kilkenny and Wexford have maintained or increased dairy cow numbers. There has been a major withdrawal of cows in the west, midlands and, apart from a small area in the east of the county, in Donegal.

Gillmor and Walsh (1993) also attribute increases between 1980 and 1991 to an expansion in the number of cows retained to provide calves for the beef sector due to a decline in dairying.

Cattle Livestock Densities

The distribution of beef cattle in the census years 1970, 1980 and 1991 is shown in figures 7-9.

One of the responses to the dairying decline was an expansion in the beef sector. This is reflected particularly in Connaught (Figs 7, 8 and 9). A comparison of Fig 7 and 8 illustrates the increased concentration in drystock (beef sector) between 1970 and 1980 with less change between 1980 and 1991. Thus high concentrations of drystock occurred in the east midlands in 1970. By 1980, the high concentration of dry cattle had spread to North and South Midlands. The density of cattle increased further in Leinster and Munster areas by 1991.

Fig 7: DRYSTOCK : 1970 DED STOCKING DENSITY

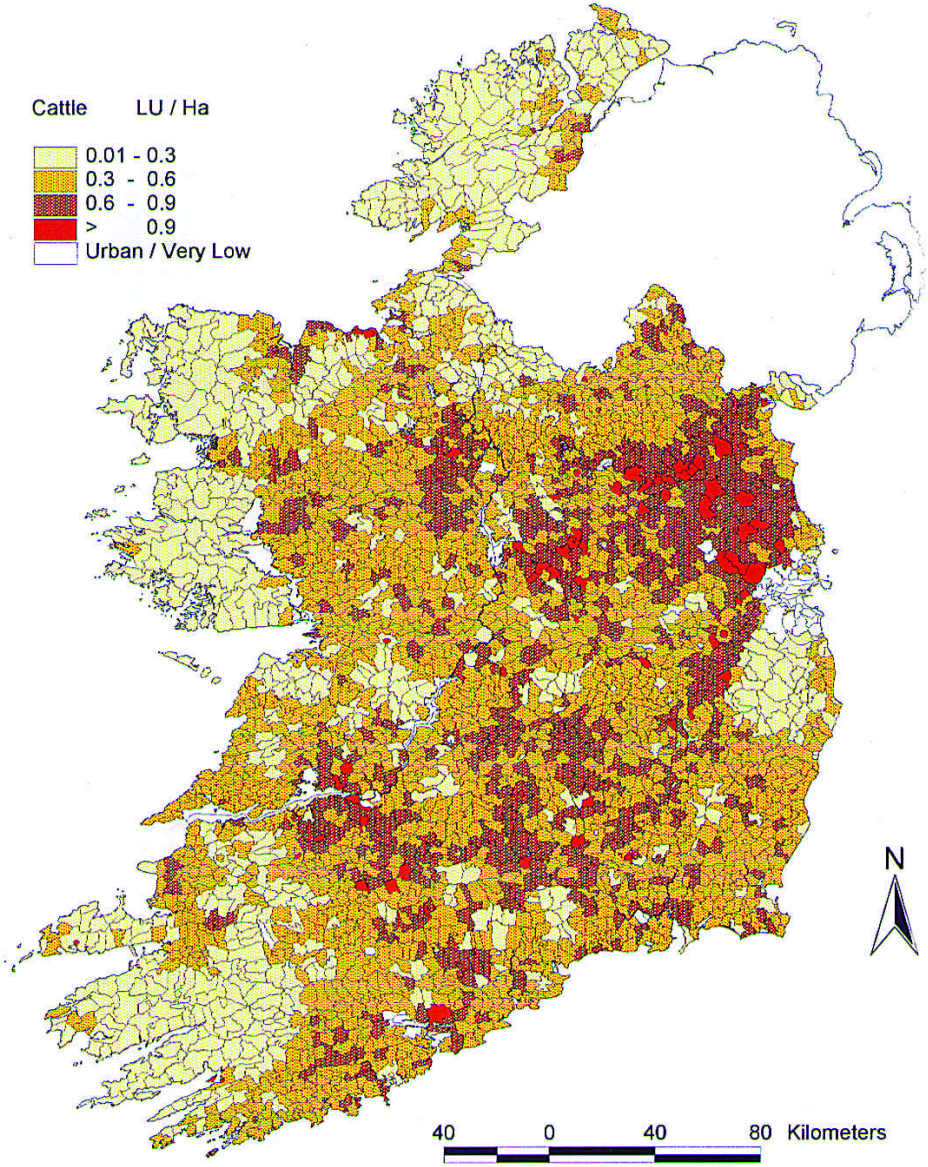

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Fig 8: DRYSTOCK : 1980 DED STOCKING DENSITY

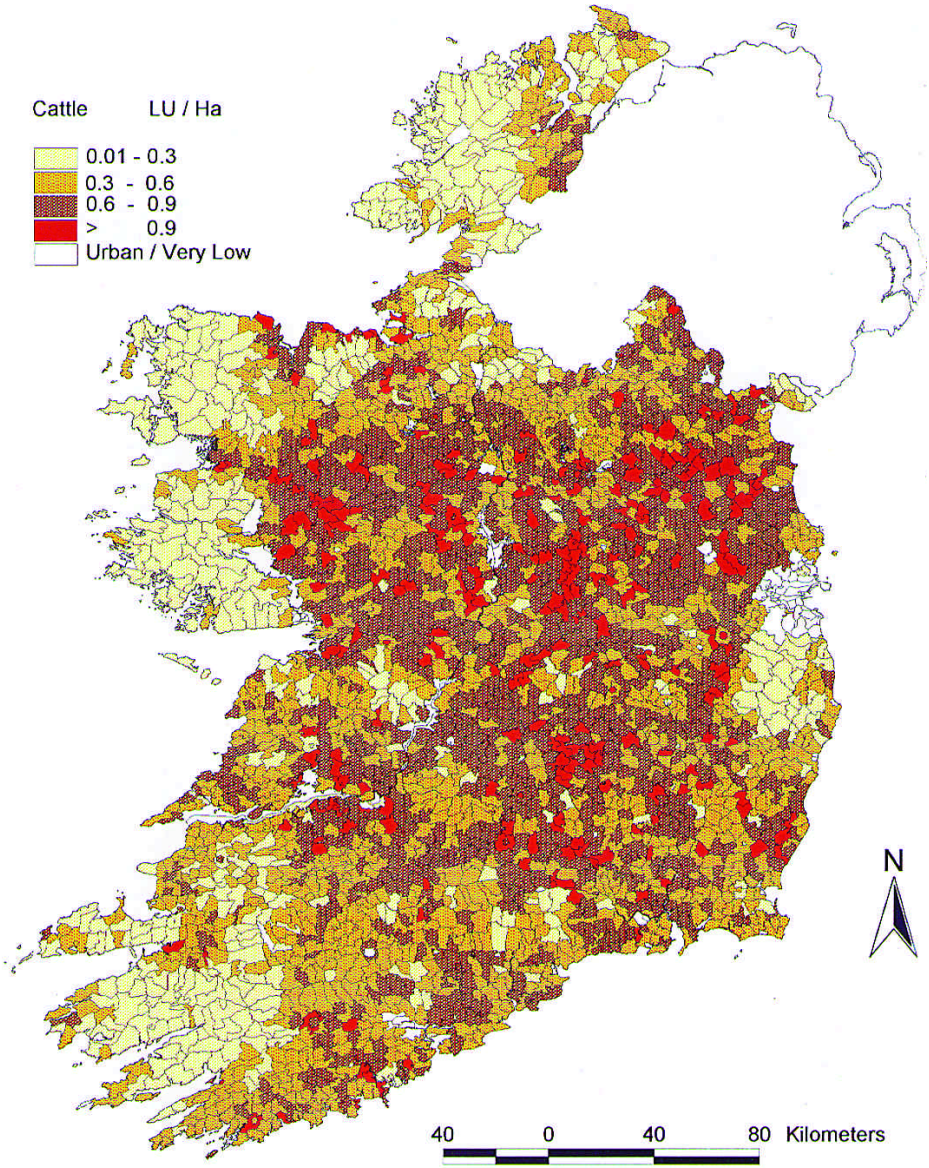

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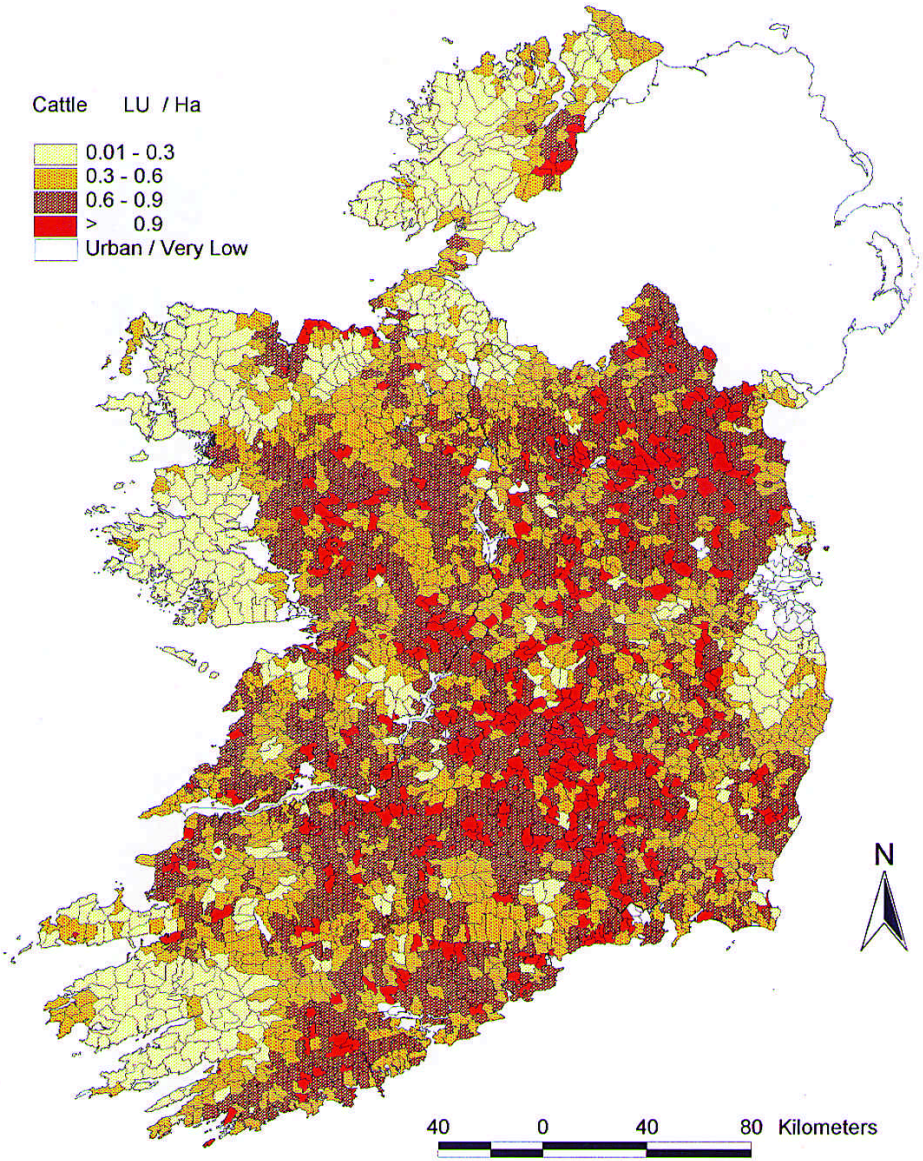
Fig 9: DRYSTOCK : 1991 DED STOCKING DENSITY



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In Connaught, where sheep numbers had increased markedly between 1970 and 1991, cattle numbers remained relatively static. An increasing concentration is also evident in the traditional Munster dairying region. This may reflect the substitution of beef on the smaller dairy farms which moved out of this enterprise or the adoption of a beef enterprise on dairy farms restricted by quota imposition. A similar pattern is evident in the Cavan/Monaghan small farm region. An increased concentration also took place in the south-central region of the country.

In the dairying areas, the practice of moving the dry cattle off the dairy farms decreased. As dairy cow numbers were restricted by milk quotas, and to some extent by higher yielding cows, increased stocking rates were achieved on the farms by leaving and finishing some of the male offspring of the dairy herds. Thus, by 1991, high concentrations occurred in both north and south midlands, in the good farming areas of the west and in parts of north Munster.

Tillage Land

The tillage land percentage (TLP) in each DED for the agricultural census years 1970, 1980 and 1991 was calculated by totalling the areas of different tillage crops and expressing it as a percentage of the bounded area of the DED. Figures 10-12 illustrate maps showing that tillage land is mainly concentrated south-east of a line running from Dundalk to Limerick but that even within this band, the distribution is very uneven. The maps also show that the amount of tillage has greatly reduced over the two decades between 1970 and 1991.

Gillmor and Walsh (1993) remarked that the area under tillage had declined in every county except Louth for the years 1980-1991. Leinster's share of the total tillage increased from 60% to 65% even though there was an overall decrease of 24% in Leinster. The contraction in tillage activity in geographic areas of comparative disadvantage is very striking.

Neill (1989) discusses the parameter, land area ploughed (LAP), as a useful environmental indicator of nitrate runoff from agricultural land. This is different from the TLP described in the last paragraph as the tillage land is expressed as a percentage of the total utilised agricultural area rather than the area of the DED as a whole. Neill found

Fig 10: TILLAGE CONCENTRATIONS : 1970 AGRICULTURAL CENSUS

(Percentage of DED area occupied by Tillage)

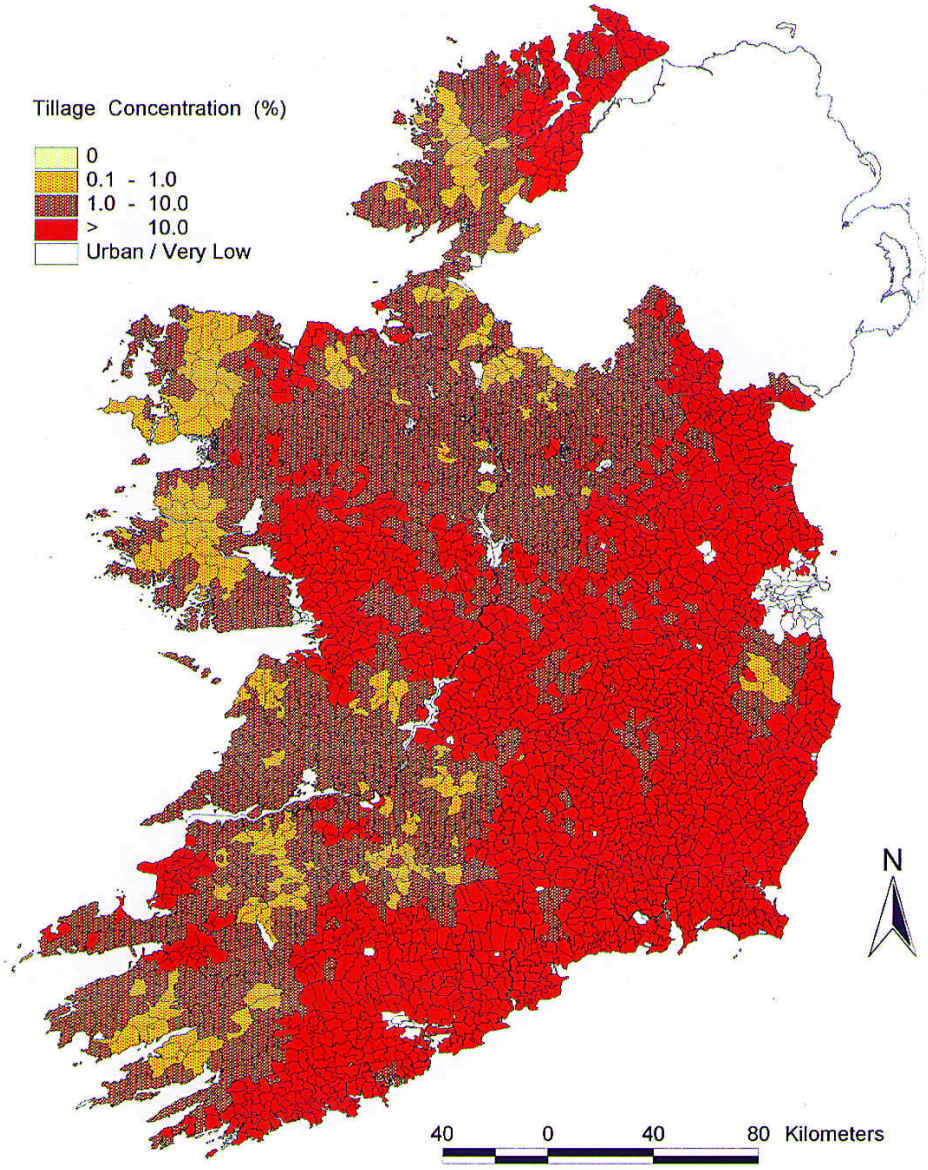

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Fig 11: TILLAGE CONCENTRATION : 1980 AGRICULTURAL CENSUS

(Percentage of DED area occupied by Tillage)

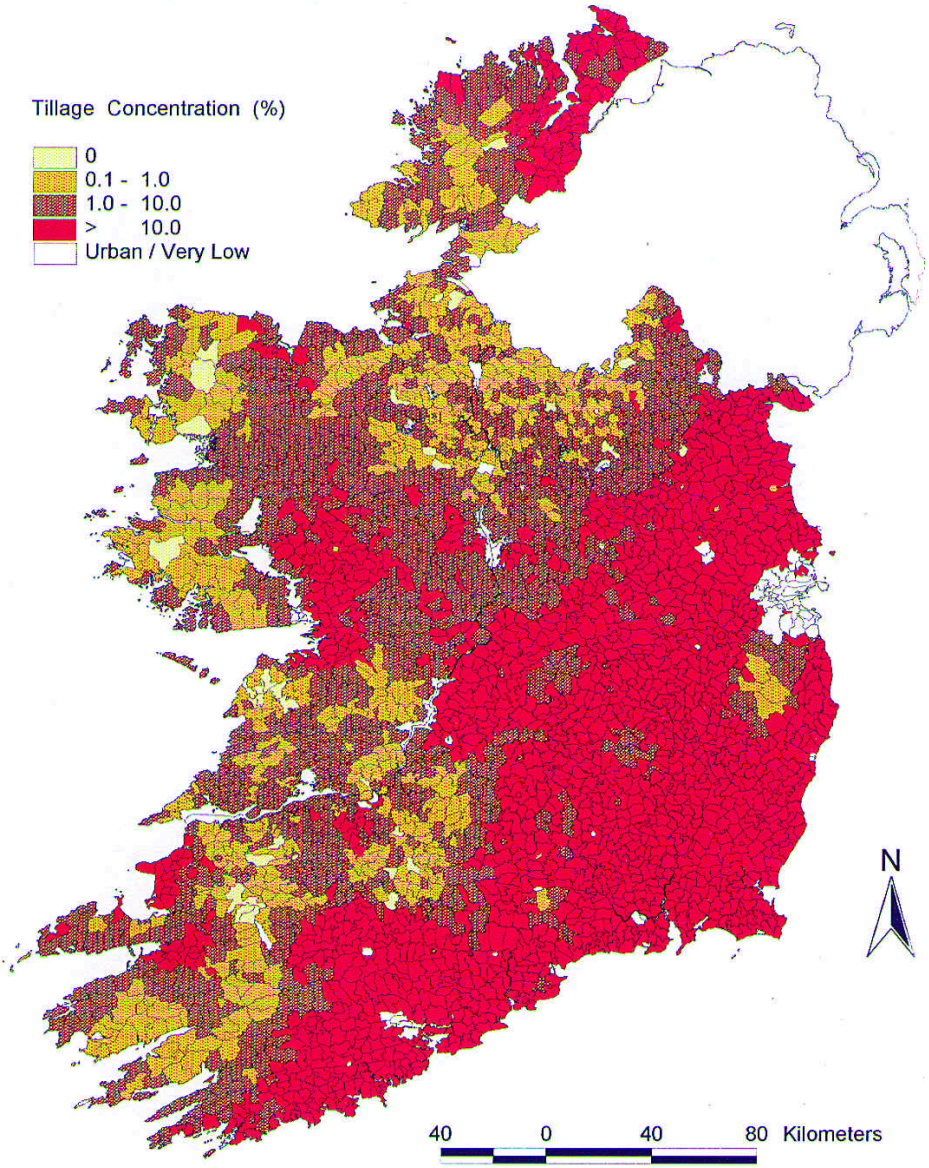

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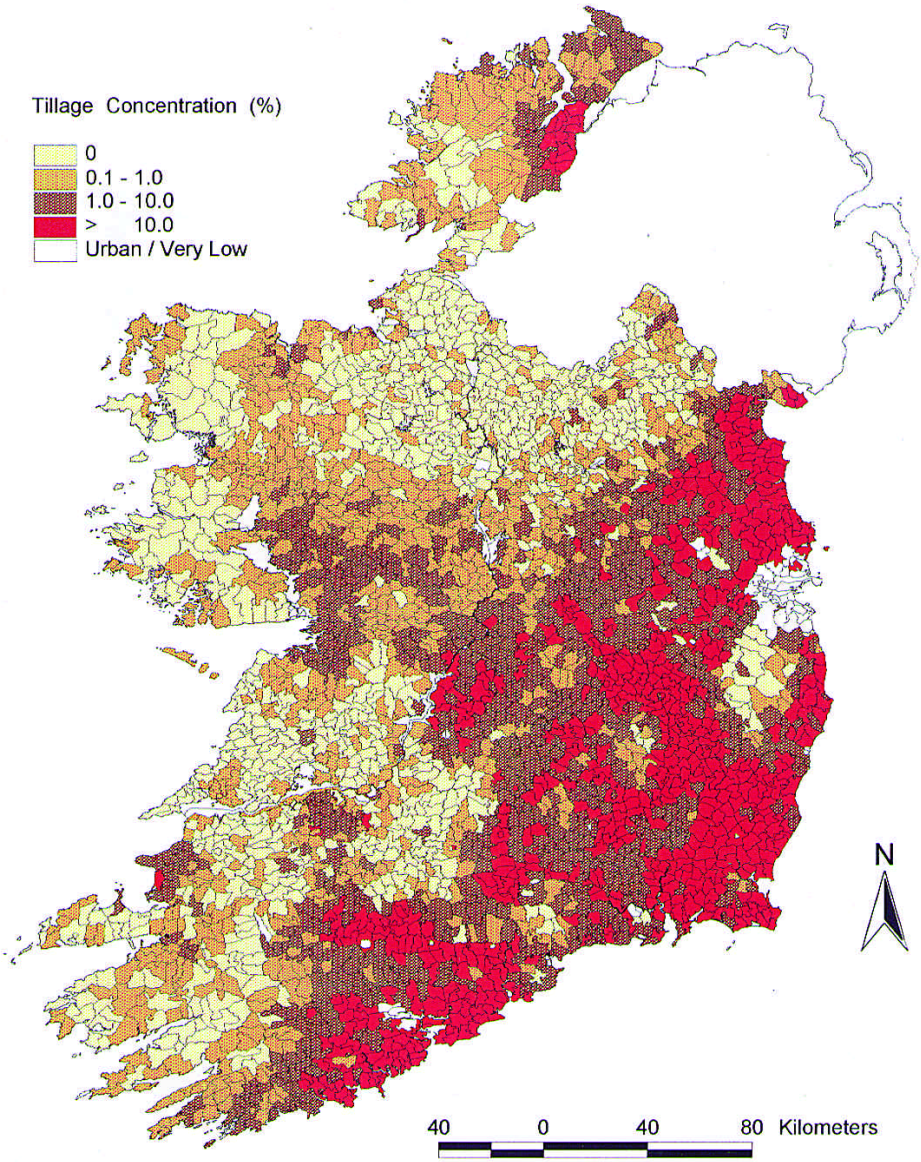
Fig 12: TILLAGE CONCENTRATION : 1991 AGRICULTURAL CENSUS

(Percentage of DED area occupied by Tillage)



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that LAP correlates well with river nitrate concentration in Ireland. A tabular summary for land area ploughed is given in table 1. This shows the range of LAP, the percentage of the DEDs in this range, the total area of the DEDs within the range, and the area expressed as a percentage of the total utilised area.

Table 1 Frequency and Amounts of Land Area Ploughed Parameter

Class	Range of LAP	% of DEDs	Area Km^2	Area %
1	<3	60	44320	65
2	3-8.99	16	9852	14
3	9-17.99	12	7088	10
4	18-29.99	7	4296	6
5	≥30	5	2684	4
Total			68240	

SOIL SURVEY DIGITAL INFORMATION

Soil Classification

In order to describe and map soils, it is necessary to group them into a hierarchy of categories so that the classification may be used to different levels of detail. The soil classification system used in Ireland is a modification of the system established by the United States Department of Agriculture in 1938. The categories used to create the map boundaries for the General Soil Map of Ireland are great soil groups (Gardiner and Radford 1980b) and for the more detailed soil map of the Lough Derg catchment is given below.

Great Soil Groups

Great Groups are soils having the same kind, arrangement and degree of expression of horizons in the soil profile. They also have close similarity in soil moisture and temperature regimes and in base status. Only Great Soil Groups are shown on the General Soil Map. There are ten main Great Soil Groups occurring in Ireland. These are the Brown Earths, Podzols, Brown Podzolics, Grey Brown Podzolics and Blanket Peats (zonal soils), the Gleys and Basin Peats the Rendzinas, Regosols and Lithosols. They are briefly described below

BROWN EARTHS are relatively mature, well-drained, mineral soils possessing a rather uniform profile, that have not been extensively leached or degraded. Most Brown Earths occur on lime-deficient parent materials, and are, therefore, acid in nature; these are called Acid Brown Earths. These soils, in general, possess medium textures (sandy loam, loam, sandy clay loam) and this, together with their friability, desirable structure and drainage characteristics, accounts for the fact that they are amongst the most extensively cultivated soils. Although often of relatively low nutrient status, they respond well to manurial amendments.

BROWN PODZOLIC soils are somewhat similar to the podzols and have been formed under the influence of the same process. They are less depleted than the podzols and the surface layer contains organic matter is intimately mixed with mineral matter. Because of their desirable physical characteristics, Brown Podzolics are often devoted extensively to cultivated cropping and pasture production. Their inherent low nutrient status is easily overcome by addition of lime and fertiliser.

GLEYS are soils in which the effects of drainage impedance dominate and which have developed under the influence of permanent or intermittent waterlogging. The impedance may be due to a high watertable, to a 'perched' watertable caused by the impervious nature of the soil itself, or to seepage or runoff from slopes. Most gleys have poor physical conditions, which make them unsuitable for cultivation or for intensive grassland farming. Their productive capacity is also affected by restricted growth in spring and autumn.

GREY BROWN PODZOLIC soils are usually formed from a calcareous parent material, which counteracts the effects of leaching. Because of this, the podzolisation process is restricted and the principal materials translocated down the soil profile are the clay particles themselves. The lighter textured Grey Brown Podzolics are good all-purpose soils, while the heavier textured members are highly suited to pasture production, responding well to manurial and management practices.

LITHOSOLS are skeletal stony soils, usually overlying solid or shattered bedrock. They are often associated with podzols at higher elevations. Generally such soil areas have bare rock outcropping at fre-

quent intervals and many also have steep slopes. Their use-range is usually limited to rough grazing.

PODZOLS are generally poor soils, depleted of nutrients by heavy rainfall leaching through an organic layer (the podzolisation process). They have high lime and fertiliser requirements and are usually found in hill and mountain areas where mechanical means of reclamation and cultivation are not feasible. For these reasons they are often devoted to forestry.

RENDZINAS are shallow soils, usually not more than 50 cm deep, derived from parent material containing over 40% carbonates. The surface horizon is very dark in colour, with a strong structure and with a neutral or alkaline reaction. Their shallow depth often limits the use range of Rendzinas. They are suited mostly to extensive grazing but where sufficiently deep they can also be excellent tillage soils.

REGOSOLS are soils which show no distinct horizon (layer) development. The texture of these soils can vary between sands and clays, depending on the material from which they are derived. They may be acid or alkaline for the same reason. Regosols can have a wide use range but they are often subject to flooding hazards. For this reason, they are mostly used for grazing.

PEATS are characterised by a high content of organic matter, over 30%, and by being at least 30 cm in depth. Two basically different types, blanket and basin peat, occur in the country.

BLANKET PEAT has accumulated under conditions of high rainfall and humidity. Such conditions prevail over much of the west of the country and in the upper parts of mountain ranges due to high altitudes and associated adverse climatic conditions. Because of poor drainage, adverse physical conditions and their occurrence in areas of poor climate, the range of uses of blanket peat in agriculture is very limited.

FEN PEAT was formed under the influence of base-rich groundwater and is composed mainly of the remains of reeds, sedges and other semi-aquatic or woody plants.

BASIN PEAT was formed in lake basins, hollows and river valleys, or where the sub-soil is sufficiently impermeable to give a high watertable. Variations in the concentration' of component plant remains in fen and basin peat depend on the topographic situation and nutrient content of the water supply.

RAISED BOG peat may be built up on top of fen peat under suitable climatic conditions. The profile usually consists of a basal layer of fen or woody fen, overlain by a layer of acid peat. In their natural state, raised bog peats vary from about three to ten metres in depth and are typically acid. When drained and reclaimed, basin peats can have a wide use range in agriculture. Recent experiments indicate their potential to produce a range of cultivated crops and pasture.

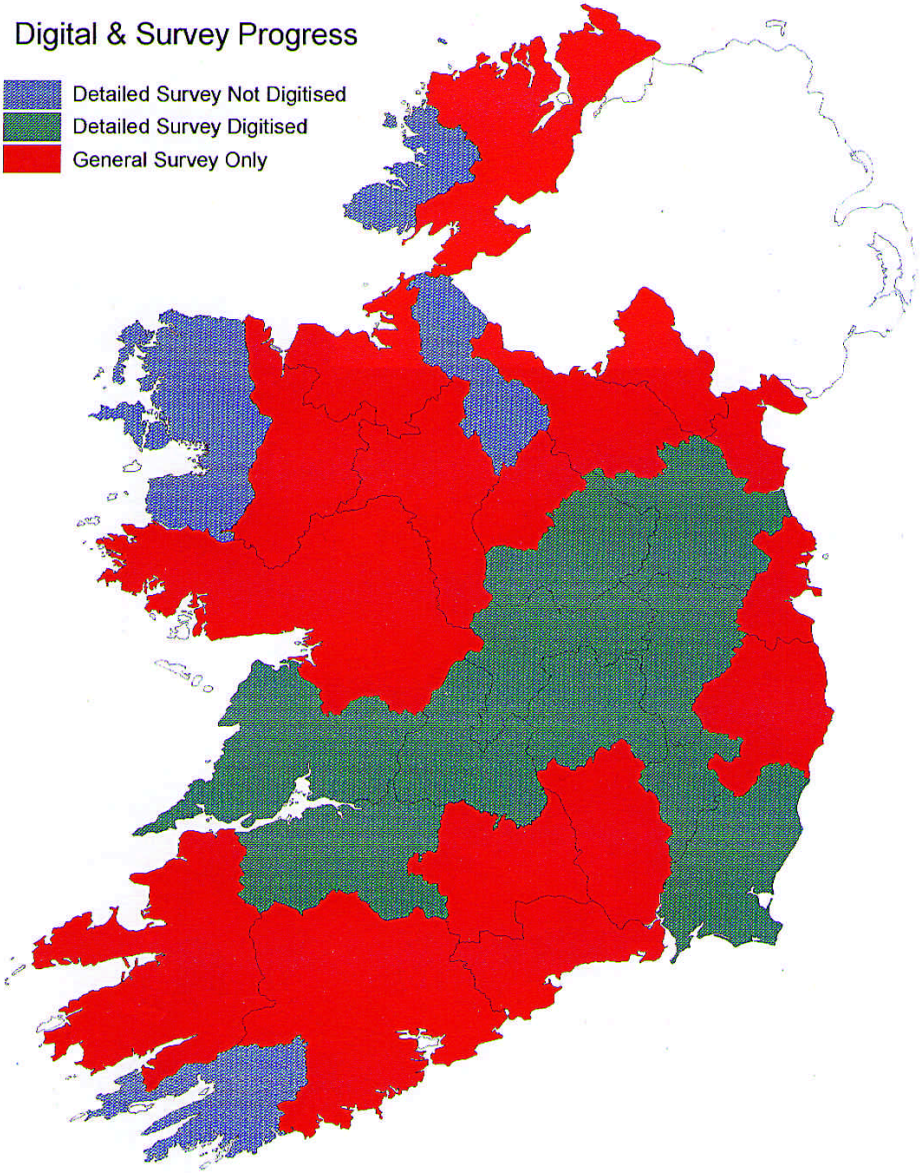
Soil Survey National Reports

The first Generalised Soil Map of Ireland was published in 1969 but the information at that time was not very reliable for many areas. Some further detailed and reconnaissance surveying was undertaken and in 1980 a second edition of the Generalised Soil Map (1:575,000) was published, together with an explanatory bulletin (Gardiner and Radford, 1980a and 1980b). This map was based on various sources of information including field survey at various scales, aerial photographic interpretation, and geological maps. A Peatland Map of the country together with an explanatory bulletin was also published at the same scale from these and other sources (Hammond, 1978).

Soil Survey County Reports

Some 44% of the country has been surveyed and mapped to date. Complete reports on nine out of twenty-six counties have been published together with reports on a number of regions and districts. Fieldwork has been completed in three other counties, and some smaller scale work has been conducted in a number of other counties. The current status of soil survey and the progress of digitisation to date is illustrated graphically in Fig 13. The land area surveyed in each of the 26 counties is given in Table 2.

Fig 13: SOIL SURVEY DIGITAL PROGRESS MAP 1998



A Soil Survey GIS programme was initiated with a view to capturing existing soil maps in digital form to facilitate the environmental brief, and so that geocoded data collected in environmental surveys and experiments could be related to soil survey data. ArcInfo and the related program ArcView were chosen as the most appropriate GIS software packages because of their widespread use within soil research institutes in the EU, and because their native dBase database system was most compatible with information technology standards in this research centre. The programme involved digitisation of existing soil survey and related maps, creating databases of soil information and linking the digital maps and databases.

It soon became clear that piecemeal digitisation of maps at different scales led to serious problems at the boundary when several adjacent maps were required for one project. The problems were even greater when edge matching digital maps obtained from originals at different scales. To obviate these difficulties, all of the Irish county boundaries were carefully digitised from film transparencies of the full series of 25 topographic maps at a scale of 1:126,720. All necessary editing and edge matching was done at this stage and the resulting map was used as a National Cartographic Template for all digital maps. Thus when digitising County Soil Maps, the county boundary was not digitised; instead, only internal features were digitised and these were carefully fitted in location, scale and orientation to the National Cartographic Template.

The General Soil Map of Ireland (1980), that was printed at a scale of 1:575,000, has also been digitised and a soil information database constructed. The outer boundary has been fitted to the boundary of the full series of 25 topographic maps at a scale of 1:126,720, so that pieces of the general map could be electronically 'cut out' and inserted into or compared to digitised versions of detailed maps.

An earlier version of the General Soil Map (1972) is also available in digital form from the European Soil Bureau (Corine) in Ispra, Italy as part of the Digital Soil Map of Europe (1988) which was designed for printing at a scale of 1:1,000,000.

Table 2 Status of Detailed Soil Survey			
County	**Area Km²**	**Completed Km²**	**Area Remaining Km²**
Dublin	922	647	275
Meath	2345	2345	-
Louth	823	-	823
Westmeath	1839	1839	-
Kildare	1671	1671	-
Carlow	896	896	-
Laois	1719	1719	-
Offaly	2001	2001	-
Kilkenny	2072	-	2072
Wicklow	2025	506	1519
Wexford	2365	2365	-
Longford	1091	-	1091
Monaghan	1294	-	1294
Cavan	1932		1932
Donegal	4862	1064	3797
Galway	6150	-	6150
Mayo	5589	2999	2590
Sligo	1837	-	1837
Leitrim	1588	1588	-
Roscommon	2548	-	2548
Cork	7505	1813	5692
Tipperary	4305	2228	2077
Waterford	1857	1857	-
Kerry	4815	-	4815
Limerick	2756	2756	-
Clare	3449	3449	-
Total	70256	31743	38512

Producing New Information from Existing Soil Survey Maps

Most of the detailed county soil maps have been digitised and information databases constructed. Digitisation of the remainder is currently in hand. The ultimate aim is to merge the data and construct a seamless coverage of the soils of the country at a printable scale of 1:126,720. This scale would be too detailed to print as one

map, but its great value would be the ability to clip out any section as a thematic map to combine with maps of other themes for environmental, land use or other purposes.

Using GIS techniques, it is also possible to combine and/or generalise features of the mapped data to construct new maps of contiguous area not limited by county boundaries. However, as Figure 13 shows, the scope for such maps is constrained by the fact that only 44% of the soils of the country have been surveyed in detail. Figure 14 shows such a combination map which was constructed for the Lower Shannon Catchment. Here the detailed maps of counties Limerick, Clare, North Tipperary, Offaly and Laois were combined and clipped using the catchment boundary of Lough Derg catchment as a 'cookie cutter'.

For the purposes of this report, the general soil map for Counties Galway and South Tipperary were also included even though the detail and reliability of the data were very much less than for the other counties. The inset map in Fig 14 shows the location of the catchment within the country and also the level of detail of the soil survey data used to compile the map.

The map is based on the boundaries of Great Soil Groups of which ten major divisions are described in Gardiner and Radford (1980b). Table 3 shows the distribution of the Great Soil Groups as a percentage occurrence in the mapped catchment. An abbreviated description of their properties of different great soil groups was given in the last section.

Table 3 Great Soil Groups in Lough Derg Cachment		
Great Soil Group	**Area ha**	**%**
Brown Earth	22559	4.6%
Brown Podzolic	26412	5.4%
Gley	98880	20.3%
Grey Brown Podzolic	138029	28.3%
Lithosol	167	-
Peat	139	-
Basin Peat	67104	13.8%
Blanket Peat High Level	5170	1.1%
Blanket Peat Low Level	19320	4.0%
Peat Complex	21943	4.5%
Fen Peat	1678	0.3%
Raised Bog Cutover Reclaimed	761	0.2%
Podzol	9548	2.0%
Regosol	10287	2.1%
Rendzina	2267	0.5%
Rock Outcrop	2	-
Soil Complex	62945	12.9%
Unmapped	115	-
Total	487326	

Thematic Maps Derived from Soil Survey Information

The soil characteristics were reclassified using the GIS system to produce thematic maps. viz a Surface Runoff Risk Map and a Groundwater Vulnerability Map.

Surface Runoff Risk

In order to illustrate the potential runoff risk of Irish soils, Gleeson (1992) has classified the soil series in the General Soil Map of Ireland (Gardiner and Radford 1980a) into 13 groups with different runoff risks. He attempted to define whether those with high runoff risk are likely to be due to impermeable soils, seepage or high water tables. The following scheme or ranking was used:

1. Persistently wet soils in high rainfall areas such as climatic peats, peaty gleys and peaty podzols; high runoff risk.

❷ Soils of very low hydraulic conductivity (< 3 mm/day) in the subsoil.

❸ Soils where seepage is prevalent on wet lower slopes.
- 3a. Soils of low hydraulic conductivity.
- 3b. Soils of moderately low hydraulic conductivity and some down-slope seepage

❹ Basin and cutover peats and adjoining alluvial flat areas.

❺ Soils on drier lower hill slopes with occasional seepage and wet hollows in wet weather.

❻ Mainly dry soils in low rainfall areas:
- 6a. Soils at the bottom of slope of undulating topography.
- 6b. Heavy soils of shaley limestone origin.
- 6c. Soils in occasional wet hollows in flat to gently undulating topography

❼ Dry soils with virtually no runoff risk:
- 7a. Permeable soils on morainic sands and gravel.
- 7b. Permeable limestone soils with shallow till cover; some with poor aquifer protection.

❽ Soils on thin till cover and poor aquifer protection; no runoff risk.

A map showing the distribution of soils with different runoff risk has been published by Gleeson (1996).

Groundwater Vulnerability

As an aid to assessment of the groundwater nitrate pollution risk at local county and national level, the vulnerability classes of Irish soils were assessed from the soil characteristics in the General Soil Map of Ireland (Gardiner and Radford 1980a) and the accompanying bulletin (Gardiner and Radford 1980b). The following scheme or ranking was used:

Soil associations where the probability of groundwater contamination conditions occurring is high. These include - areas where thin soil cover over fissured bedrock is prevalent, and areas (e.g. Burren) where soil cover is thin or non-existent.

Soil associations where the probability of groundwater contamination conditions occurring is medium. These include areas where there are infrequent occurrences of thin soil cover or very coarse textured soil cover over fissured bedrock.

Soil associations where the probability of ground-water contamination conditions occurring is low. These include areas where soil cover is generally deep or where soil cover is somewhat thin but the land is at a high altitude.

Soil associations where the probability of groundwater contamination conditions occurring is very low. These include areas of high altitude, lowland blanket peat and areas where soil cover is deep and where underlying bedrock or deep quaternary deposits has low hydraulic transmissivity.

The national distribution of soil vulnerability classes is shown in Table 4. A groundwater vulnerability map showing the soils of different classes was produced by Coulter et al (1993) under contract and was distributed by the Department of the Environment as an aid to planners faced with making planning decisions on large agricultural enterprises in sensitive areas.

Table 1 Distribution of Soil Vulnerability Classes

Class	Risk	Total Area ha	Area%
1	High	283617	4
2	Medium	1808945	26
3	Low	3027876	44
4	Very Low	1738565	25
	Total	6859003	

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