Community Action and Pest Control

Rex Davis and Steve Harrison

Paper presented at the 43rd Annual Conference of the Australian Agricultural and Resource Economics Society. Lincoln University, Christchurch 19-21 January 1998.

Abstract

Several authors have recognised pests as a negative common property resource. As a common property issue, there are often benefits to be gained in regional coordination of pest control activities. Entomologists have also recognised the potential benefits from regional coordination programs and have encouraged areawide Integrated Pest Management (IPM) strategies. However, despite the acknowledgment of differences between individual and regional economic thresholds, studies have not been conducted into the conditions that ensure or prevent collective action in pest control. This is surprising given the vast amount of literature on collective action theory and practice that has accumulated since the work of Mancur Olson. This paper discusses pest control and eradication issues that are likely to generate differences between individual and regional economic thresholds. Insituations where community action is likely to bring positive benefits, the paper examines the likely success of community coordination and possible hindrances. Australian collective action pest situation examples are provided.

Introduction

Ayer (1997) in his presidential address to the Western Agricultural Economics Association raised the issue that grass-roots collective action has potential to achieve net benefits in the agricultural industries. Producer driven collective action is an alternative to government regulation in achieving net benefits when faced with agricultural centred environmental issues which exhibit externality or public good attributes. Moreover, Ayer (1997) states that many situations can already be seen where producers have grouped together in order to handle issues such as research, environmentally sustainable agricultural practices and pest-control.

Pest-control is one area that particular warrants investigation in terms of collective action, due to its fundamental relationship to the profitability of most agricultural industries. The common property nature of pests and the externalities caused by individual pest control decisions mean that there is a significant divergence between regional and individual benefits. For example:

- a producer decides not to treat a pest, creating a higher regional population of that pest species and greater damage or treatment costs for neighbouring producers;
- spray drift situations, in which a producer sprays with a chemical that is incompatible with farming activities on neighbouring properties;
- a producer excessively utilises a pesticide expediting the level of chemical resistance for the region;
- producers refuse to provide permission for regional aerial spraying of pests that are damaging neighbouring cropping properties; and
- eradication schemes are derailed, or the cost is increased, due to poor producer cooperation.

Given these scenarios and the likely net benefits available from regional collective action for particular pest control issues, economists need to examine:

- if collective action is a viable policy alternative;
- why collective action has not arisen in many pest control situations in the past;
- what barriers exist to achieving collective action; and

- what steps (policy mechanisms) could be undertaken to make collective action more viable.

This paper examines collective action opportunities from the perspective of achieving improved control or eradication for the cattle tick (*Boophilus microplus*) in Queensland, Australia. In particular, the paper examines the role of voluntary eradication schemes (VES) for the cattle tick which are encouraged by the Queensland Department of Primary Industries (QDPI) as an alternative to current Government regulations. The theory of collective action and the likely implications for the success or otherwise of the VES are discussed. Existing economic evaluation tools that assist the pest control decision-making process for individuals (economic threshold models) and for Government (cost-benefit analysis) are examined for their usefulness in appraising collective action schemes. Means by which economic evaluation techniques can be modified to both appraise collective action programs, and act as a decision-support tool in the establishment of collective action schemes such as the VES are examined.

Common Property and Externality Issues in Pest Control

There are two factors that lead to a divergence between individual and regional pest-control benefits. These are the common property nature of pests and the externalities they create.

The major reason for collective action in pest control is the fact that many pests are negative common property resources. A common property resource is one in which no single economic agent has exclusive control (Tietenberg 1992). Normal common property resources often suffer from the "tragedy of the commons" in which the lack of property rights lead to an over-exploitation of the resource to everyone's detriment (Hardin 1968). Pests as a negative common property resource cause reduced production for all firms (producers) within a region. Producers controlling a pest not only provide a benefit to themselves but also to all other producers in the area through reduced pest damage or control costs due to a reduction in the regional pest population.

Regev et al. (1976) were the first to observe the common property nature of pest control. Their paper concentrated on the difference in the pest population level caused through control at the societal level and that which is desirable from the individual level. In their model, a producer has no reference to the regional pest-population, acting only on the pest population on their property. In the alfalfa weevil control situation examined by Regev et al. (1976), the optimal societal and private outcomes differ in the timing of chemical treatments. Achievement of the societal outcome could occur through greater use of information agencies (extension services). The possibility of (potential for) even greater divergences may have been established if resistance issues were considered.

Lazarus and Dixon (1984) also examined pests through a common property resource model. Their analysis was on corn rootworm, a problem to producers in the mid-west of the USA. The externality caused by the common property nature of this pest is that adult corn rootworms become beetles capable of flight. In this sense a producer diligently controlling corn rootworm may see no pay off for their action in the future if neighbouring properties do not control the pest. Lazarus and Dixon (1984) use a simulation model, that includes resistance effects, and find only a slight delay in the onset of chemical resistance is achieved if regional coordination occurs. The advantages to regional coordination would also have to be offset against the costs of organising the collective action, which can be substantial.

Regev et al. (1976) also observed that there are many possible divergences between individual and society pest-control viewpoints caused by external effects aside from biological interactions related to the common property component of pest-control. Many of the negative external impacts of particular pesticide practices have been well documented, most notably in Carson (1963). These external impacts include food safety issues, agricultural worker safety, and environmental consequences such as groundwater contamination. The serious and often irreversible consequences of these external impacts and have been the major foundation in Government regulations or bans on pesticide use (Zilberman, et al. 1991). The externalities of greatest interest are those imposed directly on other producers, forming a rationale for the establishment of regional coordination.

The Theory of Collective Action

The common property nature of pests and the external effects of pest control indicate that in particular circumstances regional coordination is necessary to achieve optimal results. Given this premise, the mechanisms by which people choose or do not choose to cooperate needs to be examined.

Olson (1965) in the *Logic of Collective Action* redefined the way in which economists and sociologists view examples of collective action. Olson's major contribution was the observation that economic agents (rational and self-interested) will not contribute or act to achieve group interests. Olson argued that just as economists' have argued that public goods such as services of defence forces and police would not be voluntarily paid for by the community, the same problem occurs for collective goods (Oliver 1993). A collective good is one without excludability, that is a good which once provided to one person cannot be withheld from another (Olson 1965). As Olson (1987) writes,

> **"If the individuals in some group really do share a common interest, the furtherance of that common interest will automatically benefit each individual in the group, whether or not he has borne any of the costs of collective action to further the common interest."**

Because of non-excludability, collective actions that could provide considerable benefits are often not undertaken. Three fundamental issues in determining whether collective action can be established and sustained in the absence of regulation are group size, group composition and the ability to impose selective incentives (Marwell and Oliver 1993). Firstly, as group size increases, the probability of the collective action failing increases because each person views their share of the gain to be so small that they refrain from contributing to the collective action (Sandler 1992, 10). Secondly, differences within the grouping of interest, in the form of factors such as resources, tastes and objectives will result in breakdowns. Olson (1965) observed that this would most likely result in wealthier groups to cover the majority of costs in providing collective goods. The third condition required for successful collective action is the imposition of "selective incentives". Olson (1965) refers to movements such as labour unions achieving collective action with the incentive of additional wages from a "closed shop" arrangement.

Considerable extensions and revisions to the theory of collective action from an economic perspective have occurred since Olson wrote on this topic in 1965. Many of these extensions have involved varying assumptions and situations, and evaluating the implication for the success or otherwise of a collective action. In particular, variations of the Prisoner's Dilemma (PD) situation have been most common. In the PD model, as referred to by Marwell and Oliver (1993), two persons suspected of committing a robbery, are apprehended and separated. Without a confession the police do not have enough evidence to convict them of the robbery, but are able to charge them with a lesser firearm offences. To obtain a confession, the police offer a charge less serious than that for the robbery but greater than the firearms if both confess. If only one confesses then the confessor will receive a sentence less than the firearms charge while the partner receives a maximum sentence. As both prisoner's are unable to communicate, the dominant strategy is that both prisoner's confess which results in a worse situation for both than if they had not confessed. The extensions to PD include varying the pay-offs, iterating the game and extending the group size. These variations have helped evaluate expected economic behaviour for a multitude of situations, including strategic defence relations between countries, oligopoly behaviour, labour relations and management of natural resources. A more extensive review of non-cooperative game literature can be found in Reisman (1990), Sandler (1992) (Sandler 1992), Oliver (1993), Marwell and Oliver (1993), and Baland and Platteau 1996.

One of the major benefits from studying collective action situations is that it advises of the regulatory frameworks that may be necessary to maintain collective situations in which net benefits are achieved for producers. Using Olsen's (1965) "selective incentives" criteria, taxes or subsidies may be required to ensure compliance to a particular group objective. The variety of situations that have been examined in the literature provide a guide to possible outcomes for collective action in pest control situations.

Examples of Collective Action in Pest Control

Although by no means a common occurrence, there are several examples of producer-driven collective action in pest-control situations. The collective action examples examined here are those in which producers are addressing pest-control issues on a completely voluntarily basis or with minimal government intervention.

Integrated Pest Management (IPM) appears to have a synergy with producer-driven collective action. The United States administration has announced the goal of achieving an integrated pest management scheme for 75% of all crops in the United States (Faust

1997). IPM as defined by Gardner 1996 relates to the incorporation of all control techniques, particularly natural and non-chemical control techniques to limit pest populations. Integrated Pest Management is an important consideration in pest control because of the emphasis placed on it due to control resistance problems as well as the health and safety considerations relating to chemical control use (Pimentel et al. 1993). In Australia, the emphasis has broadened to best management practice (BMP) and the cotton industry has developed a BMP manual.

In many situations, only part of an IPM scheme can be achieved successfully on an individual property. For example, if external pest populations are significant, a producer's decision to implement an IPM strategy that limits chemical control methods so as to ensure a large population of natural pest predators, is negated by a neighbouring producer continuing to engage in a high chemical control scheme that kills the natural pest predators. Despite these issues many IPM applications are focused on individual producer IPM strategies. Cowan and Gunby (1996) for example discuss IPM and traditional pesticide use as competing technologies for individual producers to choose. Interest in regional IPM strategies though is certainly increasing as pest species become more dogmatic due to chemical resistance and conventional approaches continue to fail (Comis 1997). Areawide IPM strategies are not new and have been ongoing for many years in the form of Government chemical treatments, organised pest campaigns and provision of extension information. However, what can be seen in recent examples is heightened producer cooperation and innovation in both developing and participation in collective action schemes.

Ayer (1997) provides the example of producers in Arizona banding together to combat boll weevil, pink bollworm and other pests. The collective action consists of producer meetings to plan pesticide applications and to examine ways to finance and eradicate these pests from their regions. Comis (1997) reports of an areawide IPM scouting and baiting program in Illinois in which 45 out of 46 producers in the region agreed to participate. In Australia, a similar experience can be found on the Darling Downs (Southern Queensland) and Central Queensland where producers have developed with the assistance of the Queensland Government, a regional management strategy groups to plan a regional strategy towards heliothis management. In these voluntary management strategies, QDPI officers provide technical assistance to grain and cotton producers in terms of planting and pesticide treatments.

Voluntary Eradication Schemes for the Cattle Tick

The major focus of this study are the VES schemes for eradicating cattle tick in Queensland. Cattle ticks are a major pest parasite in Queensland, which is estimated to cost producers in this State up to $134 million per annum in lost production and control costs (McLeod 1995). The tick causes weight-loss and transmits pathogenic parasites, *Babesia bovis*, *Babesia bigemina* and *Anaplasma marginal* which can lead to illness or death (Stewart and de Vos 1984). The Queensland Government's main policy against cattle tick is the maintenance of the tick-line, a boundary which divides Queensland into tick-free and tick-infested regions based largely on the tick's enzootic boundaries. The tick-line is enforced through movement regulations on stock. A complete history of the cattle tick in Australia and measures for its control can be found in Angus (1996). In 1993, the Queensland Government announced the introduction of VES. These schemes begin with producers in an area providing a proposal to the government to set up a cooperative for the eradication of cattle tick. The costs of the inspections for the eradication scheme are shared equally between the Queensland Government and the cooperative members (producers). The shared cost equates to the administration costs and the cost of the stock inspectors conducting the inspections. Management of the tick eradication program in the region is through a producer-run tick eradication implementation committee. The major component of eradication cost is that of successive treatments prescribed by the eradication program all of which is met by individual producers. Several voluntary tick eradication schemes are current in Queensland. The first, at Taroom approximately 500 kilometres North West of Brisbane, is almost complete and proved successful. The time-frame for VES eradication strategy is between 3-5 years for each cooperative scheme.

New eradication schemes are currently being undertaken in regions near the tick-line boundary with additional VES anticipated after the participants in the current schemes achieve tick-free status.

Problems for Collective Action Schemes in Pest Control

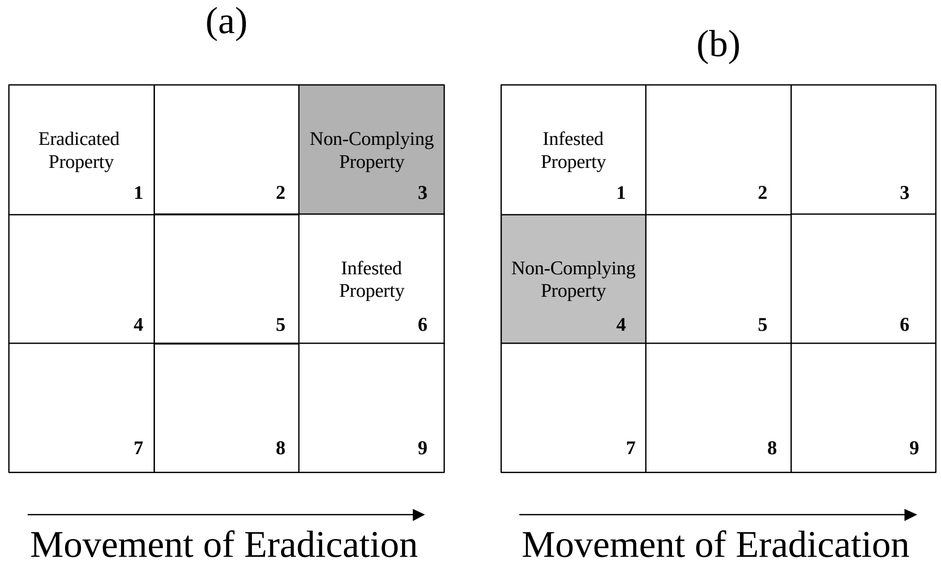
As mentioned above, the success of collective action will depend upon group size, the composition of the group and the ability to impose selective incentives. In the pest control collective action schemes described above, group size has tended to be kept small (generally no more than 100 producers). If a large area with numerous producers faces a common pest problems it may be more effective if several small collective schemes were established as opposed to one large scheme. A major determinant of group size will be the degree of compliance required to make the collective action successful. In particular pest control situations, such as tick eradication, full participation and compliance from all cattle and dairy producers in the region is necessary for success. In these situations, smaller collections of producers limit the probability of failure due to non-compliance.

Group composition has the potential for being a cause of collective action breakdown due to the emergence of non-cooperative group members. Producers may be similar in terms of the commodity they produce, however there are extensive differences between producers in terms of wealth, property size, attitudes, marketing and education. In the VES these differences manifest themselves in breed selection and where producers market their beef. High *Bos indicus* cattle breeds such as Brahman have high levels of tick resistance and graziers with these breeds may choose to provide little or no treatments for cattle tick. On the other hand *Bos taurus* cattle are highly susceptible to tick infestation and the associated side effects and require significant tick control measures to prevent economic loss. A further issue is that some producers in the tick-infested region are aspiring to produce a high quality premium beef product aimed at domestic restaurant markets whereas their neighbouring producers may prefer a quantity-driven live export market where the end quality of the meat is less important.

In terms of the success of a VES, where 100% participation is required, group heterogeneity, particularly in the composition of benefits, can lead to a complete breakdown of the collective action. For example, in particular regions a small producer with *Bos taurus* cattle who plans to send cattle south to premium domestic markets once tick-free status is achieved and movement regulations no longer apply. A neighbouring property on the other hand may be a large property of primarily *Bos indicus* cattle who sells stores cattle and occasionally transports cattle through tick-infested areas for the live export market. These producers while producing meat have significant differences and this will effect their attitudes towards tick eradication. The smaller producer will be highly supportive of the tick eradication program, whereas the benefits to the larger producer are limited. Furthermore, the larger producer may actually prefer a degree of infestation to maintain resistance to tick fever which would save the producer administrating tick fever vaccinations in the case of an outbreak. Heterogeneity in groups is extended when producers of different products group together to combat a pest, such as wheat and cotton producers' heliothis management schemes. Although not requiring full compliance to achieve benefits for producers, differences in planting and harvest times between the crops, rate of returns on the crop, effect of the pest on crops, can make coordination difficult.

Provision of selective incentives, like group composition, is a challenge in the establishment of collective action in pest control. In the heliothis example, the 27 producers in the management schemes core area and the 92 likely to join from adjacent areas are estimated to have spent $10 million on pest-control for below average crop yields (Anon., 1998). Coming from this basis, all producers in the management schemes are likely to gain personally from their participation but these benefits cannot be exclusively provided to the participants, as all producers in a region (whether they participate or not) will a resulting lower heliothis population. If one of the 27 producers in the core area does not partake or contribute to the scheme then they are still likely to have a lower heliothis problem thanks to their neighbours and have not had to pay for this benefit. In the VES example, selective incentives are possible in that only participating properties may be included in the tick free area. However, depending on the location of the non-participating producer, the participating producer may not be declared tick free either. This is illustrated in Figure 1 below.

Figure 1 – Spatial Importance of Compliance in Pest Control Eradication Situations



In Figure 1, a region consisting of nine properties of equal size attempting a VES are represented schematically. In both situations (*a* and *b*), eight properties participate and one property refuses to participate (indicated as the non-complying property). All properties to the west, north and south of the region have been declared tick-free previously and have a natural boundary with the region being examined, such as a mountain range, whereas all properties east of the region are tick infested. Here it is assumed that once the VES eradication scheme has been conducted and inspectors are satisfied that ticks have been eradicated from the property, as well as its northern, north-western, southern, south-western and western neighbours, than the line can be moved east. In situation *a*, Producer 3 is the non-complier, and due to the eastern position of that property, properties 1,2,4,5,7 and 8 are able to be included in the tick-free region. Property 6, south of the non-complier 3 and property 9 (south of property 6) remained infested. In situation *b*, Producer 4 is the non-complier and due to that property's western location, the VES is a complete failure.

The spatial importance of compliance is therefore an important additional component that needs to be considered in the establishment of collective action for pest control or eradication. Even if one producer is a non-complier, the collective action could still succeed if all the other producers in the area are willing to cover the cost of eradicating the pest on the non-complier's property, provided the non-complier agrees to this action.

This introduces a further problem for the success of collective action in pest control - the time frame under which collective action schemes occur. Consider the following scenario in which an eradication scheme of nine producers requires a three year time-frame to complete. In the second year, one producer with marginal benefits decides not to continue with the scheme. However the scheme continues with other the producers with high benefits from eradication agreeing to pay for eradication on the defector's property. As with any free-rider problem, the remaining producers may also choose to defect. The eradication schemes can now be related to an iterative non-cooperative game, where each producer makes a decision as to whether to comply with the eradication scheme, or depend on the other producers to cover the costs. As many collective action models have only been evaluated using simulated laboratory experiments or computer simulations, the voluntary eradication schemes present an excellent opportunity to establish some evidence on likely collective action outcomes.

The issues discussed above highlight that the role of government to provide mechanisms that assist the establishment of collective action. With VES, the stock inspector has wide ranging powers under the *Stock Act 1915* but requires a ministerial directive to force a non-complying producer to treat their cattle. Traditionally, there is a reluctance from government to provide these directives and heavy-handed approaches to non-compliers may influence producer decisions in the establishment of new schemes. On the other hand, tick eradication which may have high benefits to a region, particularly if chemical resistance is likely in the near future, is subject to failure due to the actions of one producer. An alternative approach is to provide a selective incentive situation in which stock movement regulations are imposed on the non-complier as if they are the only tick infested property in a tick-free region.

Mechanisms for supporting collective action programs require further investigation. Although ideally producer-driven collective action will succeed on its own merits, many obstacles make its provision unlikely, particularly given the high degree of voluntary compliance required for success and the role of the non-compliers not as free-riders but as the ultimate cause of failure in pest control collective action.

Assisting Collective Action Decision-Making

A challenge for economists is the evaluation of collective action schemes. The economic appraisal of pest control decisions has taken two forms in the past. For the optimum pest control strategy of individuals producers, the economic threshold method has been calculated to aid decision-making. For government pest control and eradication schemes, cost benefit analysis has been applied. The following discussion examines these approaches and their applicability for the economic appraisal of collective pest control schemes.

Applicability of the Economic Threshold Concept

The economic threshold is a method for assisting producer pest control decision-making. The concept was developed by Stern et al. (1959, p.86) who defines the economic threshold as "the density at which control measures should be determined to prevent an increasing pest population from reaching the economic-injury level". The economic injury level is the pest population density that will cause economic damage, that is the point at which the cost of treatment would be recouped from a higher crop yield . Since this paper was published in 1959, definitional divergences on the point of the economic threshold have developed, with Headley (1972) in particular providing a definition in which the threshold is the level of treatment provided to maximise profits. Plant (1986) and Weersink et al. (1991) have labelled the differences between Stern et al. (1959) and Headley (1972) definitions as the entomological and economic interpretations of the economic threshold respectively.

Despite these definitional differences the economic threshold concept remains a popular in assisting individual producers in their pest control decisions. A small selection of recent examples in the literature of these studies include Van den berg et al. (1997), Tumminelli, et al. (1997), Midgarden, et al. (1997), Brodersen (1997), Hartzler (1997) and Bor (1997).

Threshold models however do not address the divergence between thresholds for individual and regional viewpoints. An economic threshold may indicated how many engorged ticks on Brahman cattle or Hereford cattle[1] should be tolerated before treatment occurs. However, from a regional perspective the question is how many engorged ticks represent the economic threshold if producers of these breeds live side by side and are acting collectively to reduce tick numbers? The calculation of this threshold is likely to be complex when other contributing factors such as chemical resistance and multi-pest control are included.

A problem in attempting to construct a collective economic threshold is that pest control decisions may be made without any reference to a pest population. In the treatment of the cattle tick, QDPI recommends a preventative strategic dipping program which occurs annually, regardless of the pest population. In this regards the economic threshold, while useful in assisting individual producer pest decisions, may not provide meaningful assistance in terms of collective decision-making.

Cost-Benefit Analysis in the Evaluation of Collective Action

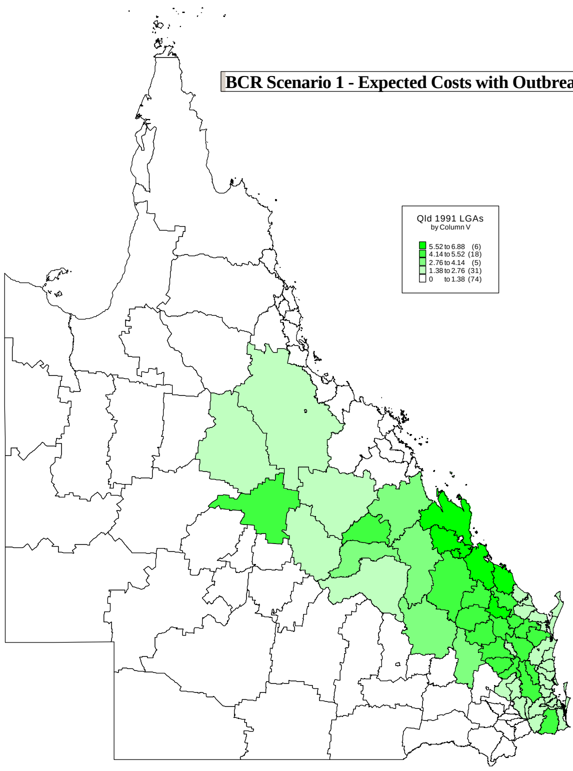
Cost-benefit analysis has widespread use in the evaluation of government programs relating to animal health or pest control (McInerney et al 1992). The advantage of the cost-benefit analysis is that it is able to compare different pest control options in terms of overall benefits and costs and provides easily understood summary estimates such as the benefit-cost ratio. Cost-benefit analyses are usually applied to examine public expenditure on pest-control projects. This has certainly been the case in relation to cattle tick in Australia and overseas (see Johnston, 1975). Since cost-benefit analyses are already conducted on a societal basis, there is high applicability of this method to collective action situations.

In Queensland cost –benefit analysis has been used to examine a short-term “major push” eradication scheme for the cattle tick (Bartholomew and Davis 1993) and the removal of government control mechanisms altogether (Davis 1998). Recently, a regional cost-benefit analysis model has been developed to examine eradication by VES on a shire by shire basis. Essentially, the benefits in this model derive from weight gains for the cattle and savings in control expenditure. The costs of the program are the additional treatments required to achieve eradication and the administration cost. Three expected outcomes were examined, viz. best, expected and worst case situations in

[1] Economic thresholds for tick control can be found in Corlis & Sutherland (1976), Burns, et al. (1977) and Sutherst, et al. (1983).

which the pace of eradication was varied in regions based on the expectations of stock inspectors. Two outbreak scenarios were included with a varying per head cost of containing and eradicating reinfestation.

Figure 2 is a thematic map of the benefit-cost ratio for each local government area (shire or council) in the selected tick infested region[2] of Queensland for the expected outcome with the low cost outbreak scenario.



This cost-benefit model is at a preliminary stage of development and the current target audience are animal health officers in QDPI. The results of this model show that there are net positive benefits for the eradication of the cattle-tick through a series of progressive VES to most of the tick infested regions with the exception of the far northern coastal areas.

As with all cost-benefit models the accuracy of the results is dependent on the assumptions pertaining to the main parameters. In this case, weight loss caused by the cattle tick, the pace of eradication, the cost of reinfestation, the existence of other parasites treated in situations by the same chemicals (such as Buffalo Fly in

Queensland) and the extent of control currently exercised by producers towards the cattle tick, will all have a significant outcome on the calculation of costs and benefits. Furthermore, these assumptions will often be regionally specific; for example, producers in each shire in Queensland are likely to have slightly different approaches to cattle tick management, and within each shire, producers are also likely to be heterogenous. Greater regional information, therefore will undoubtedly improve results. For example, incorporating the underlying herd and property structure of a region can provide more accurate results in terms of the degree of weight-loss currently caused by the cattle tick, extent of producer treatments for the cattle-tick and likely marketing benefits, such as access to premium beef-markets currently limited by tick infestation.

Given these factors, the aim of the approach to cost-benefit analysis is to make it interactive, with producers aiming to establish their own VES. A VES will generally be conducted on a shire or part-shire basis, depending on the natural topology and the number of producers in the region. The VES guidelines requires producers in an area to put forward a proposal for establishment of a VES. Stock inspectors and other animal health officers from the QDPI facilitate this process by providing information on the potential costs of the eradication scheme to the producers. To date, this information has been qualitative, with producers aware of their own control expenses and their own potential benefits. The approach that is being developed would enable producers to interactivity plan and evaluate the cattle-tick eradication process with QDPI officers. The cost of the eradication process is easily quantified and adjusted. In essence, the cost of an eradication scheme involves a number of treatments and inspections per year for infested cattle. Costs are included for:

- expenditure on chemicals for treatments;
- the cost of mustering the cattle for treatment or an inspection;
- the labour component of treating or inspecting the cattle (producer and the stock inspector's time while the treatment or inspection is being performed); and
- the administration cost for coordinating the VES.

The expenditure on chemical and labour for treatment will depend on the eradication strategy chosen. If an eradication scheme prescribed 3 treatments with Acatak®, a pour-

[2] In this model as in Batholomew and Davis (1993), removal of cattle ticks in far-north Queensland was considered to be logistically impossible based on current technology.

on chemical treatment over a set period of time, then the cost is calculated on a per head basis for both labour time taken and the chemical component. However other chemical strategies may require the inclusion of a capital component such as depreciation and maintenance costs of plunge dips.

The mustering cost is also determined on a per head basis and will depend on the underlying property and herd structures within the region. For example, the mustering cost of a large station of 30,000 ha with 3,000 cattle will have significantly different mustering costs per head to a small property with 300 head. This cost of mustering, as with many of the benefits of tick eradication, is examined through identifying a range of representative properties for the region. The region in which the VES is being established is described through representative properties. Table 1 describes the representative properties in a hypothetical region.

Table 1: Description of a Hypothetical Region through Representative Properties

	Representative Property *A* (20%)	Representative Property *B* (50%)	Representative Property *C* (30%)
Size (Hectares)	33,000	8,000	750
Herd Size (Head)	3,200	1500	350
Breed Type	¾ Brahman cross (High *Bos indicus*)	Hereford (*Bos taurus*)	¾ British breed (High *Bos taurus*)
Current Tick Control Procedures	No treatments	4 treatments all cattle	4 treatments
Form of Treatment Administration	n/a	Plunge Dip	Pour On
Chemical Used	n/a	Barricade	Ivomec
Tick Fever Administration	No	Yes	Yes
Mustering per Treatment or Inspection	4 persons, 3 days	3 persons, 3 days	2 persons, 1 day
Other Parasites	Buffalo fly, lice	Buffalo fly	Buffalo fly
Treatment of other parasites	No Treatments	As per tick treatment, control ¾ for buffalo fly, ¼ for cattle tick.	As per tick treatment, control ¼ for buffalo fly, ¾ for cattle tick.

From this information not only are mustering costs able to be determined but also the likely weight gain benefits based upon the cattle type and the control savings. A region can be made up of any number of representative properties, although as the model is to be used interactively with producers, a maximum of 10 representative properties should be considered. A database of representative properties is being developed and will be based on information received from producer surveys.

The interactive process is being developed in Visual Basic® with the standard Microsoft Office® components, such as Excel and PowerPoint and the use of the GIS software MapInfo® to assist with the visualisation of net benefits. The advantages of the interactive cost-benefit model being developed are:

- stock inspectors and producers are able to accurately describe the region in a manner which satisfies all stakeholders;
- net benefits are able to be seen in terms of the region as a whole and for the different representative property groupings;
- changes to eradication strategies are able to be discussed and the costs compared instantaneously;
- with producers assisting in the evaluation of eradication schemes, a higher degree of acceptance of the results is likely to be achieved.

Conclusions

This paper has examined the role of producer-driven collective action as a means of producing greater pest-control outcomes. Due to the common property nature of pest populations, regional pest control or eradication measures will often bring net benefits to producers. Existing literature on the success or otherwise of collective action states that group size, group composition and selective incentives are vital ingredients to the success of a collective action scheme. In pest-control situations, features such as the need for full compliance, the time-frame of the collective action, and the geographical location of non-compliers are also important considerations.

If producer collective action schemes are to play a larger part in achieving greater pest-control outcomes, supportive mechanisms need to be examined, particularly ways in which non-compliance is addressed. Furthermore, collective action can be assisted by making traditional cost-benefit analysis interactive. This assists the establishment of collective action schemes, such as a regional VES for the eradication of the cattle tick by demystifying the economic evaluation process and provide participants with the ability to examine the effect of different pest-control scenarios.

References

Angus, B. (1996). "The History of the Cattle Tick Boophilus Microplus in Australia and Achievements in Its Control." *International Journal for Paristology*, **26** (12), December, 1341-1355.

Ayer, H. W. (1997). "Grass Roots Collective Action: Agricultural Opportunities." *Journal of Agricultural and Resource Economics*, **22** (1), 1-11.

Baland, J. M. & Platteau, J. P. (1996). *Halting Degradation of Natural Resources: Is There a Role for Rural Communities?* New York: Oxford University Press.

Bartholomew, R. B. & Davis, R. (1993). "An Economic Evaluation of the Proposed Program Aimed at Eradicating the Cattle Tick (Boophilius Microplus) South of the Townsville - Mt Isa Railway Line." Discussion Paper. Brisbane, May.

Bor, Y. (1997). "Some Evidence for the Existence of Dynamic Economic Thresholds." *Agricultural Systems.*, **53** (22), 2-3.

Brodersen, C. (1997). "Economic Damage Thresholds and the Importance of Improved Information." *Agrarwirtschaft.*, **46** (2), 90-100.

Burns, M. A., Kearnan, J. F., Kearnan, J. F., Biggers, J. & Utech, K. B. W. (1977). "Dipping Brahman Crossbreds in S.E. Qld.. Does It Pay?" *Queensland Agricultural Journal*, **103** (6), November-December.

Carson, R. L. (1963). *Silent Spring*. London: Hamilton.

Comis, D. (1997). "Corn Belt Growers Give Areawide IPM a Try." *Agricultural Research*, **45** (10), October, 4-7.

Corlis, P. L. & Sutherland, I. D. (1976). "Dipping Brahman Crossbred Steers in Central Queensland - Does It Pay?" *Queensland Agricultural Journal*, **102** (6), November-December, 589-591.

Cowan, R. & Gunby, P. (1996). "Sprayed to Death: Path Dependence, Lock-in and Pest Control Strategies." *Economic Journal*, **106** (436), 521-542.

Davis, R. (1998). "A Cost Benefit Analysis of the Removal of the Tick-Line in Queensland." 42nd Annual Conference of the Australian Agricultural and Resource Economics Society. University of New England, Armidale, 19-21 January.

"Downs Farmers Join to Take on Heliothis." (1998). *Queensland Country Life*, 12 March, 22.

Faust, R. M. (1997). "Going Areawide Makes IPM Goal Practical." *Agricultural Research*, **45** (10), October, 2.

Gardner, G. (1996). "IPM and the War on Pests." *World Watch*, **9** (2), March/April, 20-27.

Hardin, G. (1968). "The Tragedy of the Commons." *Science*, **162** (3859), December, 1243-1248.

Hartzler, R. (1997). "Velvetleaf (Abutilon Theophrasti) Interference in Soybean (Glycine Max): A Survey of Yield Loss Estimates and Management Recommendations." *Crop Protection.*, **16** (5), 483-485.

Headley, J. C. (1972). "Defining the Economic Threshold." In *Pest Control: Strategies for the Future*. Washington: National Academy of Sciences, pp. 100-108.

Johnston, J. H. (1975). "Public Policy on Cattle Tick Control in New South Wales." *Review of marketing and Agricultural Economics*, **43** (1), 3-39.

Lazarus, W. F. & Dixon, B. L. (1984). "Agricultural Pests as Common Property: Control of the Corn Rootworm." *American Journal of Agricultural Economics*, **66** (November), 456-465.

Marwell, G. & Oliver, P. (1993). *The Critical Mass in Collective Action*. Cambridge: Cambridge University press.

McInerney, J. P., Howe, K. S. & Schepers, J. A. (1992). "A Framework for the Economic Analysis of Disease in Farm Livestock." *Preventive Veterinary Medicine*, **13**, 137-154.

McLeod, R. S. (1995). "Costs of Major Parasites to the Australian Livestock Industry." *International Journal for Paristology*, **25** (11), 1363-1367.

Midgarden, D., Fleischer, S., Weisz, R. & Smilowitz, Z. (1997). "Site-Specific Integrated Pest Management Impact on Development of Esfenvalerate Resistance in Colorado Potato Beetle (Coleoptera: Chrysomelidae) and on Densities of Natural Enemies." *Journal of Economic Entomology.*, **90** (4), 855-867.

Oliver, P. E. (1993). "Formal Models of Collective Action." *Annual Review of Sociology*, **19**, 271-300.

Olson, M. (1965). *The Logic of Collective Action*. Cambridge: Harvard University Press.

Olson, M. (1987). "Collective Action." In *The New Palgrave: A Dictionary of Economics*. Edited by J. Eatwell, M. Milgate & P. Newman. New York: Macmillan and Stockton Press, pp. 474-477.

Pimentel, D., Acquay, H., Biltonen, M., Rice, P., Silva, M., Nelson, J., Lipner, V., Giordano, S., Horowitz, A. & D'Amore, M. (1993). "Assessment of Environmental and Economic Impacts of Pesticide Use." In *The Pesticide Question: Environment, Economics and Ethics*. Edited by D. Pimentel & H. Lehman. London: Chapman and Hall, pp. 47-84.

Plant, R. E. (1986). "Uncertainty and the Economic Threshold." *Journal of Economic Entomology*, **79** (1), February, 1-6.

Reisman, D. (1990). *Theories of Collective Action - Downs, Olson and Hirsch*. London: Macmillan.

Sandler, T. (1992). *Collective Action - Theory and Applications*. Ann Arbor: University of Michigan Press.

Stern, V. M., Smith, R. F., van den Bosch, R. & Hagen, K. S. (1959). "The Integrated Control Concept." *Hilgardia*, **29**, 81-101.

Stewart, N. P. & de Vos, A. J. (1984). "Ticks and the Diseases They Carry." *Queensland Agricultural Journal*, **110** (5), September-October, 295-299.

Sutherst, R. W., Maywald, G. F., Kerr, J. D. & Stegeman, D. A. (1983). "The Effect of Season and Nutrition on the Resistance of Cattle to the Tick Boophilus Microplus." *Australian Journal of Agricultural Research*, **34** (3), 329-339.

Tietenberg, T. H. (1992). *Environmental and Natural Resource Economics*. New York: Harper Collins.

Tumminelli, R., Conti, D. & Saraceno, F. (1997). "Red Scale Insect of Citrus." *Informatore Agrario.*, **53** (11), 61-66.

Van den-Berg, J., Van Rensburg, G. & Van der Westhuizen, M. (1997). "Economic Threshold Levels for Chilo Partellus (Lepidoptera: Pyralidae) Control on Resistant and Susceptible Sorghum Plants." *Bulletin of Entomological Research*, **87** (1), Feb, 89-93. England; UK.

Weersink, A., Deen, W. & Weaver, S. (1991). "Defining and Measuring Economic Threshold Levels." *Canadian Journal of Agricultural Economics*, **39** (4), 619-625.

Zilberman, D., Schmitz, A., Casterline, G., Lichtenberg, E. & Siebert, J. B. (1991). "The Economics of Pesticide Use and Regulation." *Science*, **253** (5019), 518-522.