EPIDEMIOLOGY OF TUBERCULOSIS: A NATIONAL PERSPECTIVE

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Introduction and Background

Tuberculosis caused by Mycobacterium bovis probably came to New Zealand with cattle from Australia when the country was first being settled. The disease prospered in the growing cattle population. A voluntary Tb eradication scheme started for town supply dairy cattle in 1945. Compulsory testing of dairy and beef cattle began in 1961 and 1971 respectively (1). Good progress was made towards the eradication of tuberculosis in most dairying areas except the West Coast of the South Island and the Wairarapa. In these areas tuberculosis persisted in herds despite a very intensive test and slaughter programme. Tuberculous possums were first identified on the West Coast of the South Island in 1967. They were not recognised as the vector of infection for cattle until about 1970. With further experience it became obvious that once tuberculosis was established in the possum population in a defined location the disease was endemic.

Identification of tuberculosis in feral pigs and deer actually preceded the identification of Tb in possums by four and eleven years respectively.

This paper seeks to briefly quantify the increasing Tb problem in New Zealand and outline the disease control process necessary for cost-effective control measures to be implemented and monitored.

Funding

In 1990/91 approximately $16.5 million will be spent on tuberculosis control. It is proposed that the majority of funding for the tuberculosis eradication scheme will come from cattle farmers via a levy of $5.70 on an estimated 2 million cattle slaughtered. The balance of funds will be provided by government. Deer farmers contribute on an equity basis by paying for their own tests and forgoing compensation on reactors sent for slaughter. Use of monies for disease control purposes has to be approved by a farmer-dominated Animal Health Board.

The current cattle tuberculosis situation in New Zealand

The tuberculosis problem in New Zealand has gradually got worse since 1981, entirely due to the expanding tuberculous feral/wild animal problem, of which possums are the major disease vector for cattle and deer. Figure I shows that the number of herds placed under movement control restrictions has increased almost linearly at an average rate of 70 per year since 1981. Figure II shows that the number of reactor cattle slaughtered has remained relatively constant and below 5000 until the 1988/89 season, when reactor numbers rose to 5232. Almost all of this increase could be explained by more reactors being identified in those parts of endemic areas where possum control had not been carried out.

In order to manage the tuberculosis control process, New Zealand is categorised into either Special Tb Control Areas (STCA) where Tb is endemic, or Surveillance Areas where Tb is not endemic.

A STCA is a geographically defined area containing a central endemic zone, a surrounding fringe zone and an outer enclosing non-endemic zone.

The tuberculosis problem within STCAs is biologically complex. A number of descriptors are used to assess the progress of the disease on a local, regional and national basis. These include number of herds placed under movement control restrictions, number of reactors, comparison of reactor, Tb and movement control incidence rates between STCAs and Surveillance areas, and the number and sizes of endemic areas.

Over the last ten years, the number of STCAs has doubled due to the identification of new endemic areas and recognition of existing endemic areas which were previously viewed as areas with intractable Tb cattle related problems. There are now 21 STCAs in New Zealand. Of more importance however is the increase in size of STCAs that has occurred over this period. Approximately 22% of New Zealand's land area is now classified as STCA. The STCAs and their approximate sizes are shown on Map I. Changes occurring over the last ten years in the size and number of STCAs, number of movement control (MC) cattle herds and number of cattle reactors slaughtered are shown in Table I. More than 90% of reactors and movement control herds occur within STCAs.

Table I. Number of Special Tb Control Areas, percentage of New Zealand land area affected, number and percentage of movement control (MC) cattle herds and cattle reactors slaughtered for two periods since 1980.

	1980	1984/85	1988/89
No of STCAs	8	13	19
STCAs as a percentage of NZ area	10	12	22
No of MC herds in STCAs	<550	762	1072
MC herds in STCAs as a % of total	?	91	93
No of reactors from STCAs	?	4194	4864
Reactors from STCAs as a % of total	?	90	93

A summary of reactor cattle incidence rates for STCA and Surveillance Areas of New Zealand is shown in Table II. Risk analysis indicated that cattle in STCAs were, on average, between five to thirteen times more likely to be slaughtered as Tb reactors than cattle in non-endemic areas. Attributable risk analysis suggested that between 270 and 400 Tb reactors per 100,000 cattle at risk would be expected from STCAs due to factors that were unique to those areas. The major factor present within most STCAs was the presence of tuberculous possums.

MAP I.
AREAS OF NEW ZEALAND WITH ENDEMIC TUBERCULOSIS - APRIL 1990

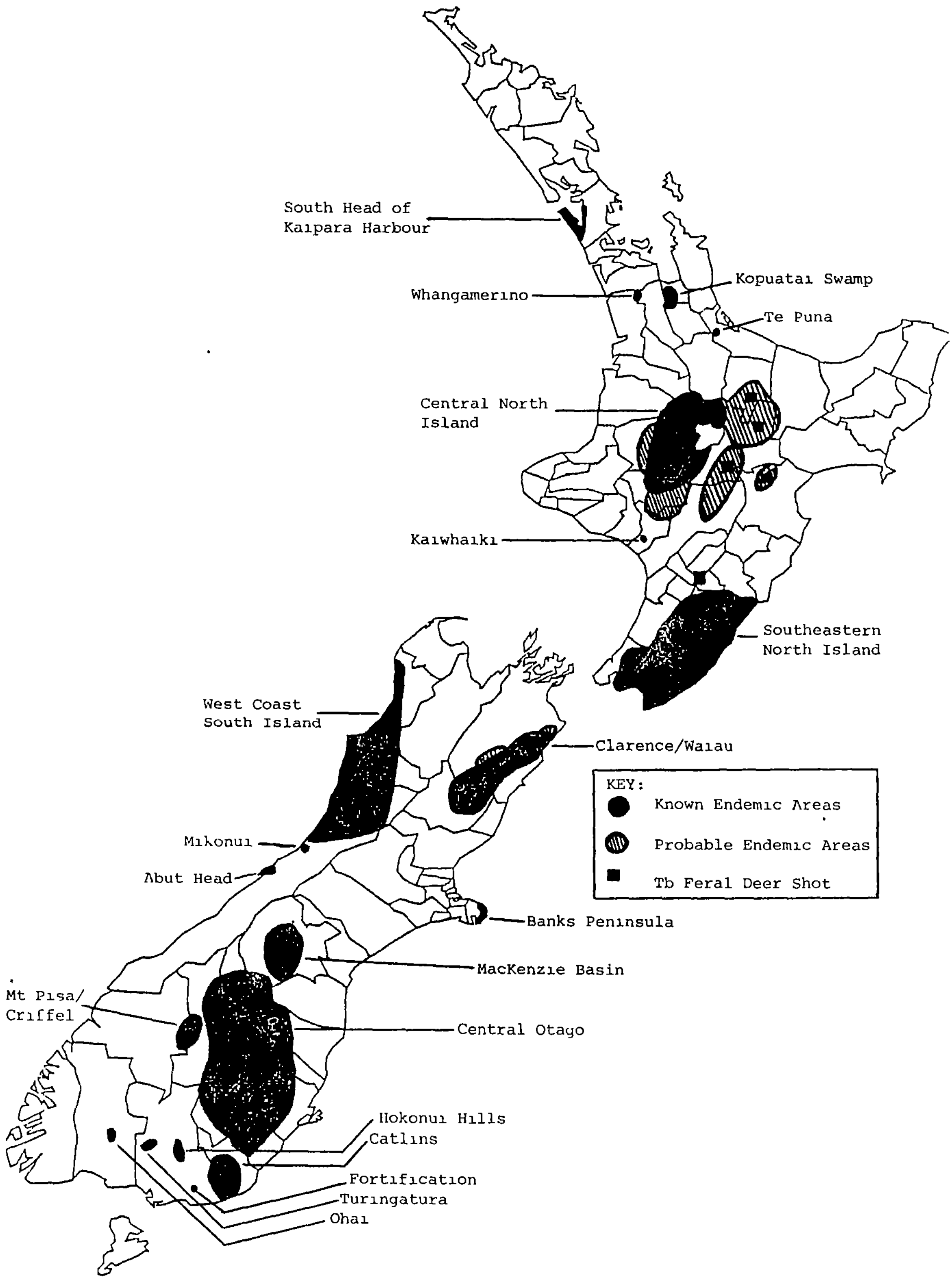


Table II. Cattle reactor incidence rates (%) for STCA and Surveillance Areas of New Zealand for the testing seasons 1984/85 to 1988/89.

	Reactor Incidence % *				
Areas	1984/85	1985/86	1986/87	1987/88	1988/89
STCAs	0.478	0.432	0.386	0.418	0.424
Surveillance	0.051	0.048	0.044	0.074	0.031
New Zealand	0.256	0.232	0.208	0.239	0.222

$$\text{* Reactor Incidence \%} = \frac{\text{No. of tuberculin reactors slaughtered}}{\text{No. of cattle under test}}$$

Table III shows the increase in number of movement control herds and reactors over time for existing and new STCAs. As tuberculosis becomes established in the feral/wild animal population of an area over a period of time, the disease problem in cattle worsens. This is due to the increasing prevalence of Tb in the possum population, the increasing size of the endemic area and priority for possum control in the various STCAs.

Table III. Difference in the number of movement control (MC) herds and reactors from the eight STCAs recognised in 1980 and eleven new STCAs.

	1984/85	1988/89	Difference
Herds on MC			
8 original STCAs	723	965	242
11 new STCAs	39	107	68
Reactors slaughtered			
8 original STCAs	4116	4563	447
11 new STCAs	78	301	223

Identifying the source of the tuberculous infection

In both Surveillance and Special Tb Control Areas, the identification of a tuberculous herd (cattle or deer) sets in motion an epidemiological process that ends with the formulation of a hypothesis as to the cause. The epidemiological process begins by investigating the herd's Tb history, contacts and management. This information is then integrated with knowledge of the surrounding area testing history, epidemiological and geographical information, together with an awareness on the presence of feral/wild animals and their ecology. If area Tb status information is inadequate, then all cattle and deer must be tested to define the extent of the problem. The direction and intensity of the investigation is dependent upon location, herd and area history.

If tuberculous possums are considered as the possible source of infection for cattle or farmed deer in a non-endemic area, then a cross-sectional possum survey may be undertaken if this is considered cost-effective. The finding of a tuberculous possum indicates that Tb is endemic in the locality. However, consideration of relevant epidemiological factors are likely to provide a more reliable and faster decision as to the probable involvement of feral/wild animals as vectors of Tb to domestic livestock. Factors that need to be assessed in order of priority are:

a) Location of an established endemic area within 10 km of the infected herd.

b) The identification of an infected herd within a 5 km radius of another herd that has also had Tb diagnosed within the last two years.

c) The infection identified has no obvious links to the movement of cattle or deer onto or off the property.

d) In the absence of possum control, Tb infection in the herd or herds in the general area persists despite a test and slaughter programme.

e) Initially only low levels of disease are detected in cattle and deer herds under annual test.

An area which on investigation satisfies either of the first two, plus the third factor, generally suffices to class an area as endemic.

Special Tb Control Areas, sources and extensions

In the last four years, the number of new STCAs and their likely source is shown in Table IV.

Table IV. Newly recognised Special Tb Control Areas and probable sources of infection.

1986/87	1987/88	1988/89	1989/90
Fortification (Tb farmed deer)	Kawhaiki (Tb cattle?) Te Puna (Tb farmed deer) Ohai (safari park deer/pigs?)	Taringatura (unknown) Mt.Pisa (released feral pigs?) Mikonui (extension of West Coast area)	Whangamarino (unknown) Maungaharuru (extension of CNI area)

As well as identification of new areas, there are radial increases in size to existing endemic areas. These occur either as small extensions of up to 5 km/year and appear to be associated with the migration of tuberculous juvenile males (2), or as larger extensions probably associated with other more mobile animals such as tuberculous feral pigs and deer.

Control strategies

The hypothesis formulated earlier as to the cause of the herd infection determines the size and likely extent of the problem. This allows a control objective to be set. Plans designed to meet the objective can then be developed, costed, instituted and monitored. Monitoring the ensuing disease situation is critical. It provides feedback as to where and what modifications are required if the objective is to be met. It also generates information which can be used to reassess the correctness of the original hypothesis.

a) Surveillance Areas

In surveillance areas, where tuberculous feral/wild animals are not suspected as the source, the application of a 120 day, test and slaughter routine will normally eradicate the infection from herds within 3 - 5 tests. If there is any concern that tuberculous cattle or deer may have spread infection to the local possum population, an immediate, localised possum control operation should be undertaken (BLIP control). This will lower the population of possums at risk, or if already infected, reduce the probability of the infection becoming established. Surrounding herds are placed under an annual testing regime as a means of monitoring the possum disease status, until the cattle or deer Tb problem has been resolved (reached accredited Tb free status).

b) Special Tb Control Areas

In Special Tb Control Areas a cost-effective disease control management plan is developed. The plan defines the area, possum control methods to be employed, testing policy needed and epidemiological data to be collected in order to monitor the disease control process.

Defining the Special Tb Control Area

This requires the area to be split into an endemic zone, a fringe zone and a non-endemic zone, to enable the possum problem to be effectively managed. The plan focuses on a central endemic area and surrounding, variable width, fringe zone. As it is impossible to identify where the Tb possum front is at any point in time, the fringe zone is critical to any eradication or containment strategy. It must be wide enough, after taking account of possum ecology and habitat, to prevent tuberculous possums migrating across it. The outer non-endemic zone provides an additional monitor to Tb possum movement should the fringe zone be breached. These zones are shown schematically in Figure III.

Possum Control Methods

Possum control methods include aerial láying of cinnamon masked 1080 pollard pellets or 1080 carrots, together with ground control using 1080 apple based paste. Traps and other poisons may be used in certain locations on farms such as around haybarns and homesteads.

A sample of possum control operations are monitored to assess the percentage of the population killed.

Possum Control Strategies

Within Special Tb Control Areas a number of possum control strategies are used based on benefit/cost analyses and Animal Health Board policy decisions. Most control strategies require 70% of the possum population to be killed initially and numbers then maintained at these low levels by annual maintenance operations. The major possum control strategies are as follows:

1) Eradication of tuberculosis from the possum population in either the whole, or a geographically defined part, of an endemic area.

In 1987, a computer simulation model of tuberculosis in the possum population was developed. The findings of the model suggest that tuberculosis can be eradicated from possum populations if they are maintained at less than half their carrying capacity for up to ten years and tuberculous possums do not migrate into the area.

There are ten Special Tb Control Areas, where eradication is being attempted based on the model findings. These areas are either newly identified or geographically contained so that the probability of tuberculous possums migrating into the control areas is minimised.

In the 1989/90 financial year approximately $580,000 (17.3%) of the possum control budget was spent on eradication. This is budgeted to increase to approximately $677,000 (13%) in 1990/91.

2) Containment of spread and control within endemic areas.

There are approximately eleven endemic areas within New Zealand where it is currently not feasible, both technically and financially, to eradicate tuberculosis from the feral/wild animal population. In these areas the strategy is to restrict spread and reduce reactor numbers where benefit/cost analysis shows this to be cost-effective.

a) Restricting Spread

This is attempted by using natural geographic barriers (mountain ranges and major rivers) where possible, and by the use of low population density 3 - 5 km wide possum buffers around the balance of the area. In addition important habitat areas outside the buffer are targeted to improve its effectiveness. This includes reducing possum populations for 10 to 15 km along all catchments that drain the endemic area.

Possum numbers will also be reduced in any major habitat outside, but close to, the buffer. Where possible some of the buffer zones have been widened on the endemic side, to reduce the density of Tb possums and therefore the risk of them spreading.

In the 1989/90 financial year approximately $1,285,000 (40%) of the possum control budget was spent on buffer related possum control. This is budgeted to increase to approximately $1,317,000 (25%) in 1990/91.

However, some endemic areas that adjoin large tracts of Department of Conservation estate or exotic forests are impossible to buffer. Checks on feral deer going through Game Depots and information from private possum hunters are used to monitor movement of the Tb front. The central North Island endemic area is a good example. Its eastern boundary merges with the Kaimanawa and Kaingaroa Forests. As can be seen from Map I, tuberculous feral deer have been taken from a number of sites within these forests. The tuberculous status of the possum population in these areas is unknown. However recent cattle testing information suggests that feral/wild animal infection may be responsible for the Tb breakdowns being identified in Reporoa, Galatea, northern Hawke's Bay and northeastern Taihape. All these areas are contiguous with these forests.

b) Reducing reactor numbers

Possum control is also undertaken to reduce reactor numbers within endemic areas if a benefit/cost analysis shows this to be economic. Control is normally undertaken on a localised geographic area basis.

In the 1989/90 financial year approximately $852,000 (26%) of the possum control budget was spent on control to reduce reactor numbers. This is budgeted to increase to approximately $1,668,000 (31%) in 1990/91.

3) Monitoring the Tb status in these areas

Cattle and deer testing is the only means available on a large scale for monitoring the dynamics of tuberculosis in the possum population. It is not a very sensitive method because of the lag in time between a tuberculous possum infecting cattle and cattle being identified as tuberculous. The sensitivity can be improved by increasing the frequency of testing.

Where eradication or containment strategies are being instituted, testing of cattle and deer provides a vital monitor of either residual or migrating Tb possums respectively. This allows for the cost-effective targeting of possum control.

The Future

If New Zealand is to eradicate tuberculosis, long term research is needed that will identify cost-effective methods of either eradicating possums or the disease. A variety of research proposals designed to meet these criteria are currently being assessed for funding.

In the meantime, the epidemiology of tuberculosis in the domestic and feral/wild animal populations needs to be elucidated. There is also a need, in the short term, to improve existing possum control methods. Research proposals that will impact on these areas are currently being assessed for funding purposes.

References

1. Animal Health Division, Ministry of Agriculture and Fisheries. 1986. History of the Tb Control Scheme. Surveillance 13 (3): 4 - 7.

2. Cowan P E, Rhodes D S. Central King Country Research Project; Final report of DSIR to Ministry of Agriculture and Fisheries, October 1988, (unpublished) pp 40 - 42.

FIGURE I.

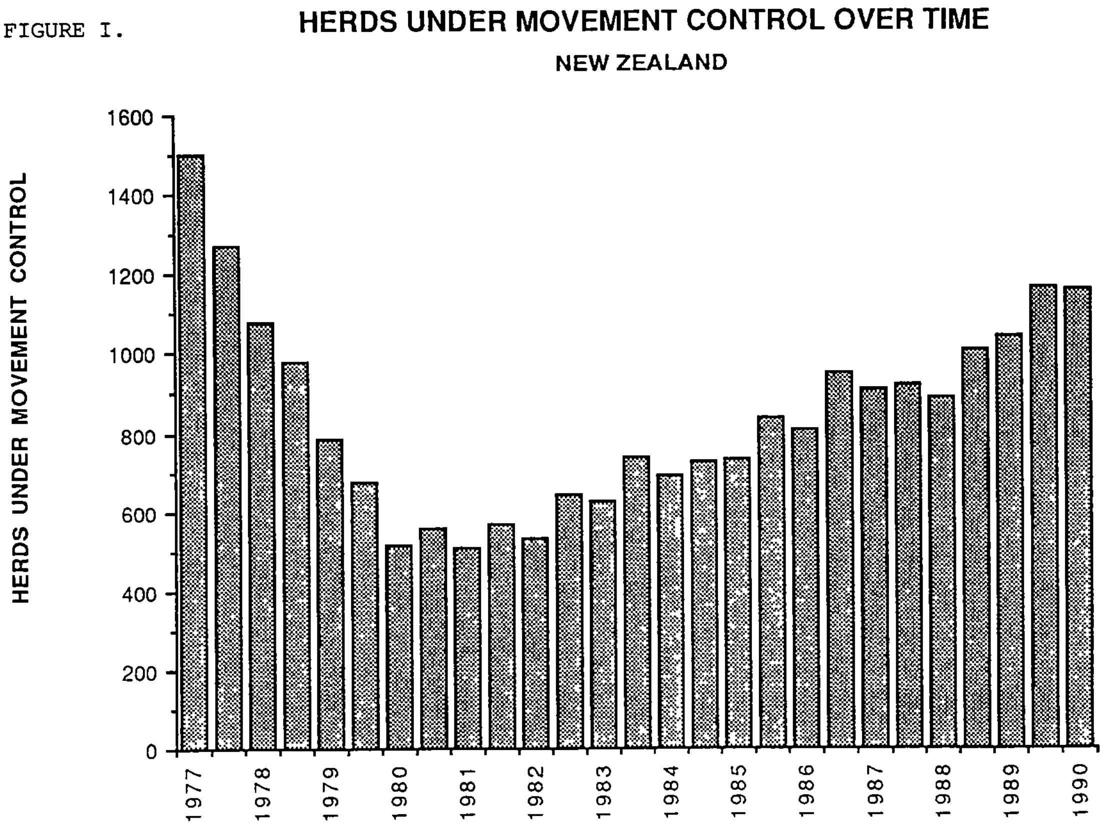


FIGURE II. Number of Cattle Reactors from Special TB Control and Surveillance Areas on a Testing Season Basis

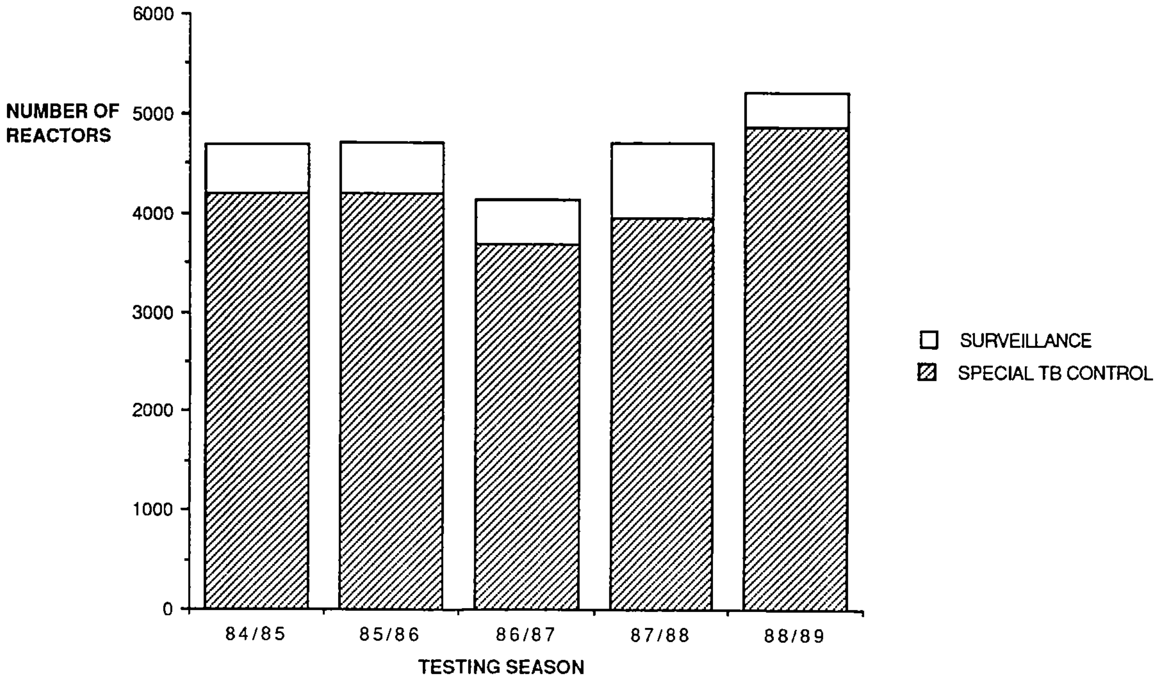
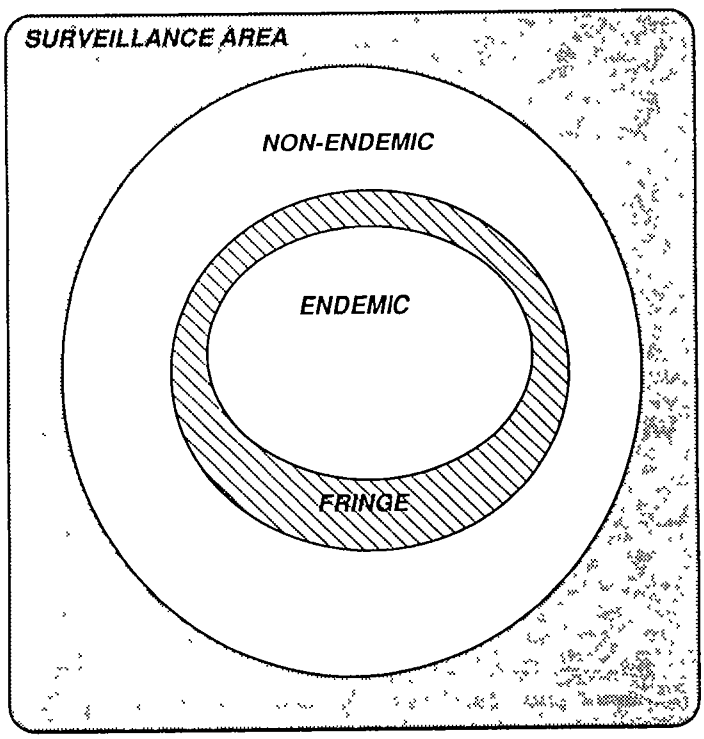


FIGURE III Special Tb Control Areas definitions



SPECIAL TB CONTROL AREA = Endemic + Fringe + Non-endemic