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A Review of Economic Evaluations of Government Policies for the Control of Cattle Tick

by

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The Commissioned Organization is the Queensland Department of Primary Industries. Collaborating institutions in Australia are CSIRO-ANHL, Geelong, Victoria and the University of Queensland (Department of Economics; Department of Geographical Sciences and Planning). In Thailand, the collaborating institutions are the Department of Livestock Development (National Institute of Animal Health; Disease Control Division), Chiang Mai University (Department of Agricultural Economics; Department of Animal Husbandry) and Thammasat University (Faculty of Economics). The collaborating institution in Laos is the Department of Livestock and Veterinary Services. Dr F.C. Baldock, Senior Principal Epidemiologist, Queensland Department of Primary Industries is the Project Leader in Australia and Dr P. Chamnanpood, Senior Epidemiologist, Thai Department of Livestock Development is the Project Leader in Thailand. Professor Clem Tisdell and Dr Steve Harrison, Department of Economics, University of Queensland are responsible mainly for the economic component of this project.

'The overall goal of this project is to develop and evaluate the .necessary tools to provide decision-makers with reliable animal health information which is placed in context and analysed appropriately in both Thailand and Australia. This goal will be achieved by improving laboratory diagnostic procedures; undertaking research to obtain cost-effective population referenced data; integrating data sets using modern information management technology, namely a Geographical Information System (GIS); and providing a framework for the economic evaluation of the impact of animal diseases and their control.

A number of important diseases will be targeted in the project to test the systems being developed. In Thailand, the focus will be on smallholder livestock systems. In Australia, research will be directed at the northern beef industry as animal health information for this sector of livestock production is presently scarce.'

For more information on *Research Papers and Reports Animal Health Economics* write to Professor Clem Tisdell (c.tisdell@economics.uq.edu.au) or Dr Steve Harrison,(s.harrison@uq.edu.au) Department of Economics, University of Queensland, Brisbane, Australia, 4072.

A Review of Economic Evaluations of Government Policies for the Control of Cattle Tick

ABSTRACT

The common cattle tick has been a problem to Australian cattle producers since its arrival from Java since 1872. Over the past thirty years, a considerable research agenda on optimum cattle tick management strategies for individual producers has been conducted. However only a limited focus has been placed on evaluating the effectiveness of Government policies towards the cattle tick. This is despite successive expensive eradication and control policies in New South Wales and a major regulatory framework in Queensland.

This paper reviews the major economic evaluations of Australian Government policy towards the cattle tick, focusing on the use of the Cost Benefit Analysis (CBA) technique. The paper also examines the evaluation of Government policy towards the tick overseas, especially the CBA of the United States sponsored tick eradication campaign in Puerto Rico.

The paper concludes that aside from the CBA conducted in New South Wales for the Cattle Tick Review Committee (1980), the evaluation of public policy towards tick control has not provided decision-makers with thorough investigations of the economic effects of alternative tick control/eradication options. The lack of a comprehensive CBA into alternative tick control policy options is especially a concern in Queensland, where the same policy has remained basically unaltered, since the early 1900s.

Keywords: Cattle Tick, Australia, livestock disease control,

JEL Classifications: Q16, I15

A Review of Economic Evaluations of Government Policies for the Control of Cattle Tick

1. Introduction

This paper examines economic evaluations of Government policy towards the cattle tick *Boophilus microplus* in Australia. The term 'economic evaluations' when used in the literature on cattle-ticks is synonymous with research on the private benefits accruing to producers from changes in cattle management techniques.[1] In particular, the emphasis has been on the effectiveness of chemical control as opposed to the use of tropical breed *(Bos indicus)* cattle in different climates throughout the tick-infested areas of Australia, especially in Queensland.[2]

While a considerable research agenda has been completed on optimum cattle-tick management strategies for individual producers (see Davis (1996b), limited attention has been provided to evaluating Government policies towards the cattle-tick and examining the social benefits of any tick management policies. This is despite the presence of costly Government controls and restrictions in New South Wales (NSW) and a major regulatory framework in Queensland.

In examining the evaluation of Government tick control and/or eradication policies, this paper focuses on the application of Cost Benefit Analysis (CBA) in the four major Government reports in Australia from the past five decades:

- **The Bureau of Agricultural Economics (1959)** - a report that estimated the cost of the cattle-tick at approximately £9.5 million dollars (approximately $87 million in 1996 dollars) focusing on the costs to producers in Queensland.

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[1] This is not particular to literature on cattle ticks. Generally, the term 'economic evaluation' when used in agricultural journals, refers to a monetary comparison between management techniques.

[2] For example, Johnston & Haydock (1969), Wharton et al. (1969), Corlis & Sutherland (1976), Bums et al. (1977), Utech et al. (1978), Sutherst et al. (1979), Sutherst et al. (1980), Sutherst et al. (1983) and Mellor et al. (1983) which are representative of the volume of work quantifying the productivity benefits accruing to producers from the use of cross-breed cattle.

- **Committee of Inquiry - The Cattle Tick Problem in NSW 1960** - this inquiry, detailed in Mackerras et al. (1961) provided a basic costing exercise comparing the costs of Government expenditure on the tick policy of the day and compared it to the costs if tick control within the Tick Quarantine Area (TQA) of Northern NSW was the responsibility of stockowners.

- **The Cattle Tick Control Commission (1973)** - the major economic analysis in the Federal Government's Cattle Tick Control Commission was an economic evaluation of tick eradication/control in the TQA, conducted by J.Johnston and G.Mason of the NSW Department of Agriculture, and published in more detail in later papers. In a separate exercise drawing on the resources of the affected State Governments' Departments of Agriculture, the Cattle Tick Control Commission also quantified the cost of the cattle-tick to producers in Queensland, the Northern Territory and Western Australia.

- **The Cattle Tick Review Committee (1980) -** a NSW Government report which examined four policy options towards the cattle tick, including the release of areas within the NSW Tick Quarantine Area, the removal of all forms of Government intervention, and removal of Government sponsored treatments but the continuance of movement regulations. This analysis was also conducted primarily by Johnston and addressed many of the weaknesses of the Cattle Tick Control Commission sponsored analysis.

In Queensland, a preliminary CBA of alternative Government control and eradication policies has been conducted by Batholomew and Davis (1993).

In examining the application of CBAs to tick policy in Australia, the paper examines the use of the technique in the evaluation of cattle-tick programs elsewhere in the world, particularly Puerto Rico and Argentina where substantial CBAs on tick eradication have been completed. The paper examines the strengths and the weaknesses of CBA as a technique for evaluating pest-control/eradication programs.

2. Cost Benefit Analysis and Government Intervention in Pest Control

2.1 Cost Benefit Analysis and Pest Control

CBA is the main tool used in the evaluation of public sector projects and policy. As expressed by Battiato (1993, p.26),

> "Cost benefit analysis is the tool of applied welfare economics which connects the decision to perform an action with its effects, in terms of benefits and costs to all members of the community."[3]

The origins of the CBA methodology can be traced to Duplait's work of 1844 on the utility of public works (Prest & Turvey, 1965) although it was not until the 1960s that the CBA methodology became widely used as an aid to Government decision-making (Nash, 1993).[4] [5]

The popularity of CBA is found in its ability to provide decision-makers with quantified evidence on all the effects of a planned project or potential policy. To provide the analysis with meaning, at least one other alternative (usually a 'do-nothing' or status quo option) is required. Decision-criteria such as an Internal Rate of Return (IRR), Net Present Value (NPV) or the Benefit-Cost Ratio (BCR) provide a 'bottom-line' summary which can be used to compare the effects of alternative project options, as well as against other Government projects. The CBA technique can therefore not only provide information on the cost efficient solution to a project, it can also prioritise projects within and across

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3 Mishan (1971, p.3) observes that more importantly than being an application of welfare economics, "the rationale of cost benefit economics is based on that of a potential Pareto improvement." The Pareto criterion states that a project is supported if some people gain and nobody loses. However, as this criterion is very restrictive, the Hicks-Kaldor criterion, is more often used in CBAs, in which a project is worthwhile, if some people gain, and gain sufficiently to be able to compensate the losers, even if the act of compensation does not occur, (Layard & Gtaister, 1994, p.6).

4 Although Hoehn & Randall (1989, p.544) state that the idea of submitting tests to a benefit-cost test can be dated back to Adam Smith.

5 Perkins (1994) attributes much of the spread of modern CBA practices to the manuals developed for the OECD by Little & J. Mirrlees (see Little & Mirrlees (1969) and Little & Mirrlees (1974)), the UNIDO manual developed by P.Dasgupta, S.Marglin and A.Sen (see UNIDO (1972)) and collected works such as Layard (1972).

portfolios.[6]

Agricultural projects were among the first areas to adopt CBA for the evaluation of projects, particularly in the evaluation of large-scale projects, such as the provision of water-infrastructure. In the fields of pest-control and animal health, however the use of the CBA technique has been rather limited, despite the scale of the projects involved. Projects, such as disease and pest eradication have been implemented based on the 'gut-feelings' of technical experts, pressure from industry groups, or to comply with international trade regulations.[7] In some situations in pest-control the lack of a CBA in aiding pest-control decisions is understandable due to the speed of decisions required and the lack of policy options. For example, if a new pest arrives, the only options are to accept the pest, contain the pest within a specified area or eradicate the pest. In these situations economic evaluation will be an ex-post exercise justifying expenditure already undertaken or refining the policy chosen. In rare cases, a CBA will have been undertaken to determine the most effective means of dealing with a potential pest, such as that done by Anaman et al. (1994) examining potential Australian responses if a screw-worm fly invasion occurred or Garner & Lack (1995) who have examined responses to foot-and-mouth disease if it appeared in Australia.

However in the case of established pest-species, the lack of a CBA can be traced to a general ignorance of economics or a lack of appropriate accountability measures. The problems with obtaining precise information in areas, particularly where there is considerable risk and uncertainty has also limited the practice of CBA within the pest-

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6 A project is worthwhile under the NPV decision criteria if $\sum_{t=1}^{n}[\frac{A_t}{(1+r)}]-C>0$ where A is the net cash flow in year *t*, *r* is the cost of capital, *C* is the initial cost and *n* is the life of the project. Using the same definitions, the IRR of a project is determined by setting $\sum_{t=1}^{n}[\frac{A_t}{(1+r^*)^t}]=C$ solving for *r**, which is the projects internal rate of return. If *r** is greater than the current or desired cost of capital the project is worthwhile. Under the BCR ratio, a project is desirable if $\frac{B}{C}>1$ where *B* is benefits and *C* is costs, (Peterson & Lewis, 1990).

7 For example, the Brucellosis and Tuberculosis Eradication Campaign (BTEC), began in 1968 in response to the possibility of Australian beef being excluded from the U.S beef market, however a CBA on the project was not undertaken until the Bureau of Agricultural Economics conducted one in 1986, (Department of Primary Industries, 1996).

control field.[8] LeVeen (1989, p.41) writes that in the evaluation of eradication strategies by CBA two disputes arise,

> "...those relating to the accuracy of the basic empirical analysis and those relating to the acceptability of the economist's judgment of a policy's viability."

Consequently, the results of CBA in eradication projects are questioned on the economist's base input, (provided by entomologists and veterinary scientists) as well as the value placed on certain outcomes by the analyst. Although an economist is often powerless in obtaining greater technical accuracy, the incorporation of well-established risk analysis techniques and the use of risk analysis software[9] can provide estimates which incorporate divergent views of possible outcomes.

Two further general criticisms of CBA as a means of evaluating public policy are:

- A CBA is a measure of economic efficiency and does not adequately consider the equity effects from potential changes. As a result, a project may return a positive benefit-cost ratio, with only one person benefiting greatly with many others losing moderately.[10] To counter this weakness, distributional analysis (involving the use of distribution weights see Perkins (1994, p.328-347)) has often been incorporated into CBAs. Other additions into a 'social' CBA may be the inclusion of values determined in additional appraisal techniques such as environmental impact

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8 In Queensland, a CBA is required for any capital project over $0.5 million as specified by the Project Evaluation Guidelines specified by Queensland Treasury, as well as for changes to Government regulations through the Regulatory Impact Statement (see Department of Business, Industry and Regional Development, 1994). U.S Federal programs are also subject to similar appraisal procedures (Hoehn & Randall, 1989).

9 Although risk analysis has been well established in economics traced back to the work of Knight in 1921, Such as Palisade @risk, a popular add-on to spreadsheet packages such as Lotus 123 and Microsoft Excel. Risk analysis software that has been able to provide comprehensive risk analysis output to those with minimal economic or mathematical backgrounds.

10 Nath (1969) provides an excellent discussion of the value judgments associated with economic efficiency. "Moreover, even if the underlying value judgments of the concept of 'economic efficiency' were found to be widely acceptable in some society, it would be unwarranted to deduce from them necessary, much less sufficient, conditions for the social optimum and brandish them to the public as objective (or even relatively value-free) conditions for 'economic efficiency'", (Nath, 1969, p. 152).

statements and multicriteria analysis.[11] Munda et al. (1993, p.60) has acknowledged the growing trend to evaluate projects beyond efficiency and over multidimensional variables such as "average income, growth, environmental quality, distributional equity, supply of public facilities and accessibility." Multicriteria analysis may appear to be a more appropriate appraisal technique in these situations, however it also faces the difficulty of obtaining precise information over output areas that are qualitatively evaluated. Nash (1993) sees the use of multicriteria analysis and other techniques, as complementary to a CBA, by synthesislug values that can be incorporated into a CBA as well as providing additional information over areas where a standard CBA may be inconclusive.

- With the values incorporated into CBAs often being subjective, the independence of the analyst is a vital, though seldom achieved component to a quality CBA. As Williams (1993, p.65) explains,

  > "... the relationship between the analyst (as a technical authority) and the decision-maker (as a political authority) is an intimate one, so intimate indeed that in practice it is sometimes difficult to disentangle the role of the one from the role of the other...and in making that observation we are not simply thinking of the situations in which the analyst deliberately usurps the politician's role by injecting his or her own values into the analysis so as improperly to influence the outcome in a desired direction..."

  This 'bastard science' issue as Williams (1973) has referred to it, does not appear evident in published CBAs on pest control, although the great majority of CBAs are unpublished (and often confidential) internal Government documents. As a

[11] A form of project appraisal, which evaluates projects across a range of key attributes determined by the analyst or the decision-maker. Several multicriteria analysis techniques exist after a rapid period of development in the 1970s and early 1980s, (Janssen & Nijkamp, 1986). The outputs of the analysis generally consist of the relative merits of different project options being displayed as some form of matrix or analytical hierarchy displaying the strengths and weaknesses of the option over the specified criteria (Saaty, 1990). Summary results are obtained through the use of weights, either assigned by the analyst from the decision-makers preferences or developed from past behavior. Multicriteria analysis are often related to decision support systems, which are a computer based information system used to support decision making activities" (Munda et al., 1993, p.59).

result the possibility that a CBA will return the 'desired results' is always present.[12]

This criticism is more a general remark against all forms of project appraisal as it is a problem not peculiar to CBA. Indeed, alternative/complementary appraisal procedures such as multicriteria analysis are also open to manipulation if desired.

Despite the issues raised above, the use of a CBA methodology in the fields of pest-control and animal health is one of the most effective means of quantifying the aggregate effects of project or regulatory change, especially where technical information and consensus exist, long-term effects are evaluated and the wider distributional issues are incorporated. As will be seen in Section 3, which examines the application of CBA in the evaluation of cattle tick policy, the achievement of these factors is arduous.

2.2 Government Intervention in Pest Control

As mentioned above CBA is a tool for evaluating public projects or policy. However, as the distribution of the benefits in a standard CBA is unimportant, so too is the distribution of the costs. In other words, the results from a CBA should be the same whether the Government finances the project or a private individual.[13] In many cases, particular in reviews of Government regulation, the rationale for Government involvement for a project is questioned. With an increasing global trend of rationalisation, privatisation and corporatisation in Government sectors, and a separation of the Government's role as purchaser and supplier of services, CBA practitioners are finding that the first step in project evaluation is to provide a justification of Government involvement in that particular project (Bailey, 1995). This is especially the case if the CBA is being conducted as part of a regulatory review.

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[12] Apart from Gardner & Lack (1995) and Anaman et al. (1994) who have already been mentioned, CBA of eradication strategies in the event of screwworm fly invasion in Australia, Norgaard (1988) CBA of the Cassava Mealybug in Africa, Bech-Nielsen et al. (1993) evaluation of swine-fever eradication in Spain, Carmody et al. (1984) are all competent CBAs in animal health and pest control.

[13] Although some CBAs may, rightly or wrongly, consider organisational and administrative structures in determining whether a project is best financed publicly or privately. See Bailey (1995) for an extension of this argument.

Generally, Government intervention is justified on the grounds of correcting market imperfections, securing the supply of public goods at an acceptable level, and ensuring a fair distribution of resources, (Trotman-Dickenson, 1996). In pest control and animal health issues, Government involvement is justified mainly on the basis of addressing market failures, primarily in the form of externalities. If market failure occurs, the outcome in an unregulated pest-control situation would be less than that possible if Government action was taken. As Johnston (1975, p.6) states,

> "On welfare economics grounds some form of government intervention in the private sector is justified if it can be shown that the allocation of resources to cattle tick control both in amount and type is significantly different from that considered desirable by society"

Government intervention in pest-control issues is justified on the following market failure grounds:

a) **Health and Safety** Most Governments maintain strict guidelines for the licensing of new chemicals before they are sold to the public. It is sometimes argued that the high level of testing and regulation on new chemicals hinders the development of new pesticides. However in an unregulated market, the possibility exists that a unsound chemical may damage crops, animals and the environment. Chemical residuals in food produce may also have a detrimental effect on the health of consumers. While the market may eventually ensure the demise of disreputable chemical manufacturers, as nobody would purchase their product, the damage inflicted may be enormous and irreversible. In a similar manner, Government intervention in pest-control practices is also justified on the grounds of occupational health and safety for agricultural workers.[14] In some situations, an existing animal disease may be eradicated on the grounds of human health. This was a significant consideration in the Brucellosis and Tuberculosis Eradication

[14] See for example, Lichtenberg et al. (1993) paper the effect of pesticide reentry regulations, which prevent people from entering chemically treated areas for a certain period. This US legislation was introduced after a number of adverse health effects being recorded amongst agricultural workers.

Campaign (BTEC). In cases such as these, although there are great benefits to be achieved in eradicating these diseases, the benefits may be minor to producers, who only suffer small production losses and inconveniences, and small for the consumers who perceive their chances of illness for these diseases as remote, and are unwilling to pay for extra protection from those particular diseases. Yet the combination of all these incremental risk-adjusted losses brings major benefits which go unrealised without Government action.[15]

b) **Imperfect Information and Ignorance -** an optimum outcome in a free market may not occur because of asymmetries of information. Producers or consumers may not have all the available information in which to make informed decisions. In the example of the disreputable chemical supplier, the market may take some time to realise that the chemicals have detrimental side-effects. Another example is information problems such as chemical resistance. A producer using numerous chemical treatments to try and achieve 100% kills, may choose a different strategy if he/she knew the present strategy was intensifying chemical resistance and thereby reducing the control method in future seasons.[16]

c) **Maximising Social Returns from Existing Resources -** A producer may not be accountable for the full benefits or costs arising from their chosen actions against a pest. For example, a producer that decides not to control a specific pest may cause a higher pest level on a neighbour's property whose produce is highly effected by that pest. As this effect is external to the producer not controlling pests, lower levels of overall output may result than would have been possible if all producers had a coordinated pest program. A similar example is where neighbouring properties produce different crops that are affected by different pest-species, and one producer's chemical treatment kills the natural predator of the neighbour's pest. With limited resources available this is often the rationale behind integrated pest management plans, which see the Government in a

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[15] In the case of BTEC, it took the possibility of exclusion from the United States beef market to bring about a national coordinated campaign in 1968 (Department of Primary Industries, 1996)

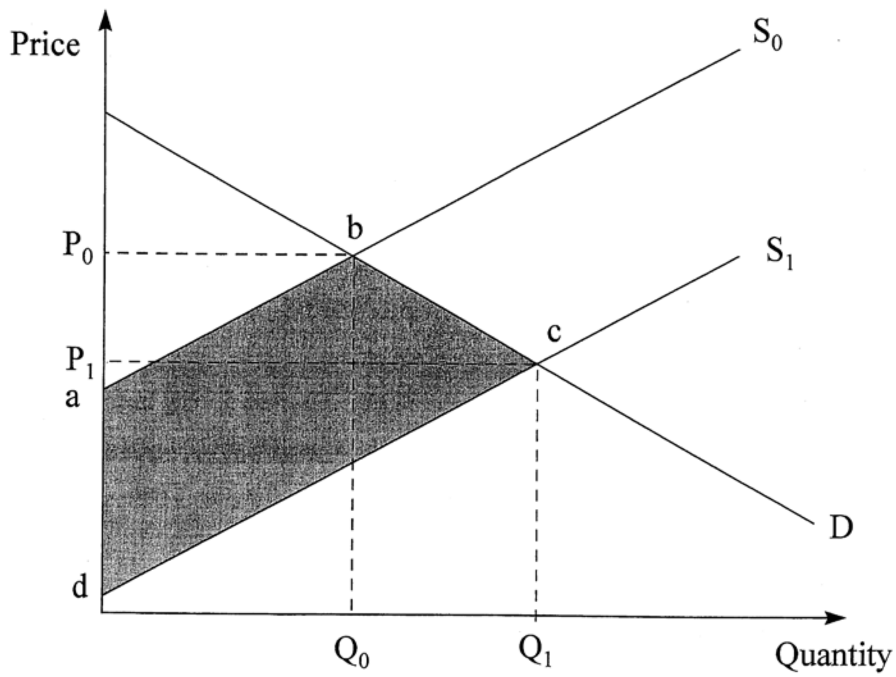
[16] Issues associated with the determination of dynamic economic thresholds with multiple pest species are discussed in Davis (1996a).

coordinating role designed to maximise environmental benefits and sustainability of chemical pest control methods in areas with different pest-control requirements. A further justification is the economies sometimes involved through collective action, which is important in situations where fixed costs are high, or producers working in isolation would not be able to secure the services of technical expertise.

d) **Changing Market Structure and/or Improved Competitiveness -** A Government may ensure eradication of a pest is undertaken to bring about greater productivity or prevent a major reduction in productivity. For example, the papaya fruit fly invasion (a significant pest to mango growers) in late 1995 in North Queensland drew a swift response from the Queensland Government for its eradication. While, North Queensland producers may have been able to combine and coordinate a response to the invasion, full compliance would be required to ensure success, a situation assured by Government through legislation. Another situation may exist where a Government program may be undertaken to bring about greater competitiveness in an industry. If a pest-control technique requires substantial establishment costs, which act as a barrier to entry to competitors, then an oligopoly market structure may arise, with the associated higher cost to consumers. A Government eradication campaign to improve productivity and remove barriers to entry, may bring about greater supply and lower prices.

With the right Government policies to correct market failure, the benefits can be described graphically through the changes to producer and consumer surplus. This can be seen in Figure 2 (following page).

In the "free-market" situation, producers organise their own pest control due to their perception of the benefits accruing to themselves resulting in an equilibrium at point *b* where the supply curve S_0 intersects with the demand curve *D*. However, due to the market failure issues mentioned above, this level of supply is lower than could have been achieved if some form of Government policy had occurred. If the Government had have addressed the market failure problems the supply curve S_1 would have eventuated with an equilibrium at point *c*. The immediate advantage is that a higher quantity of beef has been produced, Q_1 rather than Q_o, at a lower price, P_1 rather than P_o.



Source: Based on Duncan & Tisdell (1973) and Johnston (1975)

Figure 1 Benefits from Government Intervention to Correct Market Failure

The change to consumer surplus[17] from the movement of the supply curve from S_0 to S_1 is the area P_0bcP_1. The change to producer surplus[18] is the difference between the areas P_1cd and P_0ba. Johnston (1975, p.18) points out that the overall gain to society through government intervention is the shaded area *abcd* less the cost of the Government intervention.[19]

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17 Consumer surplus measures the difference between what a consumer is willing to pay for a good and what they actually pay, (Perkins, 1994, p. 113).

18 Similar to the concept of consumer surplus, producer surplus is the difference between what a producer would have sold a good for and what they actually receive for that good, (Perkins, 1994, p.116).

19 The example provided in Figure I examines only the changes to producer and consumer surplus from a parallel downward shift of the supply curve. The effects of other movements, such as a change in the slope of the supply curve, may result in a significantly different distribution of benefits between consumers and producers.

2.3 Financing Issues

In some cases in pest control, the costs to Government are minimal with the benefits from Government stemming from the ability to provide producer compliance. In other cases, Government intervention is expensive with uncertain costs and long periods of expenditure.[20] Moreover, as was discussed in Section 2.2, Government intervention may be required to ensure certain benefits and correct market failure, but these benefits may accrue solely to certain groups. The argument for Government intervention is strengthened if it can be shown that the cost of the Government intervention can be financed by the beneficiaries. There are several options available to the Government in funding a project:

- **Consolidated Revenue -** The Government can fund the project out of general revenue. In other words, no specific groups are singled out to fund the project. Funding from consolidated revenue is likely when a pest control program generates numerous small (but equal) beneficiaries or it is difficult (or legally impossible) to assign costs specifically to individual groups. For example, a pest-control eradication program that reduces the possibility of increased disease in humans across the State.

- **Charges** - If the main beneficiary of a Government pest control program are producers, then the program may be financed through a levies. These charges aim to recover the cost of the program from those receiving the most benefit, such as a levy on producer output or as a tax on a final product depending on who the target is. Some taxes may also be used to alter behaviour, such as an excise duty on chemicals to try and discourage excessive use.

- **Joint Funding -** In some cases, before Government intervention is decided upon to address a market failure action, arrangements are made with the major beneficiaries. For example, in pest control programs in which a certain producer group is the main beneficiary, joint funding arrangements are structured. For

[20] For example, the Government cost of the BTEC campaign cost $239 M in Queensland for the period 1970-1994, (Department of Primary Industries, 1996).

example in Queensland, voluntary tick eradication programs are encouraged by the Queensland Department of Primary Industries.[21] The Government contributes a certain amount of resources (50% of the costs in this case) with local industry meeting the remaining costs (Department of Primary Industries, 1995).

3. Economic Evaluation of Government Policy towards *Boophilus microplus* in Australia

This section examines the main Government evaluations towards *Boophilus microplus* in Australia. The variety of economic content varies vastly between the reports, as does the degree of policy evaluation. The 1960 review of tick control policies in NSW, (described in 3.2 below) provides only a few pages on the economic effects of the tick, whereas the CBA of alternative While the economic content of some of these reports are limited, the processes by which they have estimated costs/benefits is worth examination.

3.1 Bureau of Agricultural Economics (1959)

The first major study into the economic effects of cattle ticks was conducted by the Bureau of Agricultural Economics (1959). While not an actual CBA, the report is worth examining for its estimation of the cost to producers in Queensland, of control, lost production and damage caused by *Boophilus microplus.*

The major focus of the report was to estimate through the use of producer surveys and alternative information sources,[22] the non-Government economic effects of the cattle-tick. While acknowledging the significant costs to Government, particular the NSW and Queensland State Governments, this expenditure was examined separate and in less detail, than the estimates for the losses accruing to producers. With the cost to Government separate from the main analysis, so to was the loss to producers in NSW as

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[21] In this unique situation, once a reasonable degree of consensus is achieved among local producers wanting to undergo eradication, a local management committee with Government representatives is formed an corporatised. The involvement of the Government empowers inspectors employed by these committees with certain legislative rights. In cases where a small number of producers do not want to be part of the program, the management committee organises the additional finance but the powers envisaged in the inspectors ensures compliance.

[22] For example, turn-off rates were taken from previous Bureau of Agricultural Economics research and the observations of Government staff.

their costs were generally covered through the NSW's Governments eradication campaign. The report was therefore an estimate of the cost of the tick to the producers in Queensland, with additional costs included in subsequent chapters as supplementary evidence of the cattle tick's effect.

To estimate the costs within Queensland, the tick infested region was divided by statistical areas and average rates of production loss, chemical use, capital works, mortality and hide damage were calculated. The surveys, sent to producers across Queensland, requested estimates (in £s per annum) of the additional resources required to administer tick control and the production losses. The resulting estimate of the overall cost of the cattle-tick to producers in 1959 was £9.5 million dollars in Queensland, (approximately $87 million in 1996).

The study was conducted before the research conducted by people such as Wharton, Bums and Suthherst, mainly at the Commonwealth Science and Industrial Research Organisation (C.S.I.R.O), whose liveweight studies of different tick control strategies (particularly those utilising tick-resistant cattle) across climates in Queensland and Northern NSW provides a more accurate measure of the economic effect of the cattle tick.[23] If the economic effects of the cattle tick in Queensland was measured today, a producer survey would concentrate mainly on obtaining a description of the range of tick management strategies employed across the state rather than using subjective producer estimates of tick losses.

Even though the Bureau of Agricultural Economics report data collection most likely led to a considerable overestimation of the economic consequence of *Boophilus microplus*, it did incorporate property management opportunity costs resulting from tick infestations. Producers were asked to estimate what the turn-off period[24] of cattle would be if they did not have to contend with tick infestations. The report also noted (p.43) the existence of other pests, such as lice or buffalo fly, would mean that the costs of dips, fences and chemicals, would be required whether ticks are present or not, and if quantified in the

[23] It could be said that the massive cost of the tick in Queensland estimated by this report was a catalyst for Government funded research into cattle tick control measures.

[24] The period for which an animal is on the property. Longer turn-off periods mean that the stock is being kept on the property over a greater time frame to reach a desired weight level.

analysis, would reduce the estimated costs of the cattle tick.

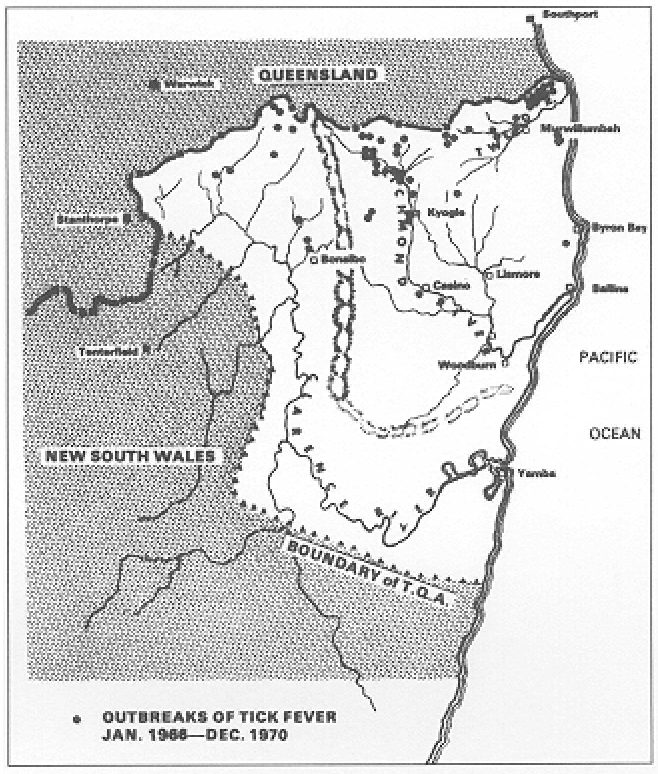
The report was the first in the world to determine, the cost of the tick and the inflation adjusted results from this report was often quoted internationally up until the release of the Cattle Tick Control Commission of 1973, (see for example Cooper Research Organisation, 1970).

3.2 Committee of Inquiry - The Cattle Tick Problem in NSW 1960

The failure of the 1956-57 campaign to eradicate the cattle tick in the Tick Quarantine Area (TQA) of Northern New South Wales led to an inquiry on the state of the cattle tick in NSW. The focus of this inquiry was to provide a report on the reasons for the failure of the eradication campaign and to focus on future policies and control measures given the experiences of the failed eradication attempt. The report was presented in December. 1960 and reported in Mackerras et al. (1961). However, since the report was considering alternative Government policies, a small section was included in the report discussing the cost of the cattle tick in NSW.

The costing exercise did not equate by any means to a CBA, or a costing exercise conducted to the same extent as the Bureau of Agricultural Economics (1959). The aim of this costing estimate was to question the expense accruing to the New South Wales and Commonwealth Governments in maintaining strict control/eradication processes within the ‘buffer’ TQA shown in Figure 2 (following page).

The involvement of the Commonwealth Government began in 1927, justified on the basis of sharing the burden of the cost to NSW which was protecting the rest of Australia from the threat of tick infestation, (Mackerras et al., 1961). The Commonwealth met approximately half the costs of the eradication campaign, which saw tick expenditures rise from £0.548 M in 1954 (approximately $5.6 M in 1996) to £1.257 in 1957 (approximately $11.66 M in 1996). At the time of the review, 600 men were employed in NSW for tick control measures. In evaluating the costs, the committee observed that costs to producers within the TQA, were limited to the nuisance value of dipping their cattle in the State provided dips. All other costs were met by Government, including the cost of dipping programs, losses incurred in the dipping process, Government inspections and quarantine. The question asked by the 1961 committee was whether producers in the TQA were receiving a 'free ride' from the Government under the basis of securing a tick-free status for the rest of Australia. Since no Commonwealth or State funded protection occurred in tick infested Queensland, then why should the TQA be any different?



Source: Cattle Tick Control Commission (1973, p.44)

Figure 2 - Tick quarantine area of NSW - showing tick outbreaks 1966-1970

Government costs were reported from actual figures and compared with the likely costs if quarantine measures were obtained and control of ticks was left to stockowners within the TQA. The simple measure of comparison was to use the extra costs per 1000 head associated with tick control in the Moreton Shire of Queensland (representing an area of similar climate to the TQA) and multiplied by the amount of cattle in the TQA. Using Moreton Shire was considered acceptable as it was likely to overestimate the costs to producers. While this was only a crude benchmark, the costs of the tick control policy in

1959, £1,088,825 (approximately $9.87 M in 1996) exceeded the expected stockowner costs of £975,000 (approximately $8.83 M in 1996) from the presence of ticks.

The NSW Government would still be up for the costs of quarantine in ensuring the tick did not spread outside the *TQA* but the possibility that the tick control policy was more expensive than potential stockowner losses was a concern for the committee. As Mackerras et al. (1961, p. 62-63) observed,

> "The view has been expressed to us on several occasions that the prime justification for the control policy that has been followed in New South Wales has been that it has protected producers in uninfested regions of Australia. In other words the tick quarantine area has been a buffer zone. Consideration of the ecological factors limiting the spread of the cattle tick...suggests that this argument for special treatment cannot be sustained.[25] Rather, our present knowledge suggests that stockowners in the area have been subsidized so adequately that any economic loss through the presence of Boophilus microplus in the region has been insignificant. It therefore becomes a matter of concern that current estimates of expenditure at £1,089,000 per annum are greater than the £975,000 estimated as the maximum potential annual loss that might be caused by the tick."

Despite the concerns raised in the report, the recommendations provided for only a modified change to NSW tick policy and a readying of stockowners for the eventual responsibility of tick control within the TQA.

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[25] Mackerras et al. (1961, p.51) in a departure from traditional beliefs concluded that the available evidence, although unsatisfactory, indicates that the tick would not be able to spread pass the TQA in economically damaging proportions except in the hottest summer. Even within the TQA, the southern and western ends of the TQA would only sustain intermediate tick populations.

3.2 Cattle Tick Control Commission (1973)

Following an outbreak of ticks in Kempsey (160 kms south of the TQA), a Commonwealth inquiry into the status of the cattle was ordered. Within the report, the Cattle Tick Control Commission (1973) provided two separate economic analyses:

1. An estimate of the costs of *Boophilus microplus* to producers and Government, including the cost of research, for NSW, Queensland, the Northern Territory and Western Australia. The overall cost of the cattle tick in Australia was estimated to be $41.27 M (approximately $240.13 M in 1996 dollars) with approximately 80% being the losses in Queensland.

2. An economic evaluation of control versus eradication as alternative Government cattle-tick control policies in NSW. This economic evaluation, conducted by Johnston and Mason, is covered in more detail in two related articles, Johnston & Mason (1976) and Johnston (1975).

In the estimation of the costs of the cattle tick throughout Australia, the cost to the Government were based on actual expenditure supplied by State Governments, generally entailing the cost of labour, dip maintenance and chemicals, with the magnitude of each State's expenditure depending on each Government's policy towards *Boophilus microplus* control. Therefore, the costs to Government reported in 1972-73 in Queensland, Northern Territory and Western Australia combined were approximately $1.2 million (approximately $6.98 M dollars in 1996), or 30% of that spent in NSW, $4.104 (approximately $23.88 M dollars in 1996). This trend continues today with NSW maintaining an expensive Government sponsored campaign against the cattle-tick while the Queensland[26], the Northern Territory and Western Australian Governments have adopted minor regulatory roles.

The costs to producers were generally determined by estimating average costs on a per head basis, such as loss of production, tick fever vaccinations, chemical control and hide

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[26] As will be discussed later, Queensland has been examining alternative cattle-tick control policies and smaller scale eradication programs, designed to decrease the size of the tick infested region.

damage and multiplying by the number of cattle within the region. Queensland was broken into five regions, whereas the other States, having smaller infested area, were single regions for each State. As this was a rather fastidious estimation, the data for the estimation were derived from the knowledge of Queensland Department of Primary Industry officers and from a previous survey of the beef cattle industry conducted by the Bureau of Agricultural Economics (Cattle Tick Control Commission, 1973, p.69). The production losses were determined using the research by Wharton et al. (1969), which estimated weight loss scenarios for different tick management schemes, rather than the Bureau of Agricultural Economics (1959) approach of asking for the producers estimate of liveweight loss. The estimates for chemical control included, labour and labour opportunity costs, were derived from the beef cattle industry survey. Indirect costs caused by tick fever deaths or illness, were determined by assuming that deaths from tick fever amounted to 1% of total cattle numbers.

One major weakness of the Cattle Tick Control Commission's costing of the cattle tick was that it does not incorporate a cost for the dairy industry. The Bureau of Economics study incorporated an estimated cost to the dairy industry of £1.555 million (approximately $14.09 M in 1996 dollars) based on producer estimates of lost production and costs, above those already estimated for chemical control.

In comparing the costing of indirect production losses from the Bureau of Economics (1959) and the Cattle Tick Control Commission (1973) a considerable spread of results can be seen. As mentioned in 3.1, the 1959 report, using producer surveys estimated the costs to producers from control and lost production in Queensland as £9.5 M (approximately $87 M in 1996). The 1973 estimation, using losses per head data from scientific observations as their costing of production losses found the total cost to producers in Queensland to be $23.54 M (approximately $136.97 M in 1996). The extra cost estimate of $50 M by the Cattle Tick Control Commission (1973) in 1996 dollar terms, goes against the expectation that cattle ticks would have inflicted greater losses in the 1950s due to a lower level of beef management technology[27], and the use of *Bostaurus* breeds in areas with large tick populations. Furthermore the producer survey estimate used by the Bureau of Agricultural Economics (1959) was likely to have overestimated cattle tick effects with producers attributing losses caused by drought and other pests to *Boophilus microplus*[28]. The 1973 cost estimate must be viewed from the perspective of an expeditious report that was included to provide a figure of the breadth of the cattle-tick problem, with many inordinate assumptions (such as those relating to tick fever deaths) and numerous issues ignored.[29]

3.3 Johnston-Mason Cost Benefit Analysis of Alternative Government Control Policies in NSW

Among the recommendations from the Cattle Tick Control Commission, was that eradication of the cattle tick should only be attempted if a number of conditions were able to be met.[30] The Commission found that with the available technology, the only area in which these conditions may be met would be in New South Wales, despite the failure of the 1956-57 campaign to eradicate *Boophilus microplus.* The Commission funded a CBA of eradication versus control in NSW, conducted by Johnston and Mason of the NSW Department of Agriculture.

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27 Elder et al. (1985) found that between 1977 and 1982 the proportion of properties with predominately *Bos indicus* blood had risen from 47.8% to 60%. This would appear to be a considerable improvement from Bonney (1973) who found that 31.2% of the female breeding herd had some level of *Bos indicus* blood. This would be undoubtedly larger than the level of *Bos indicus* infusion in 1959 as there was a rapid acceleration of *Bos indicus* popularity in the 1960s, (Skelsey, 1980).

28 The final chapter of the report (p.71-78) examines the reliability of the survey data, although no examination of the data pertaining to production losses was included.

29 Among the issues not considered in the Cattle Tick Control Commission's report were: the costs of ticks to the dairy industry; the management opportunity costs confronting producers with tick infestations; and inadequate consideration into the breed structure of the beef herd and the changing beef management techniques occurring at the time. In Queensland, in particular, the infusion of *Bos indicus* blood into the State's beef herd was escalating during the 1960s and 1970s (Skelsey, 1983). Furthermore many of the issues that would be considered in a cost estimation today, but not considered important issues in 1973, have also not been considered such as the sustainability of chemical control methods, chemical residuals and trade barriers, and the chemical costs attributable to other pests (see Davis 1996b).

30 The essential conditions required for any attempted tick eradication include (Cattle Tick Control Commission, 1973, p. 9): the ability to muster all favorable hosts; adequate treatment facilities; effective industry cooperation; reasonable prospects of no reinfestation; efficient weapons of control; adequate funding; and justification by a cost benefit analysis.

The Johnston-Mason CBA compared the Government control policy of the time, with two alternative eradication policies and with two types of buffer zones between Queensland and NSW. The control policy consisted of maintaining ticks at their current low levels in the tick-quarantine area through regular inspections and movement controls within the Tick Quarantine Area (TQA) shown in Figure 2. The eradication schemes, known as Eradication A and Eradication B, consist of 21 day inspections for all cattle and if any infestations are observed, spot eradication occurs, with dipping and inspections occurring for the following 10 months. Once an area has been tick free for two years, the quarantine is lifted. Eradication B differs in containing an additional cost for monitoring the external boundary of the TQA post eradication to limit further reinfestation. These policies were examined against two buffer zones with the Queensland border.[31]

The data was obtained from a detailed questionnaire and selected personal interviews which provided estimates for labour requirements (private and public) for inspections and treating infestations, cattle numbers, acaricide costs and other incidentals for each of the nine regions within the TQA. The categories of costs in the CBA are summarised in Table 1.

[31] The two buffer zones are less important in the overall analysis and are not discussed in further detail. Their purpose was primarily designed to evaluate suggestions provided by field officers.

Table 1 Categories of costs assessed in the comparison of control and eradication.

Public Costs	**Private Costs**	
Costs assumed certain (costs of providing policy but does not include costs of breakdown of policy)	*Costs assumed certain (costs of providing policy but does not include costs of breakdown of policy)*	
Staff Acaricides Traveling	Labour	Private labour for carrying out policy prescribed treatments.
Compensation of dipping losses[32] Leasing of unmusterable country Capital items	Marketing Costs	The cost of holding cattle for treatment before movement.
Repairs and maintenance Other general stores and equipment	Costs to motorists	Stopping at the TQA boundary gates[33]
Costs assumed uncertain	*Costs assumed uncertain*	
Infestations includes costs of staff, acaricides, traveling, leasing and compensation.	Infestations includes the cost of private labour associated with treatment.	

Source: Based on Johnston (1975, p.26)

Production losses due to tick infestations and weight-loss or bruising due to chemical treatments were not considered as all policies are assumed to maintain minimal or no tick levels within the region. The CBA was essentially a cost effectiveness analysis, with the benefits from different policies manifesting in lower costs than alternative policies. The CBA's focus, therefore, was to determine the most cost-effective policy over different time frames - ranging from 20 years through to infinity, with discount rates of 3, 5, 7 and 9%. With such a focus on each policies cost effectiveness, the major factor in determining the best long-term public policy, is the treatment of uncertainty. Intuitively, the greater the probability and the effects of reinfestation, the lower the long-term cost-savings associated with eradication will be. With production losses not considered, the uncertain cost of reinfestation is lessened by the omission of production losses, particularly stock deaths.

Johnston and Mason based probability estimates of future reinfestations on historical data of previous tick outbreaks within the TQA, as well as the consensus of a technical panel. Probability distributions were then constructed for the likelihood of tick infestations

[32] Deaths caused in the dipping process.
[33] At one stage all vehicles traveling between Queensland through the TQA were inspected at the border.

within each region of the TQA.

The likelihood of the cattle-tick developing resistance to the available chemical treatments, was considered an important issue (Johnston, 1975), however it was not a significant enough issue to be a separate scenario in which the costs of tick management increase in future years due to limited control and increased losses.[34] The effects of changing management and control techniques and a greater proportion of *Bos indicus* cross cattle, with higher tick resistance and therefore requiring less chemical control, which were beginning to be adopted in Northern NSW at the time of the Johnstone-Mason analysis, were also not included·[35]

The results of the CBA indicated that for all the policy alternatives, the proposed 5-mile buffer was shown to be uneconomical as it increases the annual costs approximately $0.87 M per annum ($5.06 M in 1996) for reductions in reinfestations. The estimated costs for Control, Eradication A and Eradication B before and after eradication are shown in Table 2. For Eradication A and Eradication B, the results are the expected costs derived from the probability distributions discussed above.

Table 2 The estimated annual costs of the alternative policies, control, eradication A and eradication B – (1973 figures)

Policy		Before eradication $m	After eradication $m
Control -	Public Costs Private Costs Total	3.60 0.61 4.21	Same as before eradication
Eradication A -	Public Costs Private Costs Total	6.23 0.94 7.18	1.64 0.16 1.80
Eradication B -	Public Costs Private Costs Total	6.23 0.94 7.18	2.28 0.29 2.57

Source: Based on Johnston and Mason (1976, p.28-35)

The expected present discounted cost of Eradication A, with the present buffer being

[34] Cattle-ticks have developed resistance to most major chemicals beginning with arsenic. The issue of chemical resistance and the lack of future control possibilities is discussed in Section 3.4 and 3.5.

[35] As will be discussed later, the use of tick-resistant cattle is a main feature in areas in Queensland where Government protection from tick infestation does not exist.

maintained, was the most cost-effective long-term strategy for discount rates up to 9.5%. Above this discount rate, control is more cost effective. Eradication B is never as cost-effective as eradication A, indicating a limited belief by the technical panel assigning probabilities that continuing extensive quarantine measures would lower possible reinfestations. However, at discount rates of up to 8%, Eradication B is a more cost-effective policy than control.

When different risk outcomes are considered the Johnston-Mason CBA a number of policy implications emerge. These policy implications are most evident in an examination of the pay-back period (the amount of years required before Eradication A is a superior policy method to Control). The pay-back periods for Eradication A, under optimistic, average and pessimistic scenarios are shown in Table 3.

Table 3 Minimum planning horizon for eradication A to be superior to control or alternatively the pay-back period for eradication A over control

Discount rate (%)	**Type of expectation on the time required to achieve eradication**		
	Optimistic (years)	Average (years)	Pessimistic (years)
6	14	22	34
7	15	23	40
8	16	26	inferior
9	17	30	inferior

Source: Johnston (1976, p.31)

These results show, that if high reinfestations are likely then the benefits of eradication as the preferred control strategy decline significantly. This is reflected in Johnston & Mason (1976) paper's conclusion which concludes by highlighting the inconclusive nature of the results if a pessimistic outcome resulted.

The Johnston-Mason analysis while the first CBA of alternative Government policy towards the cattle-tick, was deficient in the Government policies that it did not examine, especially the option of removing the Tick Quarantine Area and leaving the majority of the responsibilities for cattle-tick control in the hands of the producers, in much the same way as tick policy is conducted in Queensland. As can be seen in Table 1, all the NSW

Government policies examined ensured that the State covers most of the financial costs for tick-control, regardless of the Government policy chosen. Only by comparing an option which did not contain Government intervention can the economic effects of the Government policy be truly compared. Johnston (1975) provided a considerable justification for Government involvement as was discussed in Section 2, however did not provide any analysis which quantified its benefits.

If the justification for Government intervention in tick-control is, as Johnston (1975) suggests, to correct market failure, then the CBA should have focused on the size of the benefits provided from this intervention. In other words, the CBA should have estimated the extent of the area *abcd* in Figure 1 is, and whether those benefits are greater than the costs of implementing the policy. Finally the analysis should examine the distribution of the costs and benefits to determine the public financing issues.

In practice, the amount and distribution of the benefits will depend upon a number of factors, in particular:

- **The extra production or productivity improvements created through Government intervention** - the extent to which the supply curve S_1 moves to the right will depend upon the extra level of beef production and the lower costs incurred by producers. If the Government has established an artificial barrier against the cattle tick then the benefit will include the production and costs saved for those producers within the ticks enzootic area that are protected by the barrier.

- **The size and structure of the beef and dairy markets -** consumers mainly benefit through a lower price of beef stemming from an increase in production. The slope of the demand curve will therefore determine the extent to which consumers benefit through lower prices. Johnston (1975, p.20) observed that the demand for Australian beef has been largely export orientated, a situation that has increased considerably since 1975, making the demand curve highly elastic.

When these points are taken into consideration, the overall benefits of the NSW's Government's long-standing and expensive tick-control policy require further scrutiny.

Firstly, the area outside of the Tick Quarantine Area in which ticks are likely to be enzootic is small, providing few benefits to producers outside of the tick quarantine area.[38] Secondly, the overall cattle population within the Tick Quarantine Area is small, about 300,000 head, comprising a small proportion of Australia's overall cattle population. This means that the extra quantity of beef produced in Northern NSW, certis paribus, is also unlikely to produce any movements in the supply curve in major beef markets, providing few benefits to consumers. While it may be argued that removing tick controls in Northern NSW would lead to major losses due to tick-fever, the use of tick vaccine and tick-resistant cattle would reduce the risk of major production losses.

Producers within the Tick Quarantine Area however, benefit not only from a higher production level, but also from no significant decreases in price, an observation made by Mackerras (1961). Johnston (1975) recognising, the likely skewed distribution of benefits to producers, considered alternative means of financing Government policy as in the existing framework, funding comes from general revenue. This means that the larger burden of the NSW tick program is financed by people that will receive little or no benefits from the Government strategy. However, while it would be theoretically favourable to place any levies or taxes directly on producers within, and to a lesser extent, outside the Tick Quarantine Area, this is often difficult and illegal in practice.

3.4 Cattle Tick Review Committee (1980)

The continuing expense to the NSW Government in maintaining strict control measures in the TQA led to a review of the costs and effectiveness of the cattle tick policy in 1980.[39] The Terms of reference for this review included the constraint that and reforms to policy had to ensure that tick infestations within NSW did not pass the boundary of the TQA.

[38] This issue is discussed in more depth in Section 3.4.

[39] The costs and effectiveness of the strategic dipping and the number of border crossing treatments was questioned by Cattle Tick Control Commission (1973) who recommended a change to these processes. These recommendations were ignored by the NSW Government and tick control measures between NSW and Queensland were strengthened. Nevertheless, as recommended, Commonwealth funding for tick control in NSW ended in 1975.

Using the experience gained in the Cattle Tick Control Commission (1973), a comprehensive CBA of alternative government policies towards the cattle tick in NSW was conducted by a team from the NSW Department of Agriculture led by Johnston. The CBA examined the effects of four policy options, developed by the committee to be representative of the complete spectrum of Government involvement in tick control. These options are outlined in Table 4.

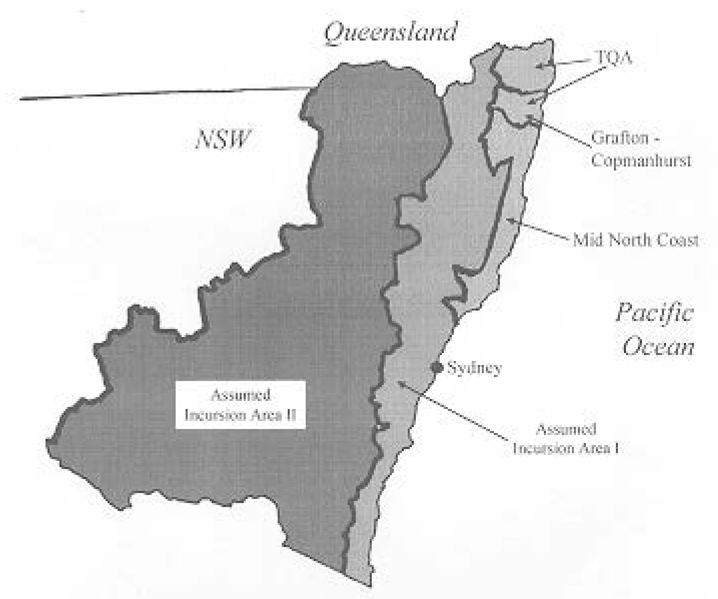
Table 4 Options developed by the Cattle Tick Review Committee (1980)

Option 1	Complete end to Government involvement in tick control policies in NSW
Option 2	Limit Government involvement to movement regulations in and out of the Tick Quarantine Area
Option 3	Continuation of existing policy which includes State managed inspections, cattle dipping and movement regulations
Option 4	Gradual release of areas within the tick Quarantine Area with Government monitoring continuing.

Source: Cattle Tick Review Committee (1980, p.30-37)

The inclusion of Options 1 and 2, provided the analysis with considerably greater depth than the Cattle Tick Control Commission (1973) CBA. Option 1, although not a serious policy option given the Cattle Tick Review Committee's Terms of Reference, provides decision-makers with an idea of the benefits/costs if Government control was removed, therefore providing a justification or otherwise for alternative policies. Option 2, provides a development of the issue which concerned the 1961 inquiry into the cattle tick, whether Government sponsored control measures within the TQA are justified.

For both of these options, the crucial information is supplied by technical experts (veterinarians and entomologists) who provide their views on the possible effects of these policies. In the case of option 1, the CBA is highly dependent on their perspectives of the spread of the cattle-tick without any Government involvement. Although, the recommendations of the 1961 report included research into the survival rates of *Boophilus microplus* inside and outside the TQA, only limited information was available in 1980 to base assumptions on the cattle ticks spread without quarantine measures.[40] With such limited information, and with the irreversibility of Option 1, assumptions on the spread of *Boophilus microplus* were cautious, with estimations tending to the extreme limits of tick infestation. effects of dismantling Government policy is dependent upon the assumptions on the effect to producers in the existing region and the spread of the cattle tick into new areas. The spread of the tick without quarantine is shown in Figure 3.



Source: Based on Cattle Tick Review Committee (1980, p.52)

Figure 3 Assumed Spread of *Boophilus microplus* without Quarantine

In Figure 3, NSW is divided into areas on the likelihood of sustainable tick infestations. Within these boundaries, the assumptions shown in Table 5 are the basis by which cost estimates are made.

40 The only source of information considered in the CBA conducted by Johnston et al. (1980) was the ecological study of tick infestations in TQA North Coast NSW, conducted by McCulloch & Lewis (1968) who evaluated tick longevity as a function of rainfall and temperature and compared climates in the coastal strip of New South Wales to research conducted at sites within the TQA. Their observation was that the winter at Williamtown just North of Newcastle would be sufficiently mild for cattle tick survival.

Table 5 Assumed tick infestations in NSW without quarantine

TQA, Grafton – Copmanhurst, Mid North Coast (Assumed Endemic Area)	• *Permanent tick infestations* – with 3 to 4 tick infestations per year.
Assumed Incursion Area I	• *Periodic tick infestations* – from nearly infestations in the inland North Coast region, and 1 in 3 years, to 1 in 5 year infestations in Southern areas.
Assumed Incursion Area II	• *Infrequent tick infestations* – few infestations although tick fever vaccination would be necessary to prevent losses in the event of an infestation.

Based on Cattle Tick Review Committee (1980, p.51-52)

The uncertainty of producer reaction to tick infestations in Options 1 and 2 was treated in the CBA by providing estimates on a matrix of possible producer decisions. Estimates were divided between producers adapting control measures and no control measures, and within these groups, estimates were provided for predominately British breed cattle and predominately resistant crossbred cattle. This matrix provides the analysis with a complete coverage of producer reactions, recognising that producers would be likely to change their production system, particularly if tick infestations are permanent. By including the 'unlikely' possibility of producers not endeavouring to control cattle tick infestations, the CBA accounts for the possibility of no pesticide control measures due to chemical resistance.

Aside from the problem of determining the extent of tick infestations into NSW, there is considerable variance in the estimates of production losses in regions that are assumed infested if quarantine measures are removed. While considerable research on liveweight tick losses had been conducted by 1980 in many parts of Queensland, no major research of possible tick effects on cattle in NSW had been conducted. Estimates of per head production losses for Options I and II were taken from the thoughts of technical experts, with minimum, most likely and maximum values given in the report. This range of estimates was also given for all the major cost factors. In determining overall cost estimates, the CBA assumed a staged spread of tick infestations so that the TQA was fully infested in 2 years, Grafton-Copmanhurst in 3 years and all other areas were likely to be effected in 6 years. Cattle numbers were multiplied by the per head values and the relative probabilities of infestation. The results for Option 1, Option 2 and Option 3 are shown in Table 6. All options are based upon a 20 year time horizon with discount rates of 4% and 7%.

Table 6 Present discounted costs - Option 1 and Option 2 (1980 dollar terms)

	OPTION 1						OPTION 2					
%	4 Min	4 Avg	4 Max	7 Min	7 Avg	7 Max	4 Min	4 Avg	4 Max	7 Min	7 Avg	7 Max
No Control												
British Breeds	278	389	503	208	291	373	154	213	276	118	163	211
Resistant Crossbreeds	100	132	165	83	107	133	91	123	158	71	94	121
Mixed Breeds	258	336	464	194	271	347	138	189	245	107	147	190
Control												
British Breeds	182	242	289	139	183	218	97	128	167	75	99	128
Resistant Crossbreeds	76	106	140	63	88	114	65	93	126	50	72	97
Mixed Breeds	171	229	273	135	174	208	89	118	155	69	92	120

	OPTION 3			
%	4		7	
Dipping Strategy	1980	Proposed	1980	Proposed
Total Cost	108	98	72	66

Source: Based on Cattle Tick Review Committee (1980, p.60)

The results of Option 1 and 2 were compared to the results for the status quo Option 3, which had been compared in more depth against Option 4. The separation of the analysis into two parts (one in which Option 1 and Option 2 were evaluated and one **in** which Options 3 and 4 were evaluated) was in order to examine sub-options, such as the existing dipping strategy for Option 3 within the TQA, with a strategy that included fewer cattle *(1980* and *Proposed* in Table 6), providing greater analysis for the more likely policy recommendations of Options 3 and Option 4. The analysis for Option 3 and Option 4 followed a methodology analogous to Johnston & Mason (1976). As in that report, the focus was on determining the cost to Government from the options, with producer losses assumed to be negligible for each policy, although in Cattle Tick Review Committee (1980) an expected reinfestation cost is included.

The observation made by Mackerras (1961), that the cost to Government in providing a strategic dipping program and therefore control for producers within the TQA is greater than the cost if the Government left tick control to producers within the TQA and maintained quarantine measures to the rest of NSW, appears to have some support from Johnston et al. (1980). This can be seen in the highlighted boxes in Table 6, where the existing policy Option 3, with the 4% discount rate would cost between $98-108 M (approximately 257-283 M in 1996) whereas Option 2, assuming producers control ticks, would cost between $65-167 M (approximately $170-438 M in 1996). This shows that if producers adjust their production systems to include resistant cattle, or at least mixed breeds, the cost to producers of *Boophilus microplus* would be less than the total cost of the existing policy.

The CBA found that Option 4, in which the southern and western areas of the TQA are released from the TQA over time, was more cost effective than Option 3, which as discussed was "on average" more cost effective than Options 1 and 2. The main benefits from Option 4, are in the cost savings from not having to engage in strategic dipping and other activities in these regions.

This CBA is archetypal of Leveen's criticism raised in section 2.1. The CBA addressed the problems of the 1973 analysis and provided the review committee with a quantification of the policy options to the best available data. An acceptance with the results of this CBA relies on an acceptance of the technical data which details the spread and effect of the cattle tick without quarantine.[41]

3.5 Other Cattle Tick Economic Evaluations Conducted in Australia

3.5.1 CBA of tick eradication versus control in Queensland

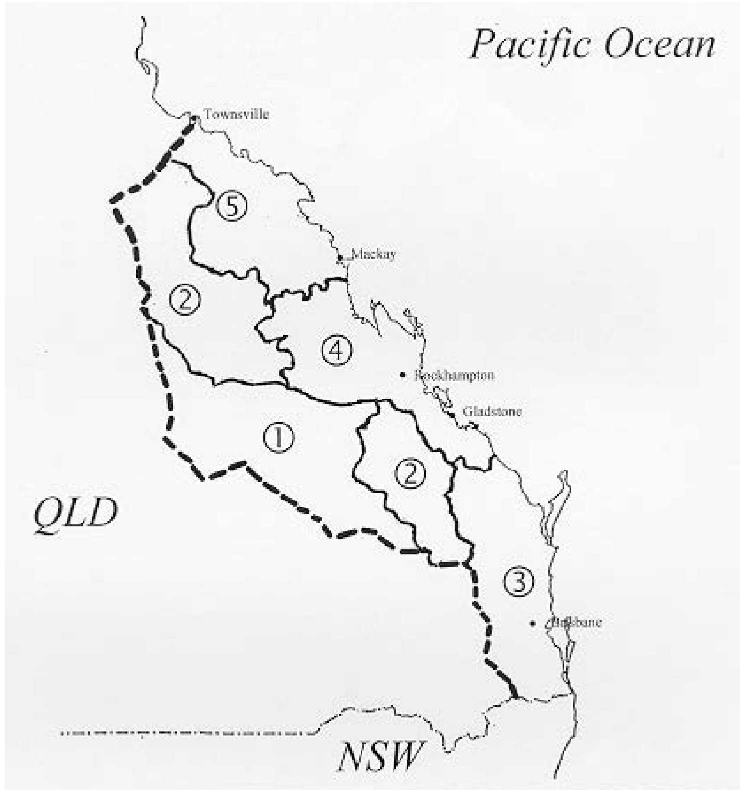
In 1992, the Queensland State Government announced as an election commitment to eradicate *Boophilus microplus* south of the Mt Isa - Townsville railway line within a ten year time frame. To evaluate the effects of this policy, Batholomew and Davis (1993) associated with the Queensland Department of Primary Industries, conducted a CBA of the proposed strategy as compared to the existing policy. The tick control policy in Queensland divides Queensland into 'ticky' and tick-free areas, with movements into the

[41] A recent study by the Cooperative Research Center for Tropical Pest Management and CSIRO has examined the spread of *Boophilus microplus* in Australia over different climate conditions up to 2070 and examined the effect these conditions would have in reducing meat production.

tick-free area regulated. Within the tick-infested areas of the State, tick control is the responsibility of stockowners.

Apart from the initial tick eradication announcement, no other Government policy was forthcoming. The initial step in the evaluation of the proposed eradication was to develop a representative strategy in which the costs could be considered. This input was provided after a series of meetings with DPI veterinarians and stock inspectors. The strategy consisted of dividing the tick infested region of Queensland was divided into five areas, shown in Figure 4 (following page). Areas were divided on their similarities in their cattle production systems and level of tick infestation. A further, convenient factor was that each area carries approximately 1 million head of cattle per region, with the exception being region 3 with approximately 1.5 million cattle based on ABARE and DPI data.

The major problem in developing a tick eradication program was the chosen eradication timeframe. The Terms of Reference for the CBA required the eradication campaign be completed within ten years. This provided a major problem as there was considerable doubt from producer groups and field experts that this was achievable.



Source: Based on Batholomew & Davis (1993)

Figure 4 Tick eradication zones

The eradication commitment was made by the Government primarily on the basis of the new tick vaccine, developed by the C.S.I.R.O and marketed as TickGard® by Hoechst Australia, being a major weapon in the fight against the tick. The vaccine, which was officially released in 1993, provides an effective means of reducing tick populations but does not produce the dramatic kill rates, initial advice suggested it might. Moreover, the BTEC experience showed that complete eradication of diseases or pests over large areas requires considerable time and complete producer cooperation. The attitude of producers towards the BTEC campaign in some areas displayed a general resistance to the level of Government interference required for that project, and no doubt necessary for the eradication of *Boophilus microplus.* The representative eradication strategy chosen was basically a progressive drive to the Coast, with the Western areas eradicated first, followed by the more problematic South-East and then the central coastal areas of Queensland. The Eradication timetable, is shown in Table 7.

Table 7 Eradication timetable

Year	Region 1	Region 2	Region 3	Region 4.	Region 5
1	Preparation				
2	Eradication	Preparation			
3	Eradication	Eradication	Preparation		
4	Eradication	Eradication	Eradication	Preparation	
5	Eradication	Eradication	Eradication	Eradication	Preparation
6	Eradication	Eradication	Eradication	Eradication	Eradication
7		Eradication	Eradication	Eradication	Eradication
8			Eradication	Eradication	Eradication
9				Eradication	Eradication
10					Eradication

Source: Based on Batholomew and Davis (1993, p.7)

A typical eradication strategy, that for Region 1, and the resources required is shown in Table 8.

Table 8 Eradication strategy and resources required - region 1

Treatment Strategies				
20% of Properties - 6 dips			20% of cattle	
70% of Properties - 4 Bayticol pour-ons			60% of cattle	
5% of Properties - Destock/Zero grazing			10% of cattle	
5% of Properties - Partial Destock			10% of cattle	
Activity Program				
Year	Activity	Success Rate	DPI Staff	Vehicles
1	Preparation	-	10	8
2	Eradication	50% (50% left)	150	120
3	Eradication	30% (20% left)	90	80
4	Eradication	10% (10% left)	35	30
5	Eradication	5% (5% left)	20	15
6	Eradication	5% (5% left)	20	15

Source: Based on Batholomew & Davis (1993, p.8)

Determining costs from the eradication strategy was a relative straightforward endeavour, requiring the 1992 value of resources was multiplied by the estimated requirements. For example, treatment costs were based on current chemical values and multiplied by the proportion of cattle requiring that treatment. With so many areas undergoing eradication at the onetime, the costs were considerably escalated evident that in the peak of the eradication period in year 4, over 800 persons would be employed in the program with over 700 vehicles.[42]

Determining the costs to producers of the existing tick policy, or the potential benefits of tick eradication, required additional information which was obtained from a survey to QDPI stock inspectors. The survey requested that stock-inspectors provide a representative property[43] and outline the existing beef production system and tick control measures. This was then compared against two alternative scenarios:

- **Scenario I -** Absence of *Boophilus microplus* - stock inspectors were asked to speculate on what effect eradication would have on a producer's chosen beef production system, such as changing breed or turning-off steers younger, and the effect on pest control.

- **Scenario 2 -** No effective chemical control - stock inspector's considered the same effects for scenario 1 but working on the assumption that *Boophilus microplus* would have developed total chemical resistance.

In essence these two scenarios enabled the eradication strategy to be compared against the status quo situation and a situation where no chemical control exists. The benefits and costs categories for the eradication strategy as compared to the current policy are shown in Table 9.

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42 The analysis ignored the problems associated with obtaining this many trained staff and their movement across the State as the eradication campaign moved from region to region. Factors such as finding suitable accommodation for staff would add considerable to the costs considered.

43 Or properties, as the regions are large the production systems chosen by producers may vary. For example in any particular region you may have larger cattle stations, through to smaller properties running only a few hundred head. This is especially the case in Region 3, where there are also hobby farmers to contend with.

Table 9 Benefits and costs of the proposed eradication strategy as compared to the existing policy

Benefits	Costs
Chemical Control Savings Chemicals Repairs & Maintenance Depreciation Mustering *Tick Fever Vaccine Savings* *Change in Net Cattle Returns*	*On Property Costs* Chemicals & Dips On Property Investment Destocking-Partial & Full Mustering Reinfestation *Public Costs* DPI staff and vehicles

Source: Based on Batholomew & Davis (1993)

The information from the stock inspectors survey was varied in quality, partially due to the amount of information requested, and the time required to complete it. A small pool of survey recipients was reduced by some non-respondents and other responses that did not provide the requested detail. However, some responses provided a copious amount of information, including effects not considered by the authors, or the technical committee designing the eradication strategy including:

- Breed changes in certain areas from *Bos indicus* to *Bos taurus* cattle were observed, but only contributing marginally to increased productivity. This is due to breed choice depending on a number of factors and more than just a function of pest control.

- Increased expenditure on tick fever vaccine in the absence of ticks. This response originating in Region 4, was based on the observation that producers would vaccinate cattle more as their natural resistance was much lower.

- A limited reduction in pest control. In some areas, pest control reduction was limited as producers do not control ticks at the moment, most apparent in Region 5, or they are actively controlling other pests concurrent with ticks, especially Buffalo Fly.

The quantification of these factors, although on only basic data, was one of the strengths of Batholomew and Davis (1993). The following results for each region were obtained and displayed in Table 10.

Table 10 Evaluation of the eradication strategy against the current control policy with future chemical control and with no chemical control (1993 dollar terms)

	Chemical Control ($m)			**No Chemical Control ($m)**		
	Benefits	Costs	BCR	Benefits	Costs	BCR
Region 1	135.260	155.124	0.87	137.368	155.124	0.89
Region 2	181.975	178.886	1.02	314.918	178.886	1.76
Region 3	338.153	248.868	1.36	423.770	248.868	1.70
Region 4	231.269	133.020	1.74	339.559	133.021	2.55
Region 5	24.350	138.225	0.18	25.902	138.225	0.19
Total	**911.007**	**854.125**	**1.07**	**1,241.516**	**854.125**	**1.45**

Source: Based on Batholomew & Davis (1993)

The costs of the eradication strategy are the same regardless of whether chemical control exists in the future. The composition of the benefits however were considerable different. In the future chemical control situation, the benefits are evenly divided between chemical control savings (45%) and lost cattle production (48%) with the remainder being tick fever savings. In the situation where no chemical control measures exist in the future, there are no chemical control savings, (as dipping would not occur in either situation) and the vast majority of the benefits are in avoided production losses which have increased with no tick control measures.

The Batholomew & Davis (1993) report provides only a simple evaluation of the Queensland's current tick policy and one widely disregarded alternative. Apart from the problems of the plausibility of the eradication strategy and the data already discussed above the results of the report are open to variance depending upon factors such as:

- a possible lack of producer cooperation;
- the inappropriateness of the ten-year time frame for eradicating cattle tick;
- the need to achieve 100% musters with partial and full destocks in certain areas;

- the removal of feral animals from tick infested areas;
- the level of tick infestations during the period of the eradication;
- the possibility of tick reinfestations;
- the possible effect of global warming;
- changing relationships with key export markets.
- Batholomew and Davis (1993) acknowledged some of these factors but the lack of any sensitivity or risk analysis limits the value of the results to conjecture. Any serious examination of the Queensland needs to take the above issues into account and begin without a thorough examination of the existing policy against the no Government intervention scenario. The development of a CBA of the existing cattle tick policy in Queensland is discussed in Davis (1996b).

4. Economic Evaluations of *Boophilus microplus* and other Ticks in other Countries

Boophilus microplus is a significant economic pest, not only in Australia, but throughout Asia, Africa and South America. Other species of cattle tick are also problems to stockowners in overseas countries, including the USA, but particularly to producers in Asia and Africa where numerous tick species co-exist. McCosker (1979) estimated the global cost of ticks and tick borne disease at US$7,000 M (over $25,000 M in 1996 Australian dollars).[44] As ticks are a major problem to many countries, a comparison of economic evaluations of Government policy towards *Boophilus microplus* (and other ticks) has been undertaken.

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[44] Based on an estimate of the 1 billion cattle in tick infested areas throughout the world costing US$7.00 per head per annum in control and lost production costs. Horn (1987) using a similar estimation method asserts costs associated with ticks in South America at US$1,000 per annum (approximately $1,800 M in 1996 Australian dollars).

Government policy throughout the world is varied. In most countries, Government involvement is limited and any tick control is the responsibility of stockowners. This is the case in African and Asian countries, where the number of tick species, the cost of chemical tick control, the lack of appropriate infrastructure, the low income levels of the countries, and the complexities involved in organising large scale pest control programs, prevents serious consideration of policy alternatives such as eradication.[45]

The United States has had Government intervention in tick control since 1906. Major losses from tick fevers transmitted by *Boophilus microplus* and *Boophilus annulatus, and* the exclusion of the 14 tick infested Southern States from important Northern beef markets had a considerable effect on the US beef market (George, 1991). Graham and Hourrigan (1977) cite a 1906 which estimated the cost of the indirect losses caused by *Boophilus annulatus* as $US130.5 M (in 1906 dollar terms). Producer lobbying led to the United States Department of Agriculture[46] (USDA) coordinating an eradication campaign for the two cattle tick species. This campaign consisted of strategic compulsory dipping and quarantine measures was completed successfully in 1947, cost a total of $US53.5 M (in 1953 dollars) (George, 1991). The support of producers, state and local authorities was essential to the campaigns success (contributing 65.1%) and most States passed legislation to ensure compliance with the USDA's campaign.

Current US Government policy consists of monitoring tick populations in neighboring countries and eradicating reinfestations if they occur, such as in Florida in 1960 (George, 1991). Bram & Gray (1979) discuss an unpublished USDA CBA which retrospectively evaluates the benefit-cost ratio of tick eradication in the US as 140:1 and the benefits of the US quarantine and control measures for tick-fever as 98:1.

In the neighbouring island countries of Puerto Rico and Cuba, eradication programs are currently underway. The Cuban program aimed at eradicating *Boophilus microplus*,

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[45] The tick symposium on integrated tick management in Africa, provided reports on the status of ticks in African and Asian countries, including Fassanmi & Onyima (1992) on Nigeria, Muberuka (1992) on Rwanda, Fanisko & Ndzinge (1992) on Botswana, Chhabra (1992) on India, Okello-Onen et al. (1992) on Uganda, Mekonnen et al. on Ethiopia (1992) & Wamukoya (1992) on Kenya. In most cases, achieving compliance with any integrated tick program was difficult because of large numbers of poor and uneducated stockowners.

[46] Through its branch the Federal Department of Animal Investigation.

Boophilus bovis and *gmblyomma cajennense*, involves dipping of the island's approximately 8.5 M cattle at regular interviews, (Milign, 1991). Information on this campaign, and associated economic benefits are limited. A significant cost-benefit analysis of the Puerto Rican campaign has been conducted and is discussed in more detail in 4.1.

In South America, the major beef producing countries of Brazil and Argentina are infested with *Boophilus microplus.* Brazil, with cattle herd of over 130 million, has a very significant tick problem, with most of the country suitable for the tropical pest. Government intervention is minor with only a few movement restrictions and some technical support (Evans, 1992).

Argentina, on the other hand, is undergoing a major eradication program of *Boophilus microplus* following on from the success of their foot-and-mouth eradication program which will open up new export markets for Argentinean beef. A costing exercise of the effect of *Boophilus microplus* in Argentina was undertaken by Späth et al. (1992) using a methodology similar (although more thorough) than the costing exercise conducted by the Cattle Tick Review Committee (1973). The costs incurred through tick infestation in the favourable regions within Argentina[47] include $US154.64 M (approximately $214 M in 1996 Australian dollars) for hide damage, weight loss and deaths, and $US34.86 M (approximately $39 M in 1996 Australian dollars) for tick control and tick fever vaccine.

4.1 Cost Benefit Analysis of Tick Eradication in Puerto Rico

Boophilus microplus was eradicated from Puerto Rico after a campaign extending from 1936-1954. However, reinfestation of the island, by *Boophilus microplus* as well as the tropical Bont tick, *Amlyomma varigatum* occurred in the 1970s (Garris et al., 1989). An eradication program, a cooperative effort of the United States Department of Agriculture (USDA) and the Puerto Rico Department of Agriculture (PRDA) began in 1978 with the aim of eradicating both tick species. Funding problems slowed the progress of the eradication program until a new source of funding, the Puerto Rico Department of Social

[47] Like Australia not all areas or Argentina are suitable for *Boophilus microplus.* The tick infested region is north of a line running roughly between Buenos Aires and Cordoba.

Services (PRDSS) and, more importantly, the United States Food and Nutritional Service (FNS) in support of its international nutritional assistance program. The justification for funding from these services was that tick eradication would increase the supply of beef, therefore providing residents of Puerto Rico with greater access to red meat.

The Puerto Rico analysis compared two scenarios. The first was the continuation of funding for the tick eradication program over the period (1990-1991) to enable its completion in 1991. The second was the termination of the tick eradication program with the PAN funding being supplied to Puerto-Ricans in the form of food stamps. The analysis was conducted through a simple computer program written especially for the CBA.[48]

The eradication campaign in Puerto Rico also included the tropical bont tick, *Amblyomma variegatum,* which was found on cattle in the country in 1974 and was widespread by 1978 (Geri et al. 1990). Cattle is a favored host of the tropical bont tick and can be treated by the same chemicals as *Boophilus microplus,* creating considerable economies for a joint eradication campaign.

The CBA concentrated on determining the production constraining effect the two tick species have on producers. The main benefits from eradication would be derived from increased meat and dairy production over the long-run, however in this model only the time-frame 1990-1995 is considered. The level of lost production was determined by estimating the average level of meat and milk production lost from the proportion of cattle with a significant tick infestation (greater than 15 females ticks) including an expected cost for tick fever mortality. The model utilised the Australian research on liveweight and milk production losses. Prices of milk and meat were exogenous to the model.

[48] The CBA computer model was written in Pascal. It is a basic computational model which could have been completed in a spreadsheet in a manner similar to that described in Harrison (1996).

The alternative to the tick eradication, distributing the funds for tick eradication in food stamps to needy families, was examined in the CBA as a ‘do nothing’ option. Benefits relating to improved nutrition from an extension of the food stamp program were not quantified although statistics were included in Geri et al. (1989) outlining nutritional outcomes and areas of ineffectiveness in the existing FNS program for Puerto Rico. The short time-frame included in the analysis meant that the costs of alternative 2, only considers the production saved by having the cattle treated (and therefore minimising any tick losses across the island) in the eradication program. Benefit-cost ratios were the decision-criteria chosen, with figure provided for the entire eradication campaign 1983-1995 (with avoided loss production considered retrospectively and for the period in which FNS was being sought 1990-1995.) The result was that tick eradication provided a benefit cost ratio of 3.56:1 for the entire campaign and 7.03:1, for 1990-1995 (Geri et al. 1990, p.29).

The Puerto Rican analysis, like many of the Australian reports was blemished by the lack of available time to effectively explore the benefits and costs of alternative policies and a lack of scientific data relating to Puerto Rican experiences. Most of the comparisons between the important criteria for the funding body, nutritional improvements for Puerto Ricans is done through comparing possible statistics. Price evaluation for milk and meat, should also have been examined as well as the benefits (and reinfestation costs) over a longer time period.

5. Conclusion

Aside from the Cattle Tick Review Committee (1980), evaluation of public policy towards tick control has not provided decision-makers with thorough investigations of the economic effects of pest-control options. The lack of proper consideration of alternative policies can often be attributed to time constraints and other external pressures as can be witnessed in both the Australian and international Government reports on tick policy. The Cattle Tick Review Committee (1980) is the only report, although cautiously, to provide any serious evaluation of alternatives to existing policy, or the policy funding is requested for within the CBA.

In Queensland especially, the lack of a thorough investigation of the current tick policy which has basically been unaltered since initial infestations of *Boophilus microplus* in the early 1900s means that the Government and producers do not know the current worth of existing policy, and if any changes bring positive benefits.

Future research by the author will be aimed initially at evaluating the worth of Queensland's current policy towards the cattle tick against a 'do nothing' situation and then extending the analysis to examine alternatives such as partial and full eradication on a region-by-region basis.

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