Spatial Analyst® Density Analysis: a New Approach to Visualising the Distribution of Bovine Tuberculosis using the Point Locations for Restricted Herds in Co. Kerry, 1997

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Introduction

The Tuberculosis Investigation Unit has published, from 1992 onwards, year on year thematic District Electoral Division (DED) maps showing the national distribution levels of bovine tuberculosis expressed as the number of reactor animals per 1000 animal tests (APT). These data were available since the mid eighties with the introduction of computerised data base management in the District Veterinary Offices. This value has been computed on a DED basis and whilst this is an adequate methodology to express disease levels, it does however, when visualised, over-emphasise the occurrence of disease levels in the country. With the average area of a DED being 2770 hectares one restricted herd can influence the outcome in a DED, giving a disproportionate view of disease to an area. The question posed is: "Is there a better way of thematically illustrating the distribution pattern of national levels of bovine tuberculosis"? This paper suggests from work carried out by the Tuberculosis Investigation Unit that there is such a methodology. These concepts are illustrated here in the following paper.

The quantitative distribution of tuberculosis in the State is related to the location of the individual herds. Since 1989 the Bovine Tuberculosis Eradication Scheme has resulted, in any one year, between 8,000 – 14,000 restricted herds arising from circa 100,000,000 animal tests. In the early nineties, a programme was initiated in all the District Veterinary Offices to determine restricted herd point locations and to build a national data base to allow research into temporal/spatial relationships, if any exist, for the restricted herds. Point locations of herds restricted because of bovine tuberculosis are now a major component of the geographical information collected by the Tuberculosis Investigation Unit.

Since 1995 the Department of Agriculture and Food have implemented a policy of requiring the Herd Breakdown Report Form (ER76) to be completed whenever a restricted herd had two standard reactors and disclosed a lesion. This form is accompanied by defined criteria to enable veterinary inspectors nationwide to apply a standardised investigative methodology to assign the attributed cause of an outbreak in the herd (O'Keeffe and O'Driscoll, 1997). These nationally collected data are being verified and collated by the Tuberculosis Investigation Unit and will be analysed to elucidate the major factors contributing to the persistence of bovine tuberculosis.

Computer/software technologies are now available to analyse such large data sets. It is also especially opportune in that, within the past year, the Unit's development work has put

in place an improved data base management system developed around Microsoft Access® which allows analysis of the herd testing data. Specific queries can be made of the data and the analysis associated with the distribution of the point locations carried out using the Spatial Analyst® v 1.1 programme developed by Environmental Systems Research Institute (ESRI), Redlands, California. This paper describes the application of Spatial Analyst® to refine the visualisation of bovine tuberculosis, using a data set of Co. Kerry restricted herds extracted from this national data base for the year, 1997. This visualisation can now be expanded to the national, scene if and when required.

Methodology

The National Database of herd data for 1997 disclosed 385 reactor herds in Co. Kerry. The downloaded data included the following variables: total reactors, total standard reactors, total lesions, herd test types, number of animals at test and the National Grid x and y co-ordinates. This data sub-set was queried in Microsoft Access® initially for erroneous National Grid co-ordinates. Incorrectly entered and missing National Grid values were corrected and a point location file created for the generation of an ArcInfo® mapping coverage. This enables the point locations to be displayed on screen and ultimately printed. The data were further modified to calculate the annual herd size by summing all animals presented at the herd tests (excluding test types 3 and 6) in any given year and dividing through by the number of tests. The variables of total reactors, standard reactors, visible lesions were then expressed as a rate of herd size.

Spatial Analyst® enables density and proximity analyses to be carried out on point data. The programme's software bases the analysis of the data points in relation to a formulated grid depending on the scale of mapping. Thus, the programme's Output Grid Cell Size sets the resolution that will be used to create the output. grid theme. In this study the cell size was set to 500 metres; this approximates to the average farm size in the country. Two types of density methods are possible, viz.

Simple - Density is calculated for each cell by summing the value found in Population Field for each point found in the Search Radius and dividing by the area of the circle in Area Units.

Kernel - Density is calculated the same way as with the Simple method except the value found in Population Field is distributed out from each point. The result is a smoother looking output.

The output density values will be the occurrences of the measured quantity per specified Area Unit used in this study, i.e. square kilometers.

The classification criteria used for the Co. Kerry data are those defined by O'Keeffe et al.(1999) as in Table 1.

Table 1. Classification Criteria used for herds restricted due to tuberculosis.

	No. Standard Reactors	No. Lesions
Group 1	2 or more	1 or more
Group 2	1	1 or more
Group 3	0	1
Group 4	2 or more	0
Group 5	1	0
Group 6	0	0

Results

The 385 herds restricted in County Kerry in 1997 represents 4.7 per cent of the national total. The data were queried in the Spatial Analyst® query builder for the categories defined by O'Keeffe et al.,(1998) prior to visualising the data.

Table 2. Numbers of restricted herds in the different categories.

Restricted herds with Standard Reactors with visible lesions			194
Restricted herds with no visible lesions			191
Restricted herds Total			385
Restricted herds with Standard Reactors	>=2	with >=1 lesions	115
Restricted herds with Standard Reactors	= 1	with >=1 lesions	66
Restricted herds with Standard Reactors	= 0	1 lesion	13
Restricted herds with Standard Reactors	>=2	no lesions	56
Restricted herds with Standard Reactors	= 1	no lesions	96
Restricted herds with Standard Reactors	= 0	no lesions	39
			385

APT data (1997) for Co. Kerry were visualised to allow a comparison to be made of the distribution pattern of bovine tuberculosis as determined in this form with the distribution of points and the density of bovine tuberculosis as determined by the Spatial Analyst® programme.

The data are presented in a series of text figures to illustrate the concept. Figure 1 shows the distribution of tuberculosis in the traditional APT format. Figure 2 illustrates the distribution of point locations of the restricted herds against the background of APT/DED. In Figure 3 shows the point locations of the separation of the restricted herds into two categories, viz. those herds with visible lesions (red) and those without (blue). Figure 4 illustrates the density analysis of the occurrence of herds with standard reactors and visible lesions based on the Spatial Analyst® programme, using a grid of 500x500 metres and a search radius of 2000 metres.

Discussion and Conclusions

Since 1992, year on year national thematic APT/District Electoral Division (DED) maps showing the national distribution of bovine tuberculosis (Figure 1) has been an important aspect of data management related to the epidemiology of bovine tuberculosis in the cattle population of the State. From 1995 onwards, the data presentation also visualises the area of non-agricultural land. This inclusion changed the visual impact of the data, removing the disease relationship from the mountainous areas and larger peat areas in the West and Midlands, so that what were once large areas of colour, now became more meaningful thematic maps related to farmed areas. This amended thematic format is shown in Figure 2, in association with the point location for the restricted herds in Co. Kerry identified in 1997.

Figure 2 also illustrates a problem of visualising the occurrence of bovine tuberculosis in the earlier APT format. District Electoral Divisions (DED's) in the south of County Kerry show APT values of 3.5 – 6.5 (green) and >6.5 (red). However, the number of point data in these DED's used to calculate APT are few and located at the extremities of the relevant DED's. This over emphasises the levels of bovine tuberculosis in those particular DED's. Furthermore, it could be argued that the true level of disease is in fact related to the occurrence of standard reactors and the presence of a tuberculous lesion in an animal from the restricted herd as illustrated in Figure 3. Thereby satisfying the definition for inclusion in an ER76 type investigation in the herd breakdown history. Figure 4, shows the areas where herds are concentrated with this level of restriction. Thus the mapping and visualisation of the data could form the basis of a focussed management plan. This paper presents a new way of visualising the distribution pattern of bovine tuberculosis and draws together several of the long term elements of the Tuberculosis Investigation Unit's work plan. This approach will allow statistical analysis of herd restrictions, based upon the following:

(i) The development of the Geographical Information restricted herds point location database.
(ii) The acquisition and implementation of newer software to assist in the epidemiological investigations of bovine tuberculosis.
(iii) Extraction and application of data for restricted herds from the newly developed national herd database.
(iv) Interrogation of the database and visualising the restricted herds in terms of standard reactors and visible lesions based on the ER76 Report Form.

References

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O'Keeffe J.J. and O'Driscoll H. (1997).
Analysis of Epidemiology Report Forms on Selected Herd Breakdowns of Tuberculosis submitted during 1996 – 1997. In: Tuberculosis Investigation Unit, University College Dublin, Selected Papers 1996, 1-5.

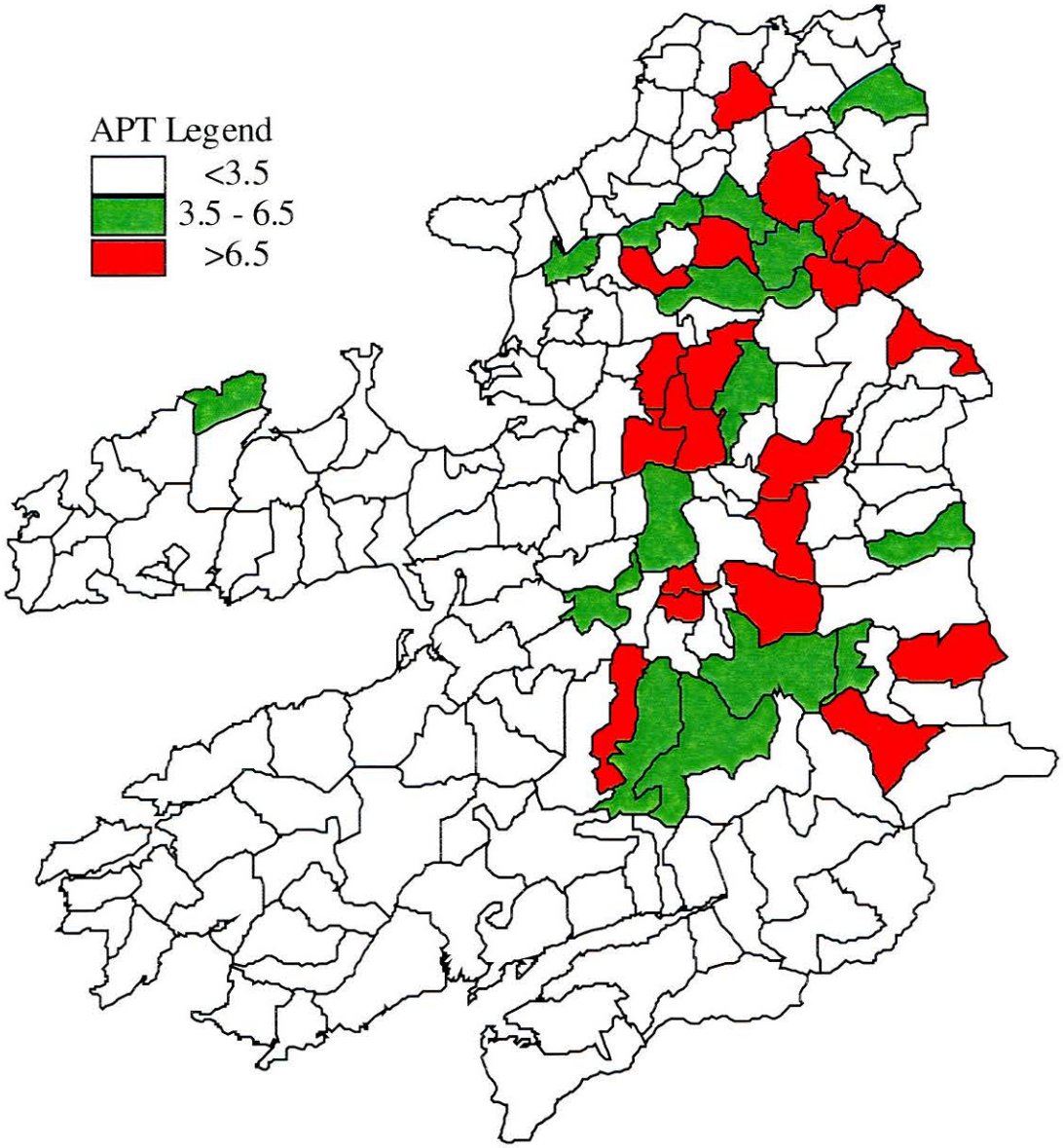

Figure 1. Thematic map showing APT for Co. Kerry, 1997.

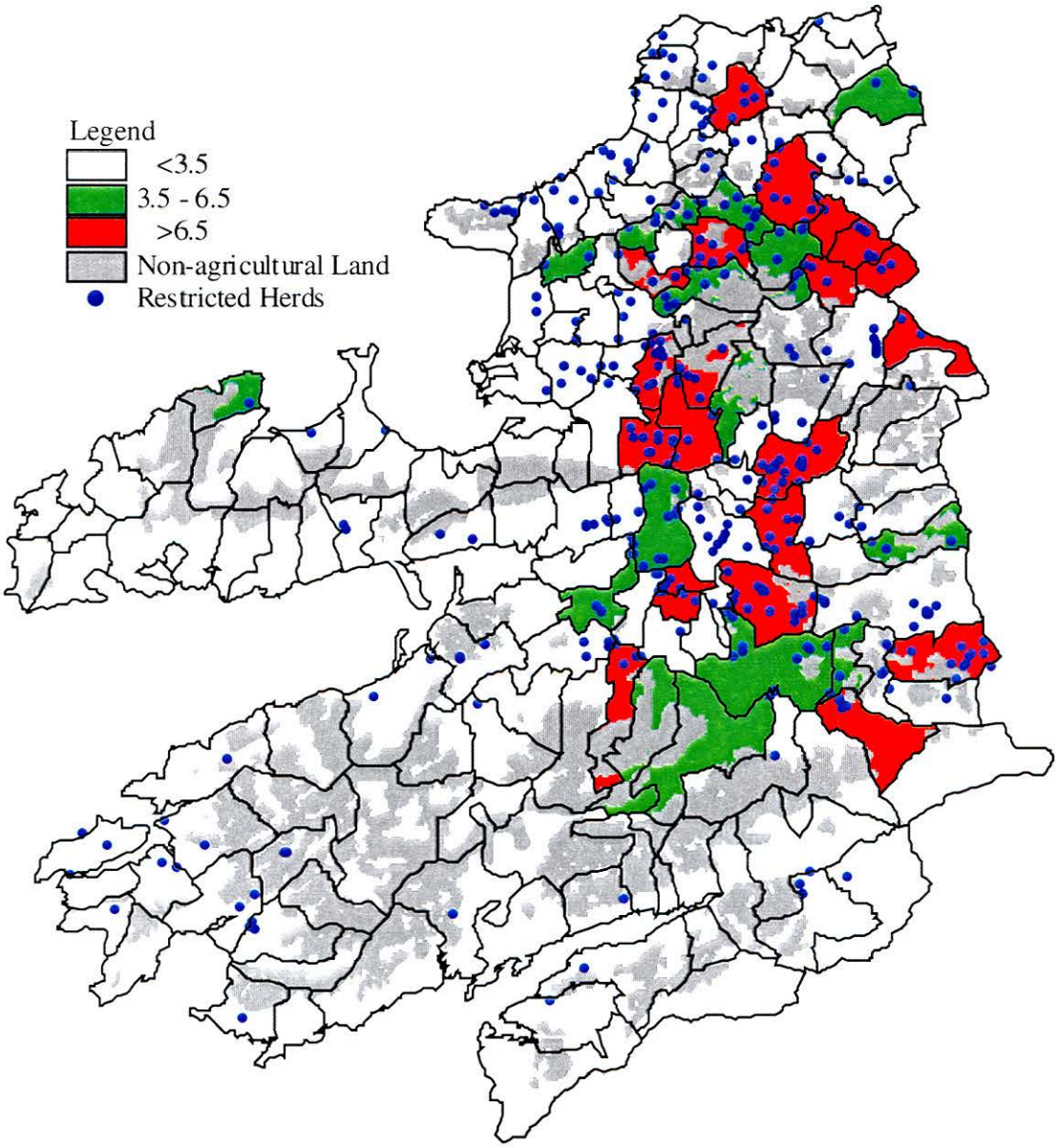

Figure 2. Point distribution of restricted herds in Co. Kerry, 1997 against a backdrop of APT by DED and non-agricultural land.

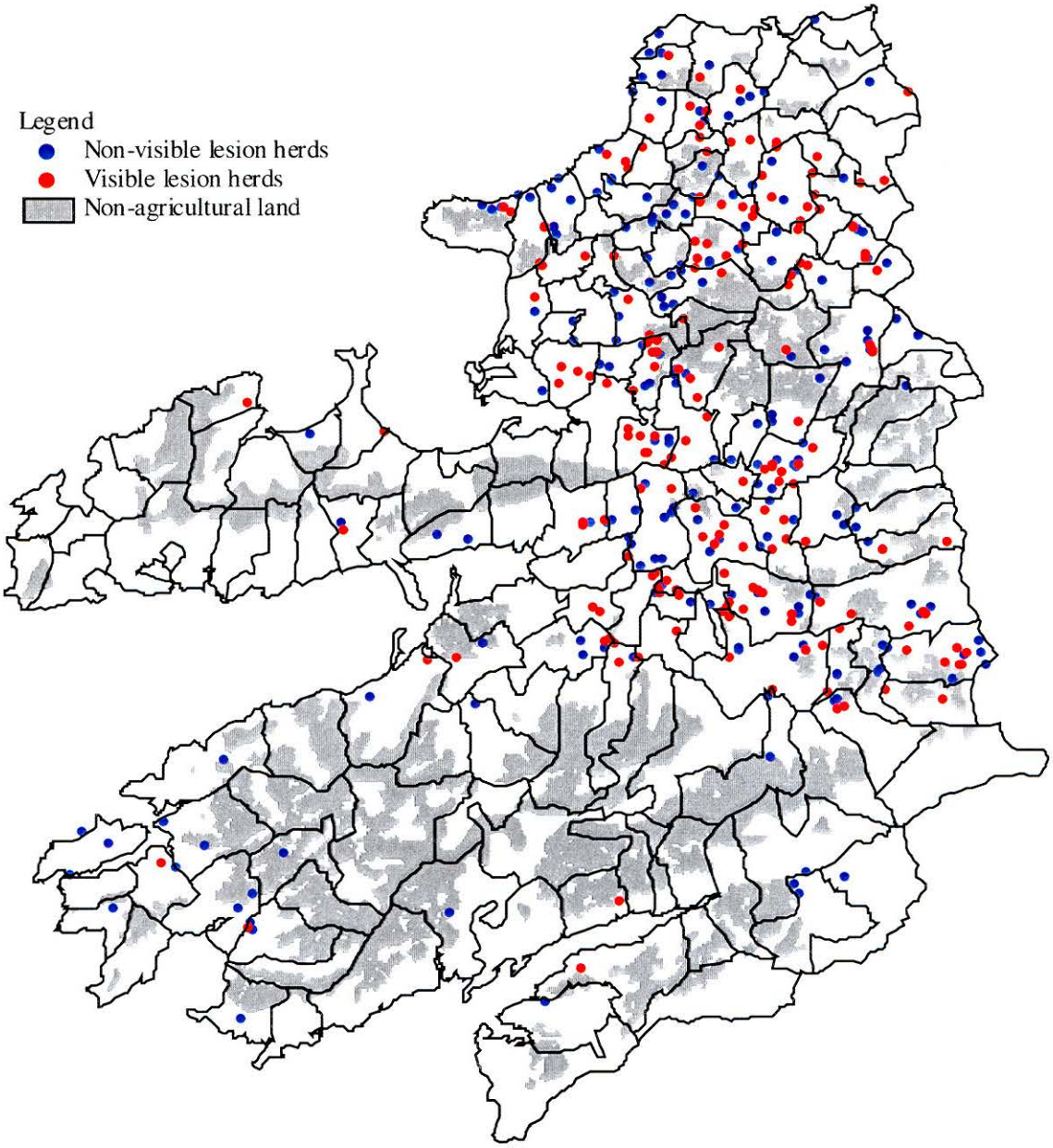

Figure 3. Distribution of non-visible and visible lesion herds, Kerry, 1997.

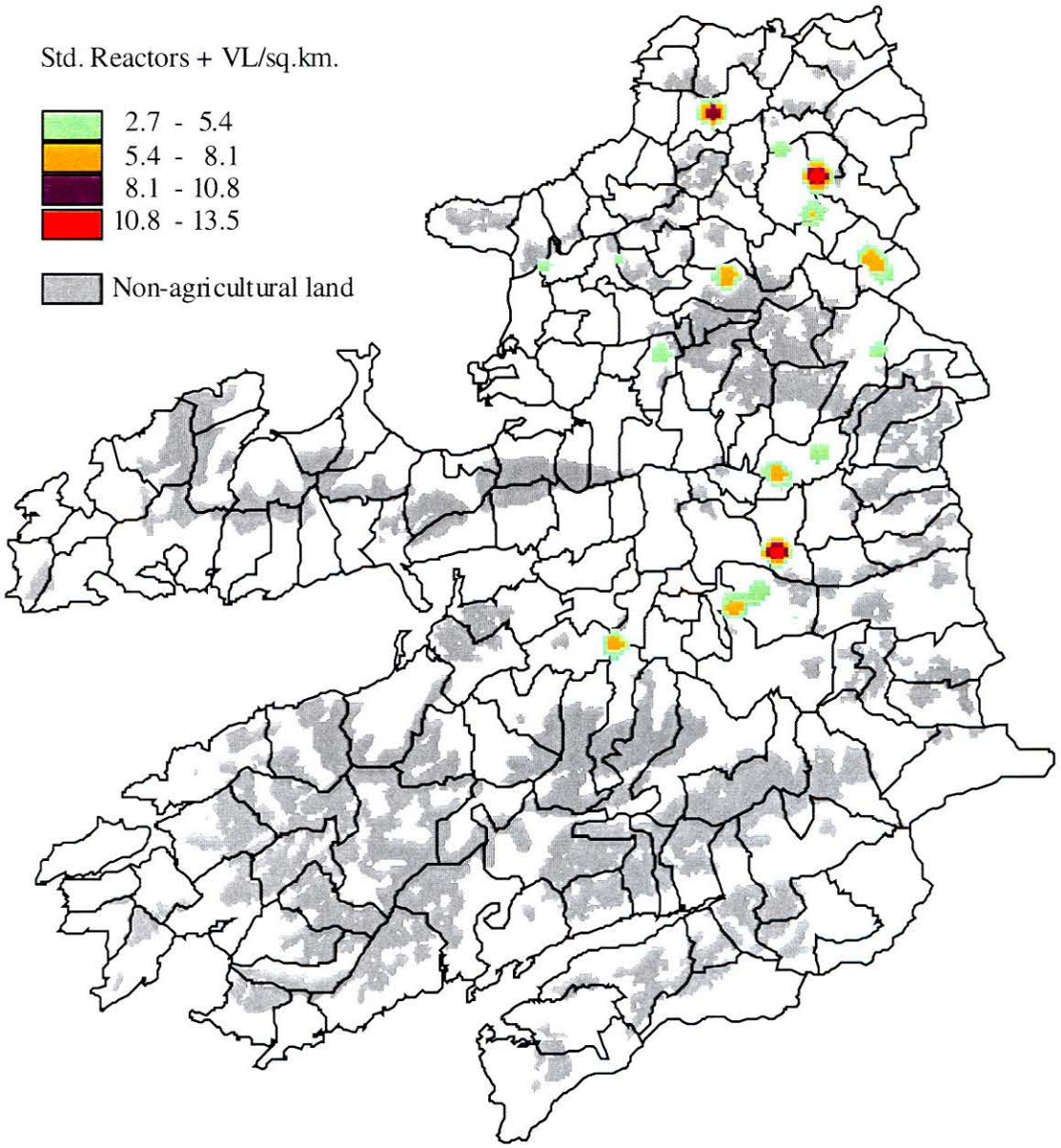

Figure 4. Density analysis of herds with standard reactors and visible lesions (VL), Kerry, 1997.