A Contributed Paper for the 43rd Annual Conference of the Australian Agricultural and Resource Economics Society, Christchurch, New Zealand, 20 –22 January 1999

Cost-Benefit Analysis of American Foulbrood (AFB) Disease Management Options in Queensland – Preliminary Results

By Ian Jarratt and Mary Ann Franco-Dixon*
(Industry Services Section, Policy and Legal Services Unit, Queensland Department of Primary Industries, GPO Box 46, Brisbane, Q 4001)

Abstract
American Foulbrood disease (AFB) is a bacterial disease of honey bees which causes significant economic losses in Queensland and other Australian states and many other countries, including New Zealand. This study:
- reviews several previous applications of Cost-Benefit Analysis (CBA) to AFB control/eradication programs
- presents preliminary results from the use of CBA to assess a range of alternatives to the present AFB control program in Queensland.

Key Words: American Foulbrood Disease (AFB), Cost-Benefit Analysis

Introduction
This paper reports on the results of work undertaken by the authors for the Queensland Beekeepers Association (QBA). The main aims of this work were to assist the (QBA) to:
- Play an active and leading role in the current national consideration of AFB control issues, including the requirements of, and uses for, CBA in policy evaluation.
- Review previous economic studies of AFB control programs.
- Initiate consideration of the costs and benefits of possible changes to Queensland's current control measures

Background
American Foulbrood (AFB) is a bacterial disease of honeybees which causes major economic losses to beekeepers in Australia and many other countries including New Zealand and the USA. It is a fatal disease of immature bees and usually kills the hive. The bacterium, *Paenibacillus larvae,* produces spores which are viable for 35 years or more. The main method of spread is contaminated equipment. Other, less important, forms of spread include: contaminated honey and pollen, and feral hives and swarms (Fraser et al. 1995). The disease does not affect humans.

AFB has been endemic in all states of Australia for many years and all have official control programs. State legislated control measures vary and include: registration of beekeepers/apiaries, reporting of cases of AFB, quarantining of AFB infected apiaries, destruction of infected bees and materials, compulsory testing of honey for AFB spores, certification of equipment etc for interstate transfer, prohibitions on the use of antibiotics to treat AFB, and compensation schemes. In addition, beekeepers use a range of management practices (eg the use of "barrier" systems) to minimise the risk of getting and spreading AFB.

Data on the current incidence and distribution of AFB (and on trends) in Australia are often unreliable and not comparable due to factors such as: different official recording systems (eg infected registered beekeepers, apiaries or hives), unreported/unrecorded/undetected cases, and variable use of a low cost laboratory test now available to detect the presence of AFB spores in honey. Fraser et al. (1995) assumed that 2% of hives were infected. More recent data suggests that the level of infection may be higher than 2% in some states and may be increasing. The incidence is often highest amongst commercial apiaries, mainly due to greater transportation of hives from site to site.

* *The authors gratefully acknowledge data and other assistance provided by their colleagues at the Department of Primary Industries (DPI) and by members of the Queensland Beekeepers Association (QBA). However, the authors are responsible for any errors or omissions and the views expressed are those of the authors not the Queensland Department of Primary Industries or the QBA.*

Reliable information on the actual or potential epidemiology of AFB in different parts of Australia and under various control programs is often not available, partly due to: bee mobility, frequent transport of hives to new sites, some infected hives being abandoned, feral hives, and the diversity of management practices and control programs.

Antibiotic therapy does not cure, and masks the signs of, AFB. The reported increased incidence of AFB in recent years in many areas may reflect the use (legal) of antibiotics to treat another bacterial disease, European foulbrood (EFB), which has become endemic and a major problem in many areas especially, in southern NSW, Victoria, South Australia and Tasmania. EFB causes reduced output from hives and can be successfully treated with antibiotics.

Many Australian producers and packers are becoming increasingly concerned about the current and long term effects of AFB on individual producers and the industry. The main concerns include: the scope for a further increase in the incidence rate; potential problems with contamination of honey with antibiotics; development of bee and bacterial resistance to antibiotics; the implications of possible future total bans on the use of antibiotics; and the potential impact of reductions in government funding and legislation for official control programs.

Currently, all sectors of the industry nationally, including the Queensland Beekeepers Association (QBA) are identifying and assessing alternative strategies for the control of AFB. In 1998, workshops were held in each state and 2 national workshops have been held. The authors have worked with the QBA on AFB and EFB issues by assisting them to conduct a postal survey of all beekeepers on the incidence of, and their views on AFB, EFB and the use of antibiotics, and to hold a workshop. This study is a continuation of this work.

The AFB control measures/strategies currently under consideration at national level include: regular bulk testing of honey for AFB spores by packers and governments, more voluntary bulk testing of honey by producers, comprehensive commercial industry QA programs, producer accreditation schemes, more use of barrier systems, controlled movement zones, EFB controls, industry management of measures, and national recording of incidence etc. Implementation of many of these measures would require action by industry and governments and decision-makers will require estimates of the potential benefits and costs of proposed measures, especially any which required government funding and/or legislation.

National consideration of AFB control/eradication strategies in 1995 and 1996 attempted to involve all governments, producer associations, packers etc in the development and consideration of new or better control options. The NSW Department of Agriculture prepared a national cost-benefit analysis (CBA) for the eradication of AFB by increased activity and expenditures on extension, regulation and testing (Fraser et al. 1995). The CBA was based on data supplied by industry and governments. Consideration of, and progress on, the issues, options and the CBA was retarded then by many factors including:

- Limited involvement of producer associations in the policy development processes, including providing input to, and comment on, the assumptions in the CBA.
- The unfamiliarity of many producer associations with the requirements of, and uses for, CBA in the development and implementation of policy.

Consequently, given the renewed national interest in examining control options, including costs and benefits, the objectives of this study included assisting the QBA to:

- Play an active and leading role in the current national consideration of AFB control issues, including the requirements of, and uses for, CBA in policy evaluation.
- Review previous economic studies of AFB control programs.
- Initiate consideration of the costs and benefits of possible changes to Queensland’s current control measures

Previous studies

CBA, and other forms of economic analysis, has been undertaken for many agricultural disease/pest prevention/eradication/control problems. Some recent examples relating mainly to non AFB animal disease issues include: Brucellosis - Stoneham and Johnston (1987); Newcastle Disease - Hafi, Reynolds and Oliver (1994); Quarantine - Hinchy and Fisher (1991); Screwworm - Anaman (1993): and Ovine Johne’s Disease - Short, Bailey and Ashton (1997). These and other studies have often drawn attention to the lack/unreliability of data on incidence levels, epidemiology, and the impacts and costs of control/eradication options.

Fraser et al. (1995), Ronan and Petrenas (1998), and Meister and Wilson-Salt (1995) undertook economic analyses of proposed/possible AFB control programs in Australia and New Zealand. Brief descriptions and reviews of these studies are provided in Appendix 1.

Some features of beekeeping and AFB (and the Australian industry in particular) make the identification, analysis and implementation of AFB control/eradication programs complex. These were described and encountered in the studies summarised in Appendix 1 and include:

- The diverse range of industry products/economic effects (honey, wax, live bees, pollination of crops etc).
- Valuation of pollination services/activities (paid and unpaid) to commercial crop producers (including forest and nursery activities), home and public gardens, native and other non-commercial vegetation.
- Bee mobility.
- Transport of hives over great distances, especially by commercial producers.
- Large numbers of amateur/hobbyist beekeepers.
- Concentration of hives for commercial pollination activities.
- Longevity of AFB spores.
- Inability to treat AFB successfully with antibiotics.
- Masking of presence of AFB by use of antibiotics to treat EFB.
- Limited industry development and implementation of Quality Assurance programs which include AFB.
- The diversity of possible control measures available to individuals, industry and government.

These studies dealt with these complexities in various ways including: excluding non-commercial beekeepers; excluding all, or only including paid, pollination services/values; and only considering one or a few control measures.

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Study objectives

As noted earlier, given the renewed national interest in examining control options, including costs and benefits, one of the objectives of our work was to assist the Queensland Beekeepers Association (QBA) to:

- Initiate consideration of the costs and benefits of possible changes to Queensland's current control measures.

This Section summarises the results of our work so far in this area.

Methodology

Standard social CBA methodology was used ie annual costs and benefits were estimated in constant $s for various options relative to those of a base case, the NPVs of the total annual costs and benefits were estimated for 10 years (using a 6% discount factor), and benefit:cost ratios were calculated. The methodology used was decided after careful consideration of those used by other AFB and non-AFB disease control studies and the requirements of the QBA.

Study scope

As was also the case with the previous studies reviewed in Appendix 1, this study also does not cover the whole industry or all its outputs/economic values. The reasons for this are discussed below.

Only commercial and semi-commercial beekeepers (assumed to be those with 101 or more hives) are covered. Such beekeepers account for 73% of the state's hives. The non-commercial beekeepers were excluded at this stage mainly because of limited information about their activities and most of their honey is not sold to commercial packers and thus unlikely to be affected by any QA program. However, AFB is present in hives managed by non-commercial beekeepers and can be spread from them. Accordingly, although they only account for about 17% of the state's hives and even less of its honey production and industry output, a case can be made for their inclusion in any analysis of control options, and (as currently) in any official control program.

Also the study currently covers only honey production. Wax production, pollination services (paid and unpaid), etc are not included mainly because of lack of reliable information on the relevant costs and benefits. Ideally, these and other activities should be included in the analysis, especially pollination services (paid/unpaid and managed/unmanaged). These are of very high value to cropping industries and increasingly important sources of income for some specialist and other beekeepers. For example, Gibbs and Muirhead (1997) estimated the value of honeybee pollination to Queensland's cropping industries to be around $300 million pa. However, only about $0.5 million was paid to beekeepers for these services. The remainder was obtained from managed hives at no charge (the beekeepers being willing to provide the service free because of the value of the nectar and pollen thus obtained) or from the activities of other honeybees (incidental/unmanaged pollination activities). Recent work by Stewart et al. (1998), also indicates the high value of the pollination activities of honeybees in Queensland, especially to crop producers. In 1996-97 the potential annual operating profit attributable to sites in SE Queensland forests used for the building of hives providing managed (paid and unpaid) pollination services on commercial crops was $16.12 million for crop owners and $0.42 million for beekeepers. These values can be compared with the Gibbs and Muirhead (1997) estimate of $10.4 million pa for the total paid value of the Queensland beekeeping industry (apiaries with more than 200 hives) of which honey production accounted for $8.4 million.

In Queensland most pollination services are provided by beekeepers who are also commercial honey producers. Therefore, some of the costs of providing pollination services are included in those of producing honey. However, additional costs are incurred and production of honey may be affected positively or negatively by providing pollination services. Also, demand for pollination services is increasing as more crop producers become aware of the benefits of the pollination activities of honeybees and a better functioning market for the provision of these services may be emerging. Inclusion of the economic effects of pollination services in AFB control program analysis should take account of these and other aspects (eg effects on non-commercial crops etc and of incidental pollination on commercial crops) of this issue.

Currently, this study also excludes the links between AFB and EFB as well as the potential effects of the use of antibiotics to treat either or both diseases. This partly reflects a lack of adequate data on these issues but also the low level of EFB incidence in Queensland compared to some other states. Improvements in antibiotic use and increased testing for its presence in products are likely to be key components of future changes to industry QA programs

Scenarios analysed

Discussions with industry and government officers and study of the literature, eg Hornitzky (1998), revealed numerous alternatives to the present official Queensland control program. This program consists of: compulsory annual registration of all beekeepers; prohibition on the use of antibiotics to treat AFB; compulsory testing of honey samples for AFB spores; quarantining of AFB infected apiaries; destruction of all AFB infected bees and frames and destruction or irradiation of other infected materials; and extension activities to increase beekeeper AFB identification, management skills etc. However, it was decided that at this stage of the study only the following relatively simple scenarios (which exclude EFB and antibiotic issues) should be examined, and that the base case should be the present program.

Base Case - the current control program involving compulsory registration and testing of honey samples for AFB spores, destruction/irradiation of AFB infected materials, extension activities, etc, continues unchanged.

Scenario 1 - present program continues and industry introduces a QA system which after 2 years results in significant price discounts for honey heavily infested with AFB spores.

Scenario 2 - present program continues and government temporarily increases expenditure on extension and regulatory programs.

Scenario 3 - combination of scenarios 1 and 2 ie the present program continues, industry QA introduced and a temporary increase in government funding for extension and regulation.

Scenario 4 - no government control program ie no publicly funded extension or regulation and assuming that the resultant AFB infection rate increases to either 10%, 20% or 30% of all hives after 10 years from the assumed base level of 1%.

Following discussions with industry and government officials on current and likely future industry practices, and consideration of other studies, the following areas of potential costs/benefits were identified for inclusion in the study and relevant data were obtained from numerous sources for analysis.

Potential cost/benefit areas	Comments

Total industry honey production	Influenced by number of infected and non-infected hives and output per hive.
Honey testing costs (routine)	Annual tests of all apiaries.
Honey testing costs (AFB positive apiaries)	Additional tests of AFB positive apiaries.
Industry inspection costs of hives in infected apiaries	Industry labour and other costs involved in inspecting infected apiaries to identify AFB infected hives.
Industry costs of burning infected hives	Industry labour and other costs of burning when hives are burned not irradiated.
Industry costs of burning infected bees and frames	Industry labour and other costs of burning all infected bees and brood frames.
Irradiation costs	Industry cost of sending infected materials for irradiation treatment and returning to apiary.
Hive replacement costs	Industry cost of replacing all or some of the hives destroyed by burning
Bee and frames replacement costs	Industry costs of purchasing or breeding replacement bees and replacing frames.
Government extension and inspection etc costs	Government expenditures net of revenues from honey testing.

The key assumptions for the above scenarios and cost-benefit areas are presented in Appendix 2.

Results

The results are summarised in Table 1.

All versions of Scenario 4 ie no government program produced negative discounted net benefits, ie net costs, over the 10 year period. The values were -$0.331 million (AFB incidence increasing to 10%), -$4.713 million (AFB incidence increasing to 20%), and -$7.303 million (AFB incidence increasing to 30%). The main costs were the decline in honey production. These accounted for around 98% of the costs and were due to the increased number of AFB infected hives and declining total number of hives in the industry.

All the other Scenarios produced positive discounted net benefits over the 10 year period, ie net benefits. Of these, Scenario 1 (the industry QA system) produced the largest net benefit, $0.998 million, followed by Scenario 3, (the industry QA system plus temporary additional government funds for extension etc), at $0.618 million. Scenario 2 (temporary extra government funding for extension etc) produced a net benefit of only $0.442 million.

The main sources of the benefits with Scenarios 1, 2, and 3 were: reduced inspection costs in AFB infected apiaries (33%), increased honey production (25%), and reduced replacement costs for hives, bees and frames (24%). The main costs were the additional government extension and regulation costs incurred with Scenarios 2 and 3. For Scenario 2 they accounted for 95% and for Scenario 3, 78%.

The benefit cost ratios for Scenarios 1, 2, and 3 were 9.3, 2.0 and 2.1 respectively.

Discussion

This study has confirmed the experiences of others that the application of CBA to agricultural disease control options requires substantial resources to collect relevant data. As was also the case with other studies of AFB, several special characteristics of the beekeeping industry, the complexity of AFB epidemiology and the diversity of AFB management/control options were also substantial challenges to overcome in order to identify and quantify appropriate future options and the current arrangements.

This study has also demonstrated the sensitivity of the results to the assumptions made about several key variables eg AFB incidence rates, changes in the total number of hives in the industry, and inspection practices and costs in AFB infected apiaries. Further work will be done to investigate the sensitivity of the results to specific changes in these and other key variables.

The study is not yet complete because it does not include the amateur/hobbyist sector or all outputs, especially pollination services. Also, it does not include the important issues of EFB control/treatment programs and methods, which can have major effects on the control of AFB, or the links between AFB and EFB control programs and issues of antibiotics resistance and presence in products. These issues and possibly also other control options and assumptions about important variables may be covered in further work on this topic.

Because the results are only preliminary and the study not completed, the CBA estimates for various alternative control options presented here are not yet suitable for use in final policy decision-making. However, they do indicate the key variables likely to influence cost and benefits and illustrate the data requirements etc required for CBA on this disease and industry. They highlight also to the need for further research on several matters, especially the valuation of pollination services. They will be used as a basis for further consideration of the issues by the QBA and possibly by the Australian Honey Bee Industry Council (AHBIC).

For numerous reasons including: the importance of interstate movements of working hives and other equipment, and the international trade issues, well conceived, coordinated and implemented national rather than individual state measures/approaches are probably required to successfully control, and possibly eradicate, AFB in most states, including Queensland. The successful adoption, funding and implementation of a national program would require coordinated action by governments and industry. The results of a national CBA would facilitate decision-making on this important and complex topic by all parties. Therefore, when further work has been completed on the control methods available and most relevant to various situations and estimates can be made of the likely costs and benefits of agreed options, a national CBA should be undertaken. This study, together with others referred to in this paper, will considerably assist the planning and conduct of such a CBA.

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Table 1. Summary of Results (Years 1-10):

	Scenario 1- QA program		**Scenario 2- temporary govt funds for extension etc**		**Scenario 3- Scenario 1 +2**		**Scenario 4 – no public program**					
AFB Incidence rate (% all hives year 1 to 10)	**1%- 0.25%**		**1%- 0.6%**		**1%- 0.2%**		**1-10%**		**1-20%**		**1-30%**	
	$	**%**	**$**	**%**	**$**	**%**	**$**	**%**	**$**	**%**	**$**	**%**
Benefits												
Increased Honey Production	421	*25*	331	*25*	435	*25*	0	*0*	0	*0*	0	*0*
Reduced Honey Testing Costs (Routine)	0	*0*	0	*0*	0	*0*	60	*2*	62	*2*	64	*2*
Reduced Honey Testing Costs (AFB positive)	3	*0*	10	*1*	4	*0*	6	*0*	6	*0*	6	*0*
Reduced Industry Inspection Costs (AFB positive)	570	*33*	439	*33*	584	*33*	398	*11*	398	*12*	398	*12*
Reduced Burning Costs of Hives	24	*1*	19	*1*	25	*1*	0	*0*	0	*0*	0	*0*
Reduced Burning Costs of Bees and Frames	96	*6*	76	*6*	100	*6*	61	*2*	31	*1*	19	*1*
Reduced Irradiation Costs	186	*11*	146	*11*	192	*11*	117	*3*	61	*2*	37	*1*
Reduced Replacement Costs of Hives	160	*9*	126	*9*	166	*9*	71	*2*	44	*1*	33	*1*
Reduced Replacement Costs of Bees/Frames	256	*15*	202	*15*	265	*15*	294	*8*	247	*7*	208	*6*
Reduced Government Extension/Inspection Costs	0	*0*	0	*0*	0	*0*	2,475	*71*	2,475	*74*	2,475	*76*
Total Benefits	1,716	*100*	1,348	*100*	1,771	*100*	3,481	*100*	3,324	*100*	3,240	*100*
Costs												
Decreased Honey production	0	*0*	0	*0*	0	*0*	4,287	*99*	10,753	*98*	14,536	*98*
Increased Honey Testing Costs (Routine)	63	*46*	21	*4*	77	*12*	0	*0*	0	*0*	0	*0*
Increased Honey Testing Costs (AFB positive)	14	*10*	3	*1*	13	*2*	1	*0*	1	*0*	1	*0*
Increased Industry Inspection Costs (AFB positive)	61	*44*	0	*0*	48	*8*	9	*0*	9	*0*	9	*0*
Increased Burning Costs of Hives	0	*0*	0	*0*	0	*0*	22	*1*	52	*0*	78	*1*
Increased Burning Costs of Bees and Frames	0	*0*	0	*0*	0	*0*	1	*0*	7	*0*	24	*0*
Increased Irradiation Costs	0	*0*	0	*0*	0	*0*	3	*0*	14	*0*	47	*0*
Increased Replacement Costs of Hives	0	*0*	0	*0*	0	*0*	10	*0*	83	*1*	159	*1*
Increased Replacement Costs of Bees/Frames	0	*0*	0	*0*	0	*0*	0	*0*	0	*0*	0	*0*
Increased Government Extension/Inspection Costs	0	*0*	500	*95*	500	*78*	0	*0*	0	*0*	0	*0*
Total Costs	138	*100*	524	*100*	639	*100*	4,333	*100*	10,918	*100*	14,853	*100*
Net Benefits ($000)		1,578		823		1,133		-852		-7,595		-11,614
Net Present Values (NPVs) (6% discount factor) ($000)												
Benefits		1,118		884		1,159		2,476		2,374		2,318
Costs		120		442		541		2,807		7,087		9,622
Net Benefits		998		442		618		-331		-4,713		-7,303

Benefit/Cost Ratio (ratio)	9.3	2.0	2.1	0.9	0.3	0.2

PREVIOUS STUDIES OF AFB CONTROL PROGRAMS

Australian National AFB Eradication Study - (Fraser et al.,1995)

This was a cost benefit analysis of expanding the present national control program to eradicate American Foulbrood Disease (AFB). Officers of NSW Department of Agriculture did it in July 1995 to help the Federal Council of Australian Apiarists' Associations (FCAAA) American Foulbrood working party, represented by all States, look at the possible eradication of AFB in Australia. All States provided data for the analysis.

Ten potential benefits were identified once AFB is eradicated and assumptions were made for the magnitude etc of each.

Additional measures to expand the current AFB control program were considered as Eradication Program Costs. Cost estimates involved in this program were provided by each State. The costs included the extra costs of: inspection staff, operating costs, and laboratory costs

Results

It was assumed that if the eradication program started in 1995, AFB would be totally eradicated after 10 years (Year 2005). Benefits, however, were assumed to filter into the industry after 8 years (Year 2003) because some of the benefits related to decreases in AFB incidence as well as eventual eradication. Total computation of costs and benefits was over 50 years.

The study indicated that the eradication of AFB for the most likely case would provide positive returns to the Australian bee industry. The expected scenario produced a net present value (NPV) of approximately $3.421 million, with a benefit cost ratio (BCR) of 1.55 and an internal rate of return of 12%.

Sensitivity analysis of expected scenario showed that the assumptions with most influence on the final estimated returns were: initial assumed AFB infection level; export price for honey, pollen and beeswax; AFB eradication program costs; and discount rate.

Comments

This study was very valuable and probably did not receive appropriately detailed consideration by industry and governments. Potential improvements to the study could have been:

- Considering more control options than eradication.
- Considering EFB and OTC issues associated with AFB control/eradication.
- Considering the effects of increasing levels of infection with the base case.
- Including the unpaid value of pollination activities not just paid services.

South Australian AFB Control Study - (Ronan and Petrenas, 1998)

This study was an economic analysis of alternative strategies for future management of AFB in South Australia. It was prepared by the Primary Industries and Resources South Australia (PIRSA) in consultation with the Apiary Industry Task Force in 1998.

Five disease control strategies were analysed using CBA relative to a base case of no public program for AFB control:

<u>Extension only</u> – private and PIRSA consultant provide timely advice and encouragement to apiarists to control AFB.

<u>QA program only</u> – honey packers implement a quality assurance program. This involves price incentives for honey that complies with export protocols requiring AFB-free honey, and disincentives for honey which tests positive to AFB.

<u>Buy back scheme</u> – enforced annual registration and testing is compulsory to identify all beekeepers and monitor AFB. This is accompanied by an industry QA program. Incentive scheme to remove unwanted hives or those who fail to submit honey test. AFB control is voluntary for 4 years.

<u>Mandatory disease control</u> – commercial QA procedures for controlling AFB in commercial apiaries. Disease

control is achieved by orders imposed and monitoring the success with increased honey testing in infected apiaries. Control is compulsory and enforced. AFB is a notifiable disease.

Mandatory disease eradication – combination of traditional apiarist inspection role and an industry QA program. Eradication is compulsory and quarantine restrictions are imposed. Enforcement is by property visits and court orders. Inspectors enforce registration and honey testing. Inspectors enforce removal of abandoned and neglected hives.

Results

Quality Assurance (QA) had a BCR of 9.0, the highest among all the strategies. The use of quality assurance strategy decreased disease prevalence in the commercial sector to 13 per cent, but the whole industry disease prevalence increased to 50 per cent. The BCRs for the other strategies ranged from 1 to 2 making them marginal investment attractions. They were all high cost options compared to QA, Mandatory Eradication was the most expensive.

Comments

The study is very valuable because:

- It examined several diverse control/eradication strategies.
- Strategies focussed on high risk areas and rapidly reducing incidence levels ie were highly targeted.
- It distinguished between commercial and recreational beekeepers.

It's value could probably be increased by:

- Extending the time period beyond 4 years.
- Including in the analysis the links between AFB and EFB and issues associated with the use of antibiotics to treat AFB and EFB.
- Including all the economic effects of the pollination activities of honeybees, not just the paid services.

The study also looked at market failure and public/private benefit issues and advocated a national approach to AFB control.

New Zealand AFB Eradication Strategy Study – (Meister and Wilson-Salt, 1995)

This study was undertaken for the National Beekeepers Association and compared the costs and benefits of the introduction of a proposed Pest Management Strategy (PMS) compared to the absence of the strategy ie complete deregulation.

Only industry costs and benefits were considered, since the legislation would require that all the costs of the program would be met by the industry. The authors noted that the study was a financial analysis rather than a CBA but annual flows of industry benefits and costs were estimated for 10 years and NPVs were calculated using a 5% discount factor.

Detail assumptions were made about trends in incidence rates, production changes, changes in industry size, replacement rates and costs of hives, inspection costs etc. Mention was made, but no account taken, of the effects of pollination activities or trade effects (testing costs and other implications of antibiotic use and AFB quarantine requirements).

Results

The analysis indicated that the proposed PMS would provide major net benefits for the industry irrespective of whether the released resources were employed elsewhere in the economy. The NPV of the net benefits were $30.9 million (resources unemployed) and $26.9 million (resources employed) over the 10 year period.

Comments

Although this was not a full CBA it was based on detailed information on key variables which influence costs and benefits for beekeepers. The without PMS scenario assumed that AFB % incidence would increase substantially then decline (from 2.5% to 10% then to 5%) and that beekeepers would leave the industry and the total number of hives would decline by 1% pa.

The value of the study could have been enhanced by the inclusion of pollination effects. These were not measured partly because of the large net industry benefits from cost reductions etc arising from the PMS. Any benefits from pollination activities were considered to be bonuses.

Appendix 2.

ASSUMPTIONS

Basic assumptions

Initial number of commercial/semi-commercial hives	94,824
Initial number of commercial/semi-commercial apiaries	279
Honey produced per hive per year (kg/hive/year) for AFB (-)	70
Honey produced per hive per year (kg/hive/year) for AFB (+)	35
AFB incidence rate (%) in the first year	1%
Price of honey per kg ($)	$1.50
Number of tests/apiary/yr	3
Cost of honey test ($)	$15
Labour needed to inspect hives with AFB (persons)	2 persons
Duration of inspections for 100 hives (hours)	8 hrs
Cost of labour/hr ($)	$15
Number of hives per yard	100
Cost of labour to inspect 100 hives	$240
Cost of irradiation ($/hive)	$29
Cost of destroying infected hives by burning ($)	$15
Cost of destroying infected bees and brood frames by burning ($)	$15
Cost of replacing infected hives ($/hive)	$100
Cost of replacement of infected bees and brood frames ($/4 frame colony	$40
Initial % infected apiaries	30%

Key variable assumptions

Assumptions	Base case	Scenario 1	Scenario 2	Scenario 3	Scenario 4		
					10% AFB	20%AFB	30%AFB
AFB incidence rate % all hives (Yr1-10)	1% - 2%	1%-0.25%	1%- 0.6%	1%- 0.2%	1%-10%	1%-20%	1%-30%
Total hives in industry	94,824 constant for 10 yrs	94,824 constant for 10 yrs	94,824 constant for 10 yrs	94,824 constant for 10 yrs	94,824 then declines by 5% by yr10	94,824 then dec by 15% by yr10	94,824 then dec by 20% by yr10
Honey production/hive with AFB (kg)	35 constant for 10 yrs	35 constant for 10 yrs	35 constant for 10 yrs	35 constant for 10 yrs	30 (yr1) to 25 (yr10)	30 (yr1) to 25 (yr10)	30 (yr1) to 25 (yr10)
Number of apiaries in the industry	279 constant for 10 years	279 constant for 10 years	279 constant for 10 years	279 constant for 10 years	279 then dec by 5% by yr10	279 then dec by 15% by yr10	279 then dec by 20% by yr10
Number of honey tests/apiary	3 constant for 10 years	6 (yr1) to 3 (yr10)	4 (yr1) to 3 (yr10)	6.5 (yr1) to 3 (yr10)	3 (yr1) to 1 (yr10)	3 (yr1) to 1 (yr10)	3 (yr1) to 1 (yr10)
Number of apiaries AFB (+)	84 (yr1) to 117 (yr10)	84 (yr1) to 43 (yr10)	84 (yr1) to 65 (yr10)	84 (yr1) to 39 (yr10)	84 (yr1) to max 200 (yr10)	84 (yr1) to max 200 (yr10)	84 (yr1) to max 200 (yr10)
Number of honey tests/ apiary	3 constant for 10 years	6 constant for 10 years	4 (yr1) to 3 (yr10)	6 constant for 10 years	2 constant for 10 years	2 constant for 10 years	2 constant for 10 years
Number of inspections/ yard	2 constant for 10 years	2.5 (yr1) to 2 (yr10)	2 constant for 10 years	2.5 (yr1) to 2 (yr10)	2 (yr1) to 1 (yr10)	2 (yr1) to 1 (yr10)	2 (yr1) to 1 (yr10)
Average number of infected hives in a yard	3.3 (yr1) to 4.6 (yr10)	3.3 (yr1) to 1.6 (yr10)	3.3 (yr1) to 2.6 (yr10)	3.3 (yr1) to 1.4 (yr10)	3.3 (yr1) to 14.7 (yr10)	3.3 (yr1) to 14.7 (yr10)	3.3 (yr1) to 14.7 (yr10)
Number of hives to	30 (yr1)	30 (yr 1) to	30 (yr1) to	30 (yr1) to	30 (yr1) to 7	30 (yr1) to 7	30 (yr1) to 7

Assumptions	Base case	Scenario 1	Scenario 2	Scenario 3	Scenario 4		
					10% AFB	20%AFB	30%AFB
be inspected in an infected yard for every 100 hives	to 22 (yr10)	62 (yr10)	39 (yr10)	70 (yr10)	(yr10)	(yr10)	(yr10)
Number of hives destroyed by burning	20% of infected hives for 10 years	20% of infected hives for 10 years	20% of infected hives for 10 years	20% of infected hives for 10 years	20% of infected hives (yr1-2), 15% (yr3-4), 10% (yr5-10)	20% of infected hives (yr1-2), 15% (yr3-4), 10% (yr5-10)	20% of infected hives (yr1-2), 15% (yr3-4), 10% (yr5-10)
Number of other infected bees and brood frames destroyed by burning	80% of infected hives for 10 years	80% of infected hives for 10 years	80% of infected hives for 10 years	80% of infected hives for 10 years	80,70,60,40, 20 (yr1-5), 10 (yr6-10)	80,70,60,40, 20 (yr1-5), 10 (yr6-10)	80,70,60,40, 20 (yr1-5), 10 (yr6-10)
Number of infected hives irradiated	80% of infected hives for 10 years	80% of infected hives for 10 years	80% of infected hives for 10 years	80% of infected hives for 10 years	80,70,60,40, 20 (yr1-5), 10 (yr6-10)	80,70,60,40, 20 (yr1-5), 10 (yr6-10)	80,70,60,40, 20 (yr1-5), 10 (yr6-10)
Number of infected hives replaced	All of infected hives burned replaced	All of infected hives burned replaced	All of infected hives burned replaced	All of infected hives burned replaced	50% of infected hives burned replaced	50% of infected hives burned replaced	50% of infected hives burned replaced
Number of other infected bees and brood frames replaced	All burned bees and brood frames replaced	All burned bees and brood frames replaced	All burned bees and brood frames replaced	All burned bees and brood frames replaced	50% of burned bees and brood frames replaced	50% of burned bees and brood frames replaced	50% of burned bees and brood frames replaced
Cost of government extension and regulatory activities (net of revenue from testing)	$300,000 constant for 10 years	$300,000 constant for 10 years	$400,000 (yr1-5) to $300,000 (yr6-10)	$400,000 (yr1-5) to $300,000 (yr6-10)	$200,000 (yr1) to $25,000 (yr10)	$200,000 (yr1) to $25,000 (yr10)	$200,000 (yr1) to $25,000 (yr10)