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Review of Biological Weed Control Investment for the Australian Livestock Industries

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EXECUTIVE SUMMARY

Meat & Livestock Association (MLA) and other funding bodies including Australian Wool Innovation (AWI) have invested in biological weed control projects since 1987. These projects have focused on identifying, rearing and releasing agents targeting Paterson's curse and five thistles (Scotch, Illyrian, nodding, variegated and Spear).

Currently the agents have been successfully identified, reared and released against the target species and impact is being noted around release sites. A review of one stage of the project which has been conducted from July 1997 to June 2002 was required in order to assist with any decision to continue funding. This continued funding would take the form of a new project that will release additional agents at the current sites. As at April 2002 researchers believed further distribution of eight of the agents was required. The project is anticipated to speed up the delivery of benefits to landholders.

The consultancy has involved a desk-top review of relevant project documents, as well as email and telephone interviews with key personnel from relevant research organisations and with others with knowledge of the project.

Some of the project documentation was lacking due to the long time frame of the project, and also possibly due to the interrupted funding of the project and the change from MRC to MLA, as well as changes in structures associated with wool industry funding.

Fourteen insect agents have been released either for the first time or have continued to be released over the life of the project (since 1997). Of these, two have failed to establish and it is too early to confirm establishment for two others. Difficulties in mass rearing one of the unconfirmed species have led to it being dropped from further work in the new application.

While the project documents included adequate information on agent releases and the number of sites monitored, there appeared relatively little attention given in the documentation to actual outcomes in terms of producer adoption on a regional scale, natural spread, changes in landholder management practices, impact on weed control costs or benefits from improved pasture production and utilisation.

There was very strong support for the project from nearly all stakeholders, as evidenced by the high response rate to our survey, as well as the consistent positive feedback about the project evident in survey responses.

Following the completion of the review of documents and the survey of stakeholders, an assessment of the project against its objectives and desired outcomes was undertaken. This found that the project had fully met four of its six objectives, while two of the objectives were only partially met (producing integrated weed management guidelines and commencing quantifying the impact on weeds). Less emphasis than what may have been expected was given to the three desired outcomes. There were perceptions among the project personnel that some of the stated objectives and desired outcomes were outside the scope of the project. Some reasons for these differences are advanced in the review.

While there are many expected benefits from the project, it is recognised that the nature of the project means that significant benefits will be evident only in the longer term. However, it is encouraging to note that several producers surveyed are already experiencing positive and tangible benefits on their properties. Benefits already observed include lowered chemical costs, improved pasture performance and increased stocking rates. It appears that the investment by MLA in this project will provide significant benefits to producers in the longer term but it is difficult to accurately predict their timing and magnitude without recourse to modelling.

Many lessons have been learnt from this project which will be valuable in the development of future biological weed control projects. Several suggestions for future requirements in any continuation of this project have been made, as well as suggestions for future investment by MLA in biological weed control. These suggestions are summarised below.

Summary of Suggestions Regarding the Project and Future MLA Strategies

Current Project	
Issue	*Suggestion*
Support	The extension to the current project should be supported
Economic analyses	The reduction in chemical costs should be included in any future benefit-cost analyses of this project There is a need to reconcile the various economic studies on *Echium* and how the results are reported CSIRO's bio-economic model that predicts impacts could be updated regarding assumptions on rate and spread of damage and validated with field data The benefit-cost analysis in the new application requires further explanation
Further distribution of agents	Speeding up of the expected impact is likely to be facilitated by additional resources ($, staff, agents) being committed to the project over and above the extended project; it is suggested that this could be considered selectively on a regional basis and on the merits of specific situations and constraints The role of agribusiness in potentially distributing agents at some time in the future of the project should be investigated
Assessment of existing network	The existing network should be defined more clearly in relation to its size, constituent type, current effectiveness and weaknesses, nature of its expansion potential, and its ability to self sustain, both technically and financially
Monitoring	There should now be more attention given to outcome monitoring including the reduction in weed numbers, impact on grazing management and costs and returns In the first instance, case studies of properties reporting impact could be provided

Future Investment Strategy	
Issue	*Suggestion*
Future investment	MLA should continue its investment in bio-weed control and consider increasing its investment due to the highly visible, valuable and practical nature of likely outcomes
Weed priorities	Based on information sighted in this review, there is a need to update the economic impact of weeds and set priorities for R&D in relation to the meat and livestock industries
Model Project	The existing project and its collaborative, distribution and extension components should be used as a model for future weed bio-control investment, provided IWM, outcome monitoring (including establishing baselines) and economic analyses are integrated from the outset
Integrated Weed Management (IWM)	Integrated weed management information should be developed and provided as part of a project rather than external to it Future bio-control projects should be embedded in an IWM framework at commencement.
Baselines and monitoring	Consideration should be given to the merits and costs of establishing baselines of growth and densities of target weeds prior to release of agents The establishment of a baseline for chemicals used in weed control at the start of any project as this is the major benefit seen by producers in the current project
Bio-economic modelling	Input into future weed bio-control investment from bio-economic modelling could enhance design, priority setting and level of resource application, and hence improve overall effectiveness
Involvement of agribusiness	An assessment would be useful as to whether and how the involvement of agribusiness at some stages in the life of a weed bio-control project could enhance overall outcomes

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ACRONYMS AND ABBREVIATIONS

APCB	Animal Plant Control Board
AWI	Australian Wool Innovation
BCA	Benefit Cost Analysis
CIE	Centre for International Economics
CRC	Cooperative Research Centre
DNRE	Department of Natural Resources and Environment (Victoria)
DSE	Dry Sheep Equivalent
IAC	Industry Assistance Commission
IWM	Integrated Weed Management
MLA	Meat and Livestock Australia
MRC	Meat Research Corporation (now MLA)
R&D	Research and Development

GLOSSARY OF TERMS

Release – all field sites with insect agents are considered to be releases. Release and nursery sites are interchangeable terms as at all release sites there is some input or management to create a nursery site.

Redistribution – the collection of insects from successful nursery sites by farmers, local community groups and/or professionals for subsequent release at another location.

Distribution – the release of insect progeny from mass rearing in the laboratory by State Departments or CSIRO.

Attack Rate – is the number of attacked ‘plant parts’ per number of total ‘plant parts’ per unit area (which ‘plant part’ depends on insect agent involved).

1. INTRODUCTION

1.1 Background

MLA and other research funding bodies have invested in biological weed control projects since 1987.

From the late 1980's biological control projects against the broad-leafed pasture weeds *Echium plantagineum* (Paterson's curse), *Onopordum illyricum* and *O. acanthium* (Scotch and Illyrian thistle) and *Carduus nutans* (nodding thistle) have been underway. Until 1996/97 Australian Wool Innovation (AWI) and MLA funded the three projects independently, with the work focusing mostly on the importation, host-specificity testing and initial establishment of agents at a small number of nursery sites. From 1997/98 the three projects were placed under one funding umbrella with a fourth project on the bio-control of *Cirsium* thistles (run by DNRE, Victoria). The post 1997/98 project focused on the establishment, redistribution and monitoring of agents across temperate Australia, with the main objective being the fast tracking of the delivery of bio-control to the end user.

Currently bio-control agents have been successfully identified, reared and released against the target species and impact is being noted around release sites.

A new project is likely to be initiated in 2002/03 that will release additional agents in the current sites. This project is anticipated to speed up the delivery of benefits to landholders.

1.2 Terms of Reference

The purpose of this project is to provide an external review of:

- the project TR.047 "Distribution of biological control agents for Paterson's curse and thistles"
- the role of MLA in biological weed control R&D using the above project, its predecessor, and the project planned, as a case study to identify that projects of this nature provide benefits to livestock producers and the community

The project objectives are:

1. Review MLA and MRC investments in the project 'Biological control of Paterson's curse and thistles', to identify the actual and predicted benefit for grazing businesses and so the livestock industries.

2. Recommend an investment strategy for MLA in biological weed control to ensure benefits to the livestock industries.

1.3 Methods

There was a very short time frame of just over 5 weeks available for the review. The consultancy has involved a desk-top review of relevant project documents, as well as email and telephone interviews with key personnel from relevant research organisations and with others with knowledge of the project.

1.4 Report Structure

The remainder of the report is divided into three more chapters. Chapter 2 deals with what could be gleaned from the documentation. The information compiled from the phone conversations and questionnaire responses is presented in Chapter 3. Chapter 4 integrates information from these sources into findings of the review and presents some suggestions for ensuring benefits are captured and are reported.

2. REVIEW OF DOCUMENTS

2.1 Research and Funding Partners

The project involved a number of partners including:

- Commonwealth Scientific & Industrial Research Organisation – Division of Entomology
- CRC for Weed Management Systems
- Australian Wool Corporation, International Wool Secretariat, The Woolmark Company and Australian Wool Innovation Pty Ltd – will be referred to in this review as Australian Wool Innovation Pty Ltd (AWI)
- Meat Research Corporation and Meat and Livestock Australia – will be referred to in this review as Meat and Livestock Australia (MLA)
- NSW Agriculture
- Victorian Department of Natural Resources and Environment
- SA Research and Development Institute
- Agriculture WA

2.2 Project Background (Until 1996/97)

Paterson's curse, *Echium plantagineum*, is a dominant pasture weed in temperate Australia. In addition to the loss of pasture production resulting from any weed infestation, *E*. *plantagineum* contains pyrrolizidine alkaloids, which can reduce wool production and weight gain in livestock and in severe cases can lead to stock death.

Thistles are also pasture weeds of concern to wool and livestock producers. Thistles, like Paterson's curse, cause additional problems on top of reduced pasture productivity. Thistle spines can cause stock injury, particularly to the mouth and eyes, lead to downgrading of the wool clip due to vegetable fault and are disliked by shearers who are often injured by spines in the fleece.

The Australian Weeds Council suggested the *Echium* species (includes three other species that are also weeds in Australia) as a potential candidate for biological control (Nordblom et al 2001). The CSIRO Entomology initiated research on biological agents for the control of Paterson's curse, in 1972, following approval by the Australian Agricultural Council. The CSIRO commenced surveys for possible insect agents in the native habitat of Paterson's curse from a base in Montpellier, France.

This work was halted in 1980 following an injunction in the Supreme Court of South Australia, lodged by a group of graziers and apiarists. An inquiry and benefit-cost analysis conducted by the Industries Assistance Commission (IAC Report 1985) concluded that a biological control program for *Echium* species should continue. During this time the Biological Control Act 1984 established procedures for assessing and authorising biological control programs in Australia. CSIRO recommenced work on

biological control of *Echium* in 1987. The biological control program for thistles commenced in 1986.

In 1987, AWI and MLA commenced funding a long-term biological control program. Up until the start of 1997/1998 the weeds included in the biological control research were *Echium plantagineum, Onopordum illyricum* (Scotch thistle) and *O. acanthium* (Illyrian thistle) and *Carduus nutans* (nodding thistles).

While the majority of the work up until 1997/1998 involved the importation of biological agents and host-specificity testing, there was also limited distribution and establishment of several biological control agents for *Onopordum* spp., *Echium plantagineum* and *Carduus nutans.* A summary of the status of the various agents as of 1997/98 is given in Table 1. A summary of the distribution network as of 1996/97 is given in Table 2.

The introduction of a biological control agent into Australia is a complex process involving multiple steps. Stahle (2000) lists the steps as:

1. Determine weed is a suitable target for biological control
2. Search weed's native range to identify prospective agents
3. Measure impact of agents in home range
4. Collect agents and rear in captivity
5. Conduct host specificity testing
6. Seek importation licence from Australian Quarantine Inspection Services
7. Convert diurnal rhythm to Southern Hemisphere
8. Mass produce agents in laboratory
9. Release agents into field nursery sites
10. Organise distribution logistics and farmer involvement
11. Coordinate distribution process
12. Study agents interactions and work out integrated control package
13. Monitor impact of agents

Table 1: Status of imported agent species as of 1997/1998

Agent	**Target**	**Released**	**Established[1]**	**Success[2]**	**Work post 1997/1998**
Dialectica scalariella	*E. plantagineum*	yes	yes	limited	no
Mogulones larvatus	*E. plantagineum*	yes	yes	yes	yes
Mogulones geographicus	*E. plantagineum*	yes	yes	unknown	yes
Ethmia bipunctella	*E. plantagineum*	no (host specificity problems)	no	na	no
Meligethes planiusculus	*E. plantagineum*	no	na	na	yes
Dictyla spp.			no	na	no
Phytoceia coerulescens	*E. plantagineum*	yes	yes	no	no
Longitarsus echii	*E. plantagineum*	no	na	na	yes
Larinus latus	*Onopordum* spp.	yes	yes	promising	yes
Lixus cardui	*Onopordum* spp.	yes	yes	promising	yes
*Eublemma respersa/amoena**	*Onopordum* spp.	no	na	na	yes
Trichosirocalus briesii	*Onopordum* spp.	no	na	na	yes
Tephritis postica	*Onopordum* spp.	yes	no	na	no

Urophora solsititialis	*C. nutans*	yes	yes	yes	yes
Trichosirocalus horridus	*C. nutans*	yes	yes	yes	yes
Rhinocyllus conicus	*Cirsium vulgare* *Silybum marianum*	yes	yes	yes	yes

[1] indicates if successful establishment at some sites not at the full range of the target species

[2] indicates if causing some damage to target species not the level of damage

* species name changes from document to document without clear indication of importation of a different species

Table 2: Distribution network as at 1996/1997

State	Network type	Number
Vic	Landcare and community groups	30
	Individual producers	73
	Extension staff from DNRE	29
NSW	Landcare groups	15
	Individual producers	405
	Extension staff from NSW Ag	11
	Shire Weeds Officers	35
SA	Landcare, Catchment or Shire groups	29
WA	Land Conservation District Committees and Agricultural Protection Officers	50

Source: project application TR.047

As of the end of the 1996/1997 release strategies for four agents targeting thistles were formulated and monitoring strategies were finalised at a CRC for Weed Management Systems workshop. Release of two agents targeting Paterson's curse was continuing.

It was thought by researchers that to enable achievement of effective biological control as quickly as possible, these insects must be distributed widely to producers in an orderly and strategic manner to ensure active producer participation and ownership of the project. These concerns led to the proposal for the joint funding of a project by both the AWI and the MLA in conjunction with CSIRO Entomology.

2.3 The Project from 1997/98 to the Present

2.3.1 Project Description

Phase 1 of TR.047 'Effective delivery and establishment of biological control agents for Paterson's curse and thistles in temperate sheep pastures', ran for three years from 1997/1998 to 1999/2000. The project was funded equally by the AWI and the MLA, totalling $1,023,666.

Under previous research by CSIRO Entomology, biological control agents had been imported into Australia. Phase 1 of TR.047 was aimed at developing an extensive producer network to rear and redistribute these agents throughout the target weed species range to enable commencement of broad scale, effective biological control.

Three agents against Paterson's curse and seven against thistles were to be redistributed to nursery sites as part of this project. Viable populations of the insect agents were to be released at strategic sites in each State and climatic zone for monitoring the establishment, spread and impact of the agents on each target weed. As of 1997 another four insects, two targeted at Paterson's curse and two at thistles were nearing the final stages of host specificity testing. If approved for release, they were to be distributed to the nursery sites together with guidelines for their mass rearing in the field. A further five years of monitoring following the completion of this project was recommended to commence in 2000/2001.

As part of this jointly funded project, the Victorian Department of Natural Resources and Environment included distribution of agents against spear (*Cirsium vulgare*) and variegated (*Silybum marianum*) thistles.

Project outcomes were to be communicated to producers within the Woolpro project to raise producer awareness of biological control. Also some Woolpro focus sites were to be established to specifically evaluate biological weed control. Community groups such as Landcare groups were targeted for development of a redistribution network for the insects and for the dissemination of information on rearing and management of the insects within an integrated weed control management system.

Partner responsibilities were:

- CSIRO/State agencies to rear stocks of each insect
- State agencies/Weed/Pest/Shire Officers to distribute insects and information kits
- Landcare/producer groups to establish and maintain regional and strategic nursery sites
- Individual producers to collect insects from the regional and strategic nursery sites and distribute to members of their group and to other producers.

Initially distribution of the insects was to be finalised after three years, with the five years of monitoring to follow. A project extension of 22 months was granted to continue distribution activities from July 2000 to April 2002. Phase 2 of the original project, the 5-year monitoring component, was to be completed in 2004/2005. This monitoring is therefore continuing to be funded. It is unclear whether this continuing monitoring component is being managed and reported on as a separate project from TR.047. The scope of the document search for this review did not locate any separate documentation or reporting of outputs for this separate project (referred to as project 186 on page 4 of the new project proposal). The separate project has therefore not been reviewed, and any discussion of monitoring is undertaken in the context of the objectives and stated commercial outcomes as defined in the project proposal for project TR.047.

As at April 2002 researchers believed further distribution of eight of the agents was required. A new project application is currently being considered which will allow distribution to continue until 2004/2005. Included in this application is the release of two new agents *Wheeleria spilodactylus* and *Deuterocampta quadrijuga* against horehound and blue heliotrope respectively. Two of the agents targeted at Scotch and

Illyrian thistles will also be released in Western Australia and South Australia against stemless thistle (*O. acaulon*).

2.3.2 Objectives and Outcomes

The objectives of project TR.047 were to*:*

(i) Set up over 1400 nursery sites on producers' properties to mass rear the insect agents

(ii) Develop a distribution network, which can deliver a complete package of bio-control insects to farmer groups and State Weeds, Pests and Shire Officers enabling redistribution of the insects at no further cost to AWI and MLA

(iii) Formulate basic best practice guidelines for the integrated control of the target weeds including biological control, herbicide control and grazing management

(iv) Raise producer awareness of the importance of integrated control for effective weed management in livestock pastures and provide producers with skills in insect rearing and distribution

(v) Evaluate the establishment, survival and spread of the released insects and commence quantifying their impact on control of the target weeds

The stated commercial outcomes of the project were:

(i) Delivery to producers of a suite of host-specific biological control insects for Paterson's curse and thistles

(ii) Delivery to producers of an integrated weed management approach incorporating the concepts of biological control, herbicide control, grazing management and pasture renovation

(iii) Active participation by producers in biological weed control leading to their ownership of the process and outcomes

(iv) Access to and involvement by producers in a motivational community-based distribution system and biological control program

(v) An improved understanding by producers of weeds in a farming system and of more effective control methods

(vi) A measurable reduction in the direct costs (e.g. weed toxicity, herbicide use, low pasture productivity) and indirect costs (e.g. stock management issues) associated with weeds

(vii) Development of methodologies to measure the performance of bio-control insects on both a regional and paddock scale

The project proposal also stated that a range of performance measures would be used including:

- number of insect nursery sites (producers' properties) established annually with a target of at least 450 sites annually
- number of other producers (excluding those with nursery sites) that commence distributing bio-control insects on their own properties

- measurement of the establishment and spread of insects against their target weeds annually
- quantification of the impact of the bio-control insects on weed infestations, pasture productivity and wool producers

2.3.3 Outputs

Monitoring protocols

Development of monitoring protocols was part of project M.593b (prior to TR.047). The protocols were:

- Level 1 monitoring establishes the relationship between agent densities and the survival, growth and reproductive potential of the target weed. It may involve experimental manipulation of agent populations at a single site and/or be extended to regular sampling of individual weeds or small weed patches.
- Level 2 monitoring is aimed at obtaining quantitative data on agent impact at representative sites throughout the weed's range. It involves an annual visit to a select number of established sites to measure the population change, spread and attack rate of the agent on the target weed.
- Level 3 requires a once-only visit to all release sites in the year following release to examine broad scale establishment and initial spread. May be completed by project staff or landholders.

Under TR.047 for level 3 monitoring, collaborators are encouraged to visit sites more than once as insects can be found in the second or third years when none were apparent in the first year.

Insect agent releases

Fourteen agents have been released either for the first time or have continued to be released over the life of project TR.047 (not including releases against *Cirsium* and *Silybum* thistles). Of these two, *Tephritis postica* and *Longitarsus aeneus*, have failed to establish. For two others, *Botanophila spinosa* and *Urophora terebrans*, it is too early to confirm establishment. Difficulties in mass rearing *B. spinosa* have led to it being dropped from further work in the new application.

Table 3 shows the number of releases and further redistributions required for each species. Releases are defined as distribution of insect agents to nursery sites and redistribution to producer's properties from nursery sites when taken from official field days, i.e. when project staff knew about the collection. (Redistribution can result in the setting up of another official nursery site e.g. by a Landcare group or it may become a nursery site just for the individual producer.) Redistribution outside these official days can occur but it is not possible to record these collections. Provided these collections are well managed—grown in a nursery site according to guidelines—on the collector's property, then these collections occurring are considered a sign of the project's success.

Table 3: Agents released against *Onopordum, C. nutans, E. plantagineum, C. vulgare* and *S. marianum* and the number of releases as of 2002

Target	**Agent**	**No. of Releases**	**Established**	**Requirement for further redistribution**
E. plantagineum	***Mogulones larvatus***	1124	yes	local
E. plantagineum	*Mogulones geographicus*	95	yes	regional & local
E. plantagineum	*Longitarsus echii*	103	yes	regional & local
E. plantagineum	***Meligethes planiusculus***	53	yes	regional & local
E. plantagineum	*Longitarsus aeneus*	unknown	no	na
Onopordum spp.	*Larinus latus*	227	yes	no
Onopordum spp.	*Lixus cardui*	549	yes	no
Onopordum spp.	*Eublemma respersa/amoena**	40	yes	local
Onopordum spp.	*Trichosirocalus briesii*	3	yes	regional & local
Onopordum spp.	*Botanophila spinosa*	2	too early	na
Onopordum spp.	*Urophora terebrans*	1	too early	regional & local
Onopordum spp.	*Tephritis postica*	unknown	no	na
C. nutans	*Urophora solsititialis*	101	yes	no
C. nutans	*Trichosirocalus horridus*	102	yes	no

***Cirsium vulgare*#**	*Rhinocyllus conicus*	22	yes	not in new application
***Silybum marianum*#**	*Rhinocyllus conicus*	9	yes	not in new application
***Cirsium vulgare*#**	*Urophora stylata*	97	yes	not in new application
***Cirsium vulgare*#**	*Trichosirocalus horridus*	8	yes	not in new application

*species names change from document to document without clear indication of importation of a different species

release data is at June 2001

Status of agent distribution and effectiveness against target weed:

(i) Nodding thistle (*Carduus nutans*)

Agents – *Urophora solsititialis* and *Trichosirocalus horridus*

- The release and redistribution phase of nodding thistle biological control is complete, with the monitoring of the performance of the agents and their host plant continuing. The seed banks at two level 2 monitoring sites have declined significantly, as have plant densities at eight monitoring sites. However, it is unclear if these monitoring sites have both or only one of the two agents present.

(ii) Scotch and Illyrian thistle (*Onopordum illyricum* and *O. acanthium)*

Agents – *Larinus latus*, *Lixus cardui*, *Eublemma amoena*, *Trichosirocalus briesii*, *Botanophila spinosa*, and *Urophora terebrans*

- Release of *L. latus*, seed weevil, is complete. Level 2 monitoring indicates that local population densities at older release sites have reached levels that are significantly suppressing seed production. Seed production is being reduced by greater than 80% at several of the eight level 2 monitoring sites. Populations of the seed weevil are routinely being found at isolated sites tens of kilometres from the nearest release site. *L. latus* is also showing potential to reduce viable seed populations of *O. acaulon*, stemless thistle.

- Release of *L. cardui*, stem borer, is complete, with monitoring of its effectiveness continuing. The impact of the stem borer was not quantified as of June 2001.

- Field redistribution of *E. amoena*, petiole moth, is unlikely to occur due to no obvious life cycle stage that lends itself to easy field collection. As the spread of the moth will only be by natural dispersal from release sites it is likely to be slower than under redistribution. Due to this at least one release in each network group area is required. No further information is available to date to confirm if this has occurred. Level 2 monitoring indicated that *E. amoena* attacked between 1.5% and 14.5% of rosettes at the 3 study sites.

- Population increase of *Trichosirocalus* sp. nov., has been low at field sites reducing possibilities of redistribution. No information was available on the effectiveness of *Trichosirocalus sp*. nov. on control of *Onopordum.*

- There has been no recovery from the two release sites for *B. spinosa*, crown fly. Two further importations of the crown fly have occurred and will be released when resynchronised to the southern hemisphere. No further work is planned in the new funding period.

- One release of *U. terebrans*, seed fly, was made in 2000. Whether establishment has occurred does not appear to have been reported.

Paterson's curse (*Echium plantagineum)*

Agents – *Mogulones larvatus*, *Mogulones geographicus*, *Longitarsus echii*, and *Meligethes planiusculus*

- Releases of *M. larvatus*, crown weevil, are proceeding quicker than expected, with attack levels at level 2 monitoring sites increasing. Attack rates in regions with late breaks remain below 10%. The Portuguese collections of crown weevil have not shown any improvement over the French weevils in over-summering ability, so separate collections will not be maintained. Experimental work carried out in 1994 and 1995 showed that pasture competition reduced growth, size and total seed weight, whereas *M. larvatus* has the ability to kill its host as well as reduce growth, size and total seed weight.

- Western Australia reported 54% establishment out of 13 monitored sites for *M. geographicus*, root weevil, whereas Victoria reported nil establishment out of 6 monitored sites. No information is available on the success of distribution or attack rate.

- Success in rearing, *L. echii*, flea beetle, has improved markedly which has led to higher numbers of releases than anticipated. The beetle has established at 84% of sites so far. The flea beetle is well suited to the Western Australian climate. Experimental evidence highlights importance of plant competition in combination with *L. echii* for reductions in plant size and seed production. This highlights the importance of integrated weed management.

- Releases of *M. planiusculus*, pollen beetle, have exceeded expectations. Information on its impact on *E.* pl*antagineum* was not provided.

Spear thistle (*Cirsium vulgare)*

Agents – *Urophora stylata, Trichosirocalus horridus, Rhinocyllus conicus*

- Releases of *U. stylata* were higher than expected. Over all releases the establishment rate has been 44%. In 2001 the percentage of plants attacked at three level 2 monitoring sites ranged from 27% to 59%.

- No *T. horridus* were released in 2001 as the weevils were establishing too slowly to allow harvesting. Establishment levels were low at 14%, with one out of the seven monitored.

- No *R. conicus* were released in 2001. Establishment at monitored sites is high at 80%.

Variegated thistle (*Silybum marianum*)

Agents – *Rhinocyllus conicus*

- No further information

2.3.4 Outcomes

There appears relatively little attention given in the documentation to actual outcomes in terms of producer interest or adoption on a regional scale, natural spread, changes in landholder management practices, impact on weed control costs or benefits from improved pasture production and utilisation.

Benefit-cost analyses

PlanEval Service Pty Ltd (1998 cited in the new project application) evaluated the biological control of nodding thistle (*Carduus nutans*) research estimating the cost to the wool industry (it is assumed the cost of the weed prior to bio-control was $9.4 million per year). The benefit-cost ratio of biological control of the nodding thistle was estimated to be 9:1. A review of this study has not been possible as no copy of the report was available.

Two prospective benefit-cost analyses have been conducted on the *Echium* project over the last 18 years, with both reporting sizeable returns on investment at the time of analysis. Initially the Industries Assistance Commission (IAC 1985) conducted an analysis following the Supreme Court Injunction on biological control of Paterson's curse in the early 1980s.

Nordblom et al (2001) from the CRC for Weed Management Systems conducted an analysis using a biological–economic model. The analysis was prepared in support of a wider economic assessment of the Weeds CRC conducted by the Centre for International Economics (CIE) in 2000. This analysis concentrated on the benefits from only one biological agent *M. larvatus* and costs from all bio-control research investment against Paterson's curse since 1972. The benefits were assumed to be realised through increased pasture productivity. Expected attack rates were extrapolated from eight years of field data and the geographic spread was based on field observations of project scientists. Three rates of spread were estimated dependent on the autumn break. Increases in the stocking rates resulting from reduced *Echium* levels were taken from the IAC (1985) report.

Estimates used were sufficiently conservative, allowing for no further releases of *M*. *larvatus* over the current 400 successful releases. No costs savings were included for reduced weed control over current producer expenditures. A gross margin of $8.00 per dry sheep equivalent (DSE) was used. This was taken from the value for wethers, which represents the lowest gross margin per DSE in NSW ($8.80). *M. Larvatus* attack levels below 50% were considered to have no economic impact.

Comments on Nordblom et al (2001) study

(i) The authors stress the importance of the extension program in improving producers' chances of benefiting from bio-control of weeds. However, no further costs are included past 2001 for producer extension work or maintenance of nursery sites. May need backup even if the agent spreads well.

(ii) What if severe drought devastates agent numbers, can they be relied upon to build up numbers along with weed reinfestation? CSIRO does maintain cultures but there would be a cost involved in redistributing insects and delay in built up.

(iii) As the benefits are realised through increased pasture productivity the cost of additional livestock should be taken into account. As a gross margin was used capital expenditure has not been included. Further, the impact on current weed control costs is likely to be significant on many properties. While the reason for this omission was given by the authors, any saved chemical costs were assumed to be offset by other management requirements. Any further analyses should include such benefits. This is because reduced use of chemical control has

environmental implications and the reduced chemical costs are paramount in the minds of producers.

(iv) The new application states the bringing forward of benefits by five years would be worth $225 m in present value terms and attributes this to Nordblom et al (2001). However, we could not find this estimate in the Nordblom et al paper.

(v) Is 50 years too long when talking about biological processes capable of mutations?

(vi) The authors also state that further work is required to test and correct the current assumptions on the rates of geographic spread of insects, rates of attack and rates of economic relief from suppression of *Echium*, under the different climatic regimes in the weed's range. This would assist in estimating the projects success in delivering weed control to producers.

Concerns about BCA in New Application

The BCAs in the new application are unusual, with the starting point being the annual cost of weeds to the wool industry, which becomes the discounted benefit. As there is no information available on what project costs are included in this estimate, e.g. for which insect agents and funding bodies, it is difficult to estimate the validity of this approach. There appears some confusion about costs and benefits.

Taking this further, the application states that the CIE report estimated the annual benefits from successful biological control of Paterson's curse was of the order of $90 m per annum from the crown weevil alone (page 6), yet the total cost of Paterson's curse to Australia's livestock industries is quoted at $74 m per annum (page 7). There appears a need to reconcile the various economic studies on *Echium* and how the results are reported.

2.4 Assessment of the Documentation

The literature includes adequate information on agent releases and the number of sites monitored. However, these statistics represent project outputs rather than outcomes. Establishment of multiple insect agents over the geographic range of the target weeds does not in itself produce useful results. Further information is required on the successful reduction in weed numbers and it is not evident if and how this is being or will be assessed.

Use of a suite of insect agents was stressed in the project application but information on combined effects is not provided in the annual reports. While it is understood that some sites do have multiple species released, the interaction between different agents in reducing weed numbers in the field is left unclear.

Development of an integrated weed management (IWM) package and extension on the importance of IWM is vital to the ongoing success of weed control post project along with a best management practice framework. The need for extension and a good understanding of integrated weed control by producers is emphasised repeatedly in project applications and the Woolmark Business Plan but almost no mention on progress on this was apparent in the literature. Communication strategy milestones are reported on in the 2001 annual report but no measurement of the success of strategy was carried out. As grazing management and pasture competition will remain a large part of weed control incorporating biological agents, particularly with some insects, e.g. *L. echii*, there appears to be insufficient information on how this is being communicated to producers.

The aim of this project (and the 1994 to 1997 project) was to bring forward the benefits of bio-control research to stakeholders. Even if there were difficulties in mass rearing some insect agents over the project period delaying releases, what was delaying the production of information packages on integrated weed control for the more advanced insects?

To establish changes in ongoing weed management practices and hence economic outcomes of the project, further information is required. Case studies or surveys of properties that have had high and medium levels of infestation of target weeds could be used to examine management practices that have changed and the financial implications of these changes.

Producers' level of ownership of and involvement in agent increase and redistribution represents a key to the projects ongoing success. Additional information, to that in the project documents, needs to be gathered to establish producers' level of ownership, perceived level of control, and understanding of the management required to rear and redistribute the agents. The importance of the producer network is emphasised in applications but little information on the network is provided in the annual reports. It would be helpful if the current network could be defined more clearly in relation to its size, current effectiveness, expansion potential, and its ability to self sustain, both technically and financially.

It is unclear whether the spread all of insect agents can be relied upon to be self-sustaining once established. An ongoing producer network may be necessary post 2005 to monitor the continued establishment of the agents and their impact on the weeds to ensure benefits from the project are ongoing. Early intervention would then be possible if agent numbers start to drop, e.g. due to emergence of a natural predator.

The costs of the weeds to Australia are frequently cited but without reference to the source. It is assumed that the source is the IAC (1985) report. It is likely that changes have occurred in weed distribution and control since 1985 if this is the principle source used.

It is possible that concentration on extension and redistribution of the successful agents before providing backup agents is likely to speed up the delivery of benefits, but this no doubt has been considered by project management. However, an impression remains from the documentation that scientists have concentrated more on establishment monitoring more than the level of control at established sites. The Woolmark Business Plan keeps defining success due to the number of releases. However, this is a preliminary output rather than an outcome. On the other hand, the degree of activity of producers in spreading the agents further could be considered an early stage outcome, but unless insects are taken from an official field day this is not monitored.

There is not much data reported on level 1 monitoring sites, which provides information on agent-weed interactions. While this work may have been reported on earlier in scientific papers, it does not appear to have been included in the annual reports.

3. INPUT FROM STAKEHOLDERS

3.1 Introduction and Methods

Following the review of project documents, a survey was carried out in order to assist in answering some of the questions that were raised during the review of documents, as well as canvas a wider opinion on whether the project has been successful in fulfilling its objectives.

The list of those surveyed was developed through consultation with MLA and CSIRO, as well as perusal of project documents. Those to be surveyed were divided into four groups:

1. CSIRO and other scientific personnel

2. State Agency personnel involved

3. Producers and other community representatives (Landcare, local councils etc)

4. Members of the scientific community who were independent of the project, but had some involvement in it.

While the contact details for the producers and other community representatives were provided by CSIRO, contact was made with an additional two producers who are involved with the project, but who were not nominated by CSIRO.

A total of 29 questionnaires were sent out, and 22 responses were received. Six of these were from Group 1 (Scientists), four were from Group 2 (State Agencies), ten were from Group 3 (Producers and community representatives) and two were from Group 4 (Others).

Most of the respondents were involved in the project to some degree, and therefore mostly positive comments were expected. However, as a number of those contacted including producers, Landcare and weeds officers were only involved to a limited extent, there was ample opportunity for shortcomings and difficulties to be expressed.

Slightly different questionnaires were developed for each of the four groups. Some groups did not receive all questions, and sometimes questions were worded in slightly different ways. Where this was the case, only one form of the question is provided below to avoid confusion. In addition, the responses to some questions have been merged where this was deemed appropriate. Copies of the original questionnaires can be found in Appendix 1.

3.2 Summary of Responses

1. Generally how do you think the project (Biological Control of Paterson's Curse and Thistles) has performed since July 1997:

(a) as an R&D project?

All respondents to the survey indicated that since July 1997 the project has performed well in terms of R&D, with some even describing it as excellent. Most indicated that it seems to have reached or exceeded all of its milestones, and that considering the level of funding, the level and success of activity has been excellent. Also to be taken into consideration in any performance assessment is that there has been concurrent attention to several insects.

Some respondents were concerned with the level of funding, and the continuity of funding for the project, and felt that continuity in particular could hinder the ultimate success of the R&D project

Several respondents indicated that the project framework had become a model for other biological control (R&D) projects, as it combines top-down and bottom-up processes across four states.

Responses indicated that the project has been successful in informing landholders about biological control as a practice and a science, and improving the reality of expectations associated with this method. The nation-wide Landcare and producer networks that have been established as part of this project for biological control agent distribution and information transfer is among the largest of its kind in Australia.

Many respondents were also impressed with the monitoring that has taken place, and how this contributes to knowledge about impact and provides lessons for the future in establishment methods. One view was that the monitoring data can also be used to set a benchmark for bio-control projects of this scale at the world level.

One CSIRO researcher responded that the success in establishing insects across the country is a tangible measure of project performance. He indicated that "compared to the international mean, where 60% of biological control insects establish, this project has had over 85% of insects establish."

Most producers spoken to indicated that in their opinion the project seemed to be very well run, with interested and responsive staff involved at all levels.

One state government respondent felt that the project has enabled participating researchers to improve

their knowledge and skills in rearing and release methods, the behaviour of agents and their effects in the field. For example, Level 1 monitoring of *M. larvatus* is starting to provide reliable indicators of the differences in the performance of this agent under different land management regimes.

In addition, many in the State Agencies felt that a key factor to success has been the close collaboration of agencies involved. Coordination and collaboration between states and CSIRO has been reported as being 'of a high order' and the national context of the project has expedited progress through a high level of cooperation. This has enabled the transfer of information between agencies on agent establishment 'breakthroughs'.

1. (b) delivering benefits to industry?

2. Is there any hard evidence of impact at a paddock or farm scale e.g. Reduced chemical use, change of pasture management practice due to absence of weeds, etc?

The responses for Question 1 (b) and Question 2 have been combined. All respondents indicated that the project has been, or will be, successful in delivering benefits to industry. Some indicated the evidence of these impacts can be found in the evaluation studies (e.g. Norblom et al 2001) undertaken to date, or more commonly, by talking to the producers who have the agents on their properties.

Examples of benefits provided by respondents from Groups 1 and 2 (as defined in Section 3.1 above) are:

- Given ownership to landholders by involving them in redistribution
- Benefit to the industry has been the successful supply of agents as well as support and feedback necessary for biological control to start to show longer term financial returns.
- The target weeds have been in Australia for more than 100 years, yet the insects have only been in Australia for 10 years, and considering this, the impact is remarkable.
- The impact has been quantified by CSIRO monitoring and many producers are saying already they see less vigorous weeds, which means more pasture and less herbicide.
- Have measured a decline in populations of nodding thistle and seeing local impacts for Paterson's curse.
- Empirical evidence to hand indicates that the biological control agents are having a significant impact on the weeds' population dynamics, long-term viability and thus their economic impact.
- Reducing seed set, vigour, plant size and plant density for a range of species at a range of sites.
- Since the commencement of the Paterson's curse project there have been 290 releases at 138 different locations of WA. One respondent believes this is strong evidence of the delivery focus of the project.
- No objective measurements due to lack of resources but there is an increasing amount of "subjective evidence" e.g. graziers stating reduced or modified chemical control regimes.
- Some farmers have indicated reductions in chemical use
- Changes in management practice beyond reduced herbicide usage would not always be a good predictor of project benefit as most pasture management should always aim to augment the beneficial pasture component as well as manage the weed. Some farmers have started to do this more

effectively following the activities of this project.

- Yes there are indications of impact from farmers but this is only at a local level for Paterson's curse, unlike *Onopordum*, which is across the entire distribution for nodding thistle.

- At a research level they have been able to demonstrate the decline of nodding thistle populations and significant reductions in the seed production of *Onopordum* thistles. Have not had funding to ask questions on changes in management practice.

- Anecdotal evidence would indicate there is a change in philosophy amongst the farming community especially towards reduced usage of pesticides.

- WA impact to date is small as numbers are still building up and most sites have only one agent established.

Examples of benefits provided by respondents from Groups 3 and 4 (as defined in Section 3.1 above) are:

- One producer reports little to no benefits on their property at this stage for Paterson's curse, however they are starting to see a noticeable decreases in numbers and spread of thistles resulting in less chemical needed.

- Benefits are being commented on by most farmers in the Harden-Murrumburrah region.

- One producer reports reduced weedicide spraying costs as well as a decreased negative impact of chemicals on the livestock. Also Patterson's curse was adversely affecting the health and performance of the stock and therefore long-term benefits to stock are evident. Already this producer is decreasing the area sprayed for Paterson's curse. During the past 6 years they have used helicopter contractors to spray. Being able to reduce this has resulted in a direct financial and social benefit (e.g. $5000 fees for helicopter). Eighty acres will not be sprayed this year. Incidentally, the agents were not directly released on this property but migrated over from the neighbouring property, to a paddock of 80 acres that was not grazed for one year.

- Another producer reports benefits to his property. He used to have 40 acres out of one hundred acres with heavy infestation (100%) and would aerial spray 40 to 60 litres of chemical with a plane at a cost of $1800. Now that the insects are established on his property he is spot spraying over 10 acres, and only about 10% is Paterson's curse. The producer can even walk through and pick the Paterson's curse plants out by hand. Seven years ago the producer had no chance of doing this and now over last three years there has been a significant difference. Some years the insects kill all weeds, other years they leave about 20%. There were only 100 bugs released, and now there are tens or hundreds of thousands evident from self propagation and there is evidence that some agents have moved up to 20 km from the release site. Also, some of the landholders sheep may have died after a few months in the infested paddocks previously. Now he has no stock losses due to Paterson's curse.

- There is not much impact evident yet, however there is some impact evident in a National Park that isn't grazed.

- There is a small percent reduction in weeds, especially for Scotch thistle. The seed bank is down and now thistles are only about 2 feet high instead of 6 feet

- There is evidence of plants being under stress, however at this stage no substantial economic benefits.

- Most sites have a good reduction in the number of plants (Wagga City Council).

- Hard evidence of impacts is probably not available as benchmarks were not established prior to release of insects, but there is verbal evidence that farmers believe reduction has occurred. Pasture and grazing management changes over the past years has led to better management of weed infestations with insects having a place.

- On our property we are reducing chemical use, pasture is improving and stocking rates are improving in combination of a decrease in weeds, improved soil fertility, improved pasture species and improved grazing practices.

- Thistles are less prevalent around Yass allowing better stock movement to feed and water.

- One property owner reported that the insects had spread all over the farm and onto neighbouring ones without any assistance. In addition around 100 farmers from a 50 km radius have taken insects from his property to their own properties. In 1995 the farm was spending $15,000 per annum on Scotch thistle control, and in addition, dense stands of thistle reduced the carrying capacity by about 1.5 sheep per acre, which at the time could be valued at $20 per acre. Therefore the property now has a saving of around $30,000 per annum. However some of this is also due to increased knowledge about grazing systems and the use of more competitive pastures.

3. Are you confident that the impact by 2010 and associated financial benefits to industry will be as expected (e.g. $90 million benefit per year from the control of Paterson's curse by crown weevil)?

Most of the respondents who were familiar with CSIRO's economic model assumed that this model was the source of the $90 million per annum benefit referred to above. All indicated confidence in the assumptions and model used to calculate that figure. However, one respondent felt that the economic model that predicts impact of Patterson's curse biological control contains flawed assumptions on the impact of the weed in some States. Also, they believe it bases the rate of spread and damage from the agents on preliminary and unreliable data and is based on the impact of sheep farmers only. This person believes that the model requires an overhaul and validation with field data.

Respondents to the questionnaire who were not familiar with the model, indicated that substantial financial benefits would be evident in the future, however they were not in a position to place a quantitative estimate on those benefits. Overall, they did not think that $90 million per annum to Australia was an unrealistic estimate, however it is unclear whether respondents were considering the impact of only the crown weevil on Paterson's curse, or all agents on both Paterson's curse and thistles

Many respondents did point out however that any economic benefit is dependent on factors such as the price, supply and demand of wool, beef and lamb, as well as climate factors such as prolonged drought. Also the figure is based on current stock levels, which may change.

One respondent was aware of an ex-post assessment of a skeleton weed project that showed benefits of a similar magnitude.

Some respondents also indicated that there are not only financial benefits but also wider social and environmental benefits from reduced chemical use.

4. If not by 2010, what is a more realistic timeframe where producers will have modified their pasture management program (i.e. reducing weed control costs) as a result of the impact of the program?

Many respondents indicated that benefits will start to "kick-in" around the year 2010, and that these benefits will not be evenly spread by region. Benefits will vary by location and climate and will accrue over many decades. It was recognised that selected landholders are seeing some benefits now, but that

by 2010 many are expecting to have all agents widely established and impacting on plants. However others point out that some properties will still not even have agents by this time. This will be dependent on the reliance on natural spread, versus the continuing establishment of more nursery sites and releases.

One respondent pointed out that any economic benefits would be dependent on any savings in spray costs being pumped back into more effective pasture management to reduce other weed incursions. The economic benefits of this project are seen by this respondent as part of a broader package and pasture management strategy.

5. What do you see as the major risk factors that will influence the actual achievement of the stated benefits? For example

(a) the efficacy and spread of the agents

(b) the adoption of biological control by graziers

(c) seasonal conditions

(d) inappropriate management actions by graziers

The efficacy and spread of the agents was seen as a significant risk by many respondents, however it was pointed out that this risk can be, and has been, minimised through the careful selection process undertaken at the outset of the project. Agents have been selected with efficacy in mind but may be limited by climate (e.g. areas with a late break to the season).

The efficacy, and in particular the spread of the agents, are also dependent on the farm system and resources put into rearing and redistribution. The number of sites and the initial level of release determine the spread of agents, which is a function of funding. One respondent was of the opinion that cessation of redistribution programs and reliance on natural dispersal will lengthen the timeframe for the stated benefits to be achieved. Likewise, another respondent stated that efficacy has been demonstrated but there is a need to accelerate the number of established sites to enable the insects to maximise their biological impact in a shorter timeframe.

The on going monitoring that is undertaken is critical in providing opportunities to fine-tune the rearing and release processes. The efficacy of the agents can also vary by location and time. Therefore monitoring across a range of environments was seen as critical.

Almost all respondents felt that the willingness of graziers to adopt biological control is not a significant risk. In fact, it is not the numbers of graziers willing to adopt that is the limiting factor but rather that the ability to supply agents is limiting. There is in fact a backlog of producers in Western Australia waiting to participate. In other areas, growers are establishing their own nursery sites and taking the agents from other properties where the agents have become established. For example one producer in the Euroa area reports a field day at his property where around 20,000 agents were taken from the property by other landholders. However, it is unlikely that that there is any records of the use or establishment of these agents on other properties.

Another risk factor reported was the unrealistic expectations and high levels of enthusiasm of growers. This can lead to disillusionment in some cases. Another issue with unrealistic expectations relates to weed and pasture management by graziers. Some landholders are of the opinion that bio-control removes the need to continue to be actively involved in weed management and they abandon traditional methods of weed management.

Another risk issue is a reluctance to make the necessary management changes to optimise the establishment of the agents. For example some landholders are reluctant to reduce the grazing level on establishment areas.

The education and extension involved in the project is aiming to rectify these issues and reduce the risks of inappropriate management by landholders. One respondent felt that the results to date indicate that the education messages are getting through.

Some respondents suggested that the level of supervision, screening and training of collaborators could also help to overcome issues with inappropriate management by graziers.

Seasonal conditions were highlighted as one of the highest risk factors. Seasonal conditions, particularly extreme conditions, are particularly critical during the establishment phase prior to the agents reaching a "critical mass". Flood, drought, summer rain and the autumn break are all critical factors, however the impacts vary. For example the recent hot dry summer in Western Australia did not result in the loss of established populations in the field.

One respondent indicated that attempts to reduce the impact of climate have been undertaken by increasing the number of bugs released and they also referred to Best Management Practices for release that was developed by the CRC.

A risk factor identified by many respondents was the possible future lack of funding. Many felt that this will severely diminish the likely benefits from the project as the rate of spread and establishment of the insects will be greatly decreased if more nursery sites are not established and more releases are not undertaken. Funding is also critical to education, which is seen as the most effective method of reducing many of the risks associated with establishment.

6. Has extension material post 1996/97 been developed and provided to producers and Landcare groups on:

(a) management of agents, and

(b) IWM

CSIRO and State Government personnel felt that adequate information on the management of agents had been provided to collaborators through the distribution of the glossy information kits released. These information kits contained colour photographs of agents at each life stage and through the season. Other establishment and management techniques are also provided in the information kits.

These personnel also acknowledged that little or no information had been developed and provided on Integrated Weed Management, as they perceived this as outside the scope and funding of the project. However they felt that there was a significant amount of information available from IWM from other sources including Departments of Agriculture and the CRC.

One respondent indicated that in August 2001 Agriculture WA reprinted a 23-page handbook on Managing Paterson's Curse.

Landholders and weeds officers were less certain about the adequacy of information provided to them. Some felt that sufficient information was available, and that they did not require any more in order to able to manage the insect populations on their properties. Most however felt that they did need more information and follow-up advice, particularly on IWM. Some did acknowledge that their existing information on IWM has come from other sources including attendance at field days and through talking to scientists visiting the property during the establishment and monitoring of the nursery sites. Several landholders acknowledged the importance of field days as a source of information and education.

7. Are appropriate systems in place to monitor the impact over time on graziers' properties?

(a) regarding the producer initiated versus natural spread of the various insects from nursery sites

(b) regarding interactions between different agents in the field

(c) regarding financial gains on individual properties

(d) regarding financial gains on a regional basis within a consistent nationwide framework

Most respondents indicated that all of these levels of monitoring were outside the scope of the project, and that funding was not made available for these types of activities. One respondent stated that the philosophy has been "what is the least work that can be done to generate the most basic of information". All respondents however indicated that this type of monitoring would have been valuable, and would be a valuable addition to the project in the future.

Respondents did indicate that the monitoring of natural spread beyond the immediate release area, and the monitoring of interactions between various agents, only occurs at selected higher level monitoring sites.

Producer distribution is not currently measured but obviously this type of distribution will only add to the impact. The training of graziers should allow them to identify if they need to spread insects themselves to a particular infestation.

A Western Australian respondent indicated that monitoring protocols have been developed and data is submitted to a central CSIRO database. This data quantifies the density of agents, the density of the weed and estimates rates of spread. Measurements of the seed bank are also undertaken.

One community representative felt that the monitoring process needed to be made easier to allow landholders to participate more fully. South Australia indicated that they are currently redefining monitoring techniques to make them more user friendly to Landcare groups, weed officers and producers.

Examples provided of some of the monitoring activity undertaken includes:

- Farmer weed control practice surveys before and after the project. (It is not clear how widespread the use of this type of survey is.)
- Reductions in weed density correspond to increases in pasture productivity as measured at the IWM sites.
- Agriculture WA personnel monitor with a butterfly net over a certain area on an individual property and then use calculations and extrapolations to assess the spread of the insects. Agriculture WA also pulls weeds out to inspect root damage etc.
- Trial plots, monitoring and using insecticide to kill bugs on some plants, then compare plants with and without plants to measure the effect of the weevils on an area basis compared to a neighbouring block.

8. Do you know of any similar other biological weed control initiative (Australia or elsewhere) that has been successful and can be used as evidence of likelihood of success for this project? What about failures?

Many respondents who were aware of other similar initiatives felt that this project was in fact setting the benchmark for many other national and international biological weed control projects to compare themselves to. CSIRO believes that this is the first attempt to undertake such an organised redistribution on a national scale and has served as a model for more recent projects.

Others were hesitant to make extrapolations from or to other projects, and felt that predictions from past case histories ill advised.

Examples of successful Australian biological control projects identified were:

- Prickly pear using the agent Cactoblastis (many respondents gave this example)
- Dock moth
- Ragwort using the agent *L. jacobaeae*
- St John's wort mite
- Horehound plume moth

9. What do you see as the primary role of a new project (funding period 2002-2005)? How will it enhance the overall effort in weed biological control?

CSIRO personnel see the role of the new project as to complete the task by redistributing the remaining agents from the selected guild of agents. They state that the bio-control strategies for these weeds depend on the interaction of complementary agents. If all agents cannot be redistributed control will be greatly diminished and the value of the earlier industry investments greatly reduced.

Other suggestions/opinions relating to the role of any new project include:

- Any new project should have an integrated systems approach using biological control as one tool in pasture weed management to lead to producer practices that increase the long-term productivity of pastures.
- Accelerate the distribution of agents and their establishment; complete the basic distribution of new insects; continue with the monitoring of agents and their performance; develop robust IWM systems and modelling.
- Enabling the continuation of redistribution releases of agents in order to satisfy demand. This should take advantage of the enthusiasm of the redistribution network members. It should enable continuation of all levels of monitoring to improve scientific rigour and reliable estimates of agent impacts.

Landholders and others involved in the project at a community level were asked if they felt that the release of more agents was warranted. Some respondents interpreted this as more releases of agents that have already had a significant number of releases, while some interpreted it as the release of completely new agents that have had limited or no release to date. Regardless of the interpretation, all respondents overwhelmingly felt that the release of more agents is warranted, and will be of great benefit.

10. How could the impact of the agents in the field be improved?

Some respondents felt that at a local level there is little that can be done to improve the impact of the agents in the field. They felt that they agents will reach their natural potential given local conditions and careful releases, and that resources should be put into more releases of the agents.

Others felt that some improvements could be made at the local level. Suggestions included:

- More effective pasture management.
- Can be improved by managing release sites to maximise the reproductive potential of the insects.
- Ensuring the post release management of sites confirms to best practice will speed up maximum impact. However you can only educate farmers, not make them follow best practice.
- Research on integration techniques will enhance agent impact.
- Establishment of the suite of agents at each site. To date the majority of nurseries have involved release of a single agent.
- Improve monitoring techniques.
- Farmers could maximise the insect's reproductive capacity by setting aside small areas of heavily weed-infested land to act as local nurseries. These would not be grazed or sprayed etc.
- Larger releases, with improved coordination to assist in knowing where things are happening and what's going on in other projects for other weeds.
- Continuing research combined with careful management by the grazier ensuring the agents in the field have the best chance of survival.
- More research on their establishment in the field as some have had problems with this. E.g. should they be in bushland where it is not grazed, should they have a Northerly aspect?
- More full time staff in the field to help nursery sites survive and then each release would be more effective. Also larger number of insects released at each site
- A good monitoring system and continued release, appropriate personnel, detailed information on the agents and appropriate management regimes.

11. What aspects of the project would you suggest could be improved upon, if this project were to be started again, say for a different group of insect agents and target weed?

Most respondents were unable to offer any significant improvements to the way in which the project has been carried out. Some suggestions include:

- Increased monitoring, involving a bioeconomist, in order to more readily assess the likely spread and quantitative impact of the agents. However it was recognised that increased funding would have been required to carry out this monitoring and assessment role more effectively.

- Concentrating only one or two agents at a time, and then sequentially working through the agents could have enhanced the project. However this approach was not possible due to funding as it would have taken longer and more resources. It was felt that it was more cost-effective to work on many agents concurrently.

- All future biological control projects should also be couched within an IWM framework where the adaptive management is the general philosophy on which biological control and weed management is applied.

- The project has already invested in overcoming cultural differences in the state organisations so any future work will benefit from this and streamlining will be possible.

- All co-funders should be initially identified and required to enter into a contract for the specified duration of the project to ensure costs are shared between beneficiaries etc. Typically project funding ceases after the release phase and the impact of agents is not determined and IWM strategies may not be devised.

- More information to landholders at the start of the project and larger numbers of insects to each new site.

- Monitoring growth rates of target weeds etc prior to release of agents to ensure an appropriate baseline for ongoing monitoring.

12. Can the existing distribution/extension model be improved?

Most respondents were happy with the current distribution/extension model, and could see little room for improvement. Most improvements suggested were in the form of greater staff numbers, which requires greater funding.

Others noted that the model is adaptive and is continually changing as a result of feedback. Some felt that there is a risk that without continued funding the network will be difficult to maintain, and that the network is unique and can be valuable in the future. For example any future project in a related form could take advantage of the established network, which seems to involve a high level of cooperation between State agencies.

Some felt that more effort could be made in capturing the interest of cooperators in the field, (for example Landcare and community groups), through increased attendance by officers from CSIRO and State departments at relevant conferences. It is thought this would increase the level of collaboration and understanding at a regional level. These activities have previously been on an ad hoc basis due to lack of funding.

One respondent suggested that the involvement of commercial sponsors would have been useful in achieving the goals of the project more quickly.

13. What bodies should be involved in distribution, and who should be the appropriate body/agent for coordinating the release and monitoring of the insects?

Most respondents felt that it was appropriate for the bodies currently involved in distribution to continue with that involvement. Some felt that there was a greater role for Landcare and other community groups, but others felt that there were sometimes problems involving these groups and that local government officers were a more appropriate option.

Some respondents did indicate that the involvement of Landcare and other community groups could help to increase 'ownership' of the project by the community.

All respondents agreed that for reporting and organisational purposes a coordinating body is essential and that CSIRO should continue to fill this role. They should also continue to undertake initial research and evaluation studies. CSIRO should then transfer information to the State Departments, who have the links and networks to be able to transfer information to local government, or other community level groups for distribution of the agents. Some suggest that the State Departments could directly transfer information to the landholders via Animal and Plant Control Officers.

One respondent felt that once the agents are more clearly established, that the coordination role should be shifted to a network of Farm Management Consultants or a commercial agribusiness company interested in growing, distributing and monitoring the product.

14. How involved has been the Landcare Network with respect to this project? How many Landcare groups or other producer groups have been actively included in the State network (for your State)?

The NSW State Department acknowledged that the Landcare network is an integral part of project, however its importance varies according to location and the strength of Landcare networks in particular locations.

The Victorian DNRE informed that since 1995 a total of 47 Catchment Management Officers, 7 Landcare Facilitators and 35 Landcare groups have made 236 releases of Paterson's curse bio-control agents on to 192 properties. Since 1997 the thistles project has set up a total of 124 nursery sites involving 18 Landcare groups across Victoria.

South Australia found Landcare groups unreliable so instead set up a network of local Animal Plant Control Board Officers (APCB). These Officers have established links to the growers and assist in looking after nursery sites. There are approximately 20 APCB officers actively involved. Some of these officers have collected agents from an established population at Yanco and then released agents in their own area.

Western Australia currently has more than 50 personnel involved in identifying locations of Paterson's curse infestations. The personnel are made up of local government officers, LCDC members, community catchment groups, agricultural advisers and District Agricultural Protection Officers.

15. Is it correct that for *U. solstitialis* and *T. horridus* on nodding thistle the release stage is complete? Does this mean that the producer and Landcare groups are fully informed of what is required to maintain nursery sites and require no more input from researchers or extension officers?

Only the respondents from the NSW and Victorian State Departments had any knowledge on this issue. They acknowledged that the release stage is complete and information has been widely distributed through agent information kits and field days. However, the view was this does not guarantee that there will be no further need for involvement of CSIRO or the State Departments, as some do not want to read literature and would rather phone and ask. In addition, personnel within the State Departments often change and there will always be a role for researchers to provide up-to-date information to extension officers to ensure that producers and community groups are well informed.

16. Do you believe the group/yourself has an adequate understanding of the rearing and redistribution process for agents?

Most respondents felt that they had a reasonable understanding of the on-farm aspects of rearing and redistribution of the agents. However, it was acknowledged that they are still learning and that continued support and communication with the scientists is desirable. Most also indicated that to date, CSIRO personnel have been extremely helpful in terms of constant updates, communication and advice.

17. What would happen if the group/yourself received no further technical or financial support, would the group/yourself stop rearing and distributing the agents?

18. What is your/the groups understanding of the ongoing role of you/your group following the completion of the 'science' part of the project?

Most respondents indicated that their ongoing role will be to enhance the spread of the current agents and any new ones they may receive. They will also continue to promote the benefits of biological control to other members of the community. However they indicated that the establishment of new nursery sites on new properties would be difficult without ongoing funding and support. One particular aspect that would suffer would be the monitoring of the distribution of agents from established sites. One respondent felt that it "would be a national tragedy if it were perceived by the funding bodies that the 'science' of the project is complete".

4. FINDINGS

4.1 Introduction

This chapter provides a summary of the principal findings of the brief review. These findings are drawn from an inspection of the documents that were available and from input from a range of stakeholders via a structured questionnaire. An initial assessment against the project objectives is made first (Section 4.2) This is followed by an assessment of the benefits to livestock producers and the community (Section 4.3). Finally, some suggestions for a future investment strategy for MLA concerning biological weed control are provided (Section 4.4).

4.2 Assessment Against Project Objectives and Desired Outcomes

Each of the objectives of Project TR.047 are examined to assess the level of achievement attained. There were five objectives as stated earlier in Chapter 2.

(i) *Establish 1400 nursery sites on properties:* Over 1400 releases (release = nursery site) have occurred since the start of this project (1745 by June 2001). The CSIRO in Canberra have a database of graziers and release site details.

(ii) *Establish a distribution network that is self-sustaining*: Continued development of a distribution network above that already in place at the start of this project appears limited. The Woolmark Business Plan produced in support of funding for the project extension has the number of groups identical to the start of the project. In the new project application there is reference to links with over 100 Landcare groups and more than 1600 woolgrowers and meat producers, showing a marked increase in networks in the last two years. It is acknowledged however, that this increase is likely to have been over the whole project period but not collated for the Woolmark Business Plan.

(iii) *Formulate best practice guidelines for IWM:* The formulation of basic best practice guidelines for the integrated control of the target weeds including biological control, herbicide control and

grazing management is not mentioned in either the June 2000 or 2001 reports. A control agent release kit was developed for *Onopordum* thistles under an earlier project. This kit was updated during this project to include *Eublemma respersa* and *Trichosirocalus sp.* nov. The *Onopordum* thistle kit provides information on the weeds, the chemical and cultural practices for control of the weeds and the release of the insect agents, plus how to establish and manage a nursery site. In addition there is a response sheet to give details on the release of the agents and a survey form to be returned to CSIRO. While information on other weed control practices is provided, it is not at a level that would satisfy the criteria of the formulation of best practice guidelines. No best practice guidelines were sighted for nodding thistles or Paterson's curse. Many producers sourced this information from other sources but would like further information.

However, those involved in the project viewed this area as not being within the project's scope despite the development of best practice IWM guidelines being a stated project objective. Given the beliefs of the project personnel, it is not surprising therefore that it was not addressed in the project. However, there is need for an explanation of why this objective was discarded. One possibility is that this objective was given lower priority due to resource shortages or it was decided that it could be addressed more effectively through some other avenue (e.g. via the Weeds CRC, outside the project).

(iv) *Raise producer awareness of IWM and skills in rearing and distribution:* The raising of producer awareness of the importance of integrated control for effective weed management in livestock pastures has been attempted. Field days have been conducted but it is not clear to what level integrated weed control has been emphasised. There is more evidence of provision of skills and information packages for producers on insect rearing and distribution. Producers were provided with an information package on insect rearing and distribution of *Onopordum* thistle control agents as mentioned in (iii) above. A nodding thistle control agent release kit was produced in an earlier project and updated with minor changes in this project. The nodding thistle kit provides information on the weeds and the insect agents plus how to establish and manage a nursery site. 'A guide to managing nursery sites of the Paterson's curse crown and root weevils' was developed in an earlier project but no updates made during this project have been sighted. While these kits meet part of this project objective, no information appears to have been gathered or assessment made on whether the kits and field days have provided the producers with the necessary skills to rear the various insect agents. The responses to the current survey were quite positive with regard to awareness and knowledge of rearing and distribution techniques and it is concluded that this objective was met.

(v) *Evaluate agents and commence quantifying their impact:* Evaluation of the establishment and survival of agents has occurred at numerous sites. However, information on the spread of the released insects and the quantification of their impact on the control of the target weeds is somewhat sparse. Several scientific articles and the 2000 and 2001 annual reports provide some data on several species control of the weeds, but a clear picture on the progress on all agents is not available. The impression given through the reporting is that establishment rather than damage to/control of the weeds is seen as meeting project objectives. Similarly to objective (iii), those in the project who responded to the questionnaire did not see impact quantification as being in the scope of the project.

The pursuit/achievement of four of the commercial outcomes stated in the original proposal is assessed below. The achievement of the other commercial outcomes are not specifically discussed here as they are adequately covered in the objectives above.

(i) *Deliver agents to producers*: The project has delivered to some producers a suite of host-specific biological control insects for Paterson's curse and thistles. However, it is likely to be the level of producer involvement in redistribution and maintenance of nursery sites that will determine the project's success and the timing of benefits. This is examined further under objective (ii) above.

(ii) *Establish ownership by producers:* The success of active participation by producers in biological weed control leading to their ownership of the process and outcomes is not reported on in a manner that is conclusive. That some Landcare groups have taken over responsibility for redistribution and that redistribution is occurring outside official field days is a sign of producer involvement and belief in the project. However, even though there appears to be a lack of reporting on producer involvement and ownership, the input to the review from producers strongly confirmed that this is being achieved. Further, it is noted that in the new project application there is an objective of gaining feedback from participating landholders on their perceptions of the effectiveness and value of the investment by AWI and MLA.

(iii) *Reduce weed control costs:* Assessment of whether direct costs (e.g. weed toxicity, herbicide use, low pasture productivity) and indirect costs (e.g. stock management issues) associated with weeds have been measurably reduced has not been attempted. At this stage assessment of reduced costs appears to have been disregarded and was considered to be outside the scope of this project according to involved personnel. Either this outcome was neglected or it may have been consciously recognised that it may be too early to observe or record changes in management practices and costs.

(iv) *Assess performance of agents at both paddock and regional scale:* Development of methodologies to measure the performance of bio-control insects on both a regional and paddock scale were developed prior to the project, with only minor changes due to the project itself. The methodologies appear to monitor at the paddock scale and whether this is then collated to provide regional level information is unclear. Also, whether the regional level monitoring envisaged was to do with the spatial location of sites, or to do with regional impact is not clear.

Overall, all of the five project objectives appear to have been met, and in some cases met particularly well, with the exceptions of objectives (iii) and (v). Less emphasis in reporting than what may have been expected was given to the stated outcomes. Regarding outcome (iii) and (iv) above, the translation of the apparent propensity of the agents to reduce plant numbers and vigour to assist landholders is a central focus for achieving industry benefits. It is surprising therefore that more attention was not given to the outcome end of the project, at least developing processes for monitoring management and cost changes, and attaining structured feedback from producers. However, as noted earlier, the separate monitoring project has not been explicitly reviewed and it is not clear if some additional activity has taken place with respect to this type of monitoring. The input from project personnel indicated that this type of monitoring was outside the scope of the project and no funding was made available for such activity.

While it is understandable that the initial focus of the project focus may have been on "getting the agents out", it is now time to focus on management and economic impacts and the pasture and grazing management systems that maximise benefits in the longer term.

4.3 Benefits to Livestock Producers and Community

Introduction

The emphasis on the project to date understandably has been on the science and the disbursement and spread of the agents. The delivery of benefits to landholders necessarily will take place over a long time period due to the nature of biological control. From the input from stakeholders described earlier in this review, benefits are just commencing to appear.

Benefits Anticipated

The benefit categories identified in the documentation included:

- Lower penalties for contaminated wool
- Increased pasture productivity
- Increased stock carrying capacities and increased wool and meat production through improved pasture production and improved stock health resulting from reduced pyrrolizidine alkaloid ingestion and less soft tissue damage by thistles
- Increased producer use of integrated management techniques including increased pasture production due to improving pasture to increase competition
- Lower herbicide use and costs
- Environmental impacts reduced
- Reduced tillage
- Reduced weeds on public lands
- Improved enjoyment of public lands

Benefits reported

- Of most value to producers appears to be an anticipated lower requirement to use chemicals. Two producers reported that they have either reduced or intend to reduce the areas that they aerially spray and most producers referred to this benefit unprompted.
- Other observations reported include reductions in weed densities and improved pasture performance, improved soil fertility, some reduction in the seed bank, increased stocking rates, reduced stocking deaths which used to result from long term grazing on Paterson's curse, and improved stock movement to feed and water due to the reduction in thick stands of thistles.
- However, it was pointed out by one respondent that hard evidence of impact and benefit is difficult to measure as benchmarks were not established prior to the release of the insects.
- Also, most of those producers who are reporting impacts on their properties, also indicate that they have not only introduced the agents to their properties, but have also altered other pasture management practices at the same time. Therefore attribution of pasture improvement to the insect agents is more difficult.

Probability of Success

While there are examples of successful biological control of weeds in Australia (eg skeleton weed, prickly pear), there was insufficient time in the review to assess the various previous Australian attempts at targeted releases for weed control that might have provided a guide to likely success of this particular project. Further, attempts at ascertaining views of those independent of the project met with limited success. Also, it was not possible to benchmark this project internationally nor provide indications of likely success from what might have occurred overseas.

Based on the views of producers and others who were considered able to provide a reasonably dispassionate view, we would conclude that there is much optimism and that it is likely that some degree of success will be achieved.

Risks to the achievement of the anticipated benefits

- Experience to date shows that adverse seasonal conditions during the establishment phase is a significant factor in the success of the establishment of the insect agents. Once the agents are established adverse seasonal conditions can knock populations, however experience to date suggests that most agents appear to be able to recover fairly rapidly.

- The willingness of graziers to adopt biological control does not appear to be a significant risk provided natural spread will occur anyway. However the unrealistic expectations and high levels of enthusiasm of growers can lead to disillusionment in some cases.

- A related problem is that some landholders are of the opinion that bio-control removes the need to continue to be actively involved in weed management and they abandon all other methods of weed management.

- Some landholders are reluctant to make the necessary management changes to optimise the establishment of agents, for example reduce the grazing level on establishment areas.

- Distribution systems currently in place may not be self sustaining with further scientific and extension resources required from CSIRO and State government agencies that may not be available. In addition, populations of agents may not become self-sustaining in some areas and may continue to need nursery sites to allow redistribution in cases of extreme seasonal effects or in case of predator introduction. The role of agribusiness in potentially distributing agents in the future should be considered if such a need arises.

Maximising Future Benefits

The maximisation of future benefits to producers and the community from this important project will depend on the efficacy of the agents under commercial production conditions. The monitoring of future impacts and feedback under property management conditions would appear to be important in order to develop and fine tune management systems that maximise profitability, taking the presence of the agents into account. Also, it may be necessary to monitor the rate of spread on a geographical basis in order to focus extension and redistribution activities within and between properties.

Conclusion

There is evidence that benefits are starting to emerge to producers. However, it is likely to still take some time before significant benefits will accrue on a wide basis across the different regions. In the meantime,

further attention to monitoring impact under total property management conditions is required as well as the consideration of further scientific and extension support to assist in minimising the major risks to the attainment of benefits. That is, ensuring an appropriate scientific and management information response to difficulties in managing the agents under commercial production conditions.

4.4 An Investment Strategy for MLA in Biological Weed Control

Lessons learnt from this project

The major lessons learnt from this project include:

- There is a need for the integration of the scientific, extension and producer aspect of such a project, rather than an abrupt "handover" from science to extension.
- Patience and management of expectations is required by all in a long duration project of this nature.
- The distribution model is praiseworthy, as there is a need to take advantage of those producers who are keen to be involved and enthusiastically support the project. Hence, developing the mix of Landcare groups, weeds officers, individual producers etc has demonstrated an adaptability to achieve maximum impact.

Future requirements for this project

We were not asked to comment specifically on the current application for a project extension to 2005. It is our view, however, that the current application should be supported on the grounds that it might not only bring the benefits from the project forward in time, but that it might also provide a greater probability that the overall biological control program will work effectively in the long run.

Future requirements for this project could include the following:

- The existing network should be defined more clearly in relation to its size, constituent type, current effectiveness and weaknesses, nature of its expansion potential, and its ability to self sustain, both technically and financially.
- Existing monitoring will most likely need to be extended post 2005 together with changes in the type of monitoring such as an increased focus on outcomes including management changes.
- There is a need to prepare immediately for monitoring and reporting of impacts. Outcomes are likely to be highly visible and could be a good selling point for MLA if benefits are as high as predicted/hoped for.
- A review of the economic model and its use as part of reporting and validation of future expectations of benefits would be helpful. This might best be undertaken as an external review and would ensure that assumptions are based on the latest field data. This is recognised by CSIRO personnel who state that further work is required to test and correct the current assumptions on the rates of geographic spread of insects, rates of attack and rates of economic relief from suppression of *Echium*, under the different climatic regimes in the weed's range. Rather than just using the IAC assumptions regarding changes in pasture productivity data, it would be better to collect data on what is actually happening from this project on changed management practices and stocking rates.

- Consider appointing a bioeconomic modeller to assist CSIRO, States and funding bodies in carrying out an appropriate degree of outcome monitoring and aggregation. This would be carried out in order to identify gaps in the impact of the agents, and to prepare and extend material on the individual benefits to producers from becoming involved in redistribution to their properties and further redistribution within their own properties. Such a modeller could also extend the model for Paterson's curse to one for thistles.

A future strategy for biological weed control

- The views of a range of those involved in the project suggest that the CSIRO - State Department cooperation and integration of effort in this project was highly successful. This relationship and the existing network can form a base for future projects of this nature.

- It seems that the selection and screening of appropriate collaborators is best done on a case by case basis, perhaps influenced by the level of 'professionalism' of the community groups.

- There is a need to establish a current baseline for chemical use in weed control. Chemical use is expected to be reduced and this will be a major benefit as perceived by the wider community. Further such use should not be that difficult to measure.

- MLA need to ensure that other projects are handling the IWM aspects satisfactorily as there appears some confusion about this - it is an important issue that will significantly determine the degree of success of investment in biological weed control.

- There is a need to update and prioritise the economic impact of weeds in relation to the meat and livestock industries, as most material sighted is quite dated. This will be particularly important if priorities are to be set for further weed projects using biological control.

4.5 Summary of Suggestions

Table 4: Summary of Suggestions Regarding the Project and Future MLA Strategies

Current Project	
Issue	*Suggestion*
Support	(i) The extension to the current project should be supported
Economic analyses	(i) The reduction in chemical costs should be included in any future benefit-cost analyses of this project (ii) There is a need to reconcile the various economic studies on *Echium* and how the results are reported (iii) CSIRO's bio-economic model that predicts impacts could be updated regarding assumptions on rate and spread of damage and validated with field data (iv) The benefit-cost analysis in the new application requires further explanation
Further distribution of agents	(i) Speeding up of the expected impact is likely to be facilitated by additional resources ($, staff, agents) being committed to the project over and above the extended project; it is suggested that this could be considered selectively on a regional basis and on the merits of specific situations and constraints (ii) The role of agribusiness in potentially distributing agents at some time in the future of the project should be investigated
Assessment of existing network	(i) The existing network should be defined more clearly in relation to its size, constituent type, current effectiveness and weaknesses, nature of its expansion potential, and its ability to self sustain, both technically and financially
Monitoring	(i) There should now be more attention given to outcome monitoring including the reduction in weed numbers, impact on grazing management and costs and returns (ii) In the first instance, case studies of properties reporting impact could be provided
Future Investment Strategy	
Issue	*Suggestion*
Future investment	(i) MLA should continue its investment in bio-weed control and consider increasing its investment due to the highly visible, valuable and practical nature of likely outcomes

Weed priorities	(i)	Based on information sighted in this review, there is a need to update the economic impact of weeds and set priorities for R&D in relation to the meat and livestock industries
Model Project	(i)	The existing project and its collaborative, distribution and extension components should be used as a model for future weed bio-control investment, provided IWM, outcome monitoring (including establishing baselines) and economic analyses are integrated from the outset
Integrated Weed Management (IWM)	(i)	Integrated weed management information should be developed and provided as part of a project rather than external to it
	(ii)	Future bio-control projects should be embedded in an IWM framework at commencement.
Baselines and monitoring	(i)	Consideration should be given to the merits and costs of establishing baselines of growth and densities of target weeds prior to release of agents
	(ii)	The establishment of a baseline for chemicals used in weed control at the start of any project as this is the major benefit seen by producers in the current project
Bio-economic modelling	(i)	Input into future weed bio-control investment from bio-economic modelling could enhance design, priority setting and level of resource application, and hence improve overall effectiveness
Involvement of agribusiness	(i)	An assessment would be useful as to whether and how the involvement of agribusiness at some stages in the life of a weed bio-control project could enhance overall outcomes

REFERENCES

Australian Wool Innovation Pty Ltd, 2002, *Delivery of biological control agents for broad-leaf weeds in temperate pastures*, Funding application.

Briese, D.T. and McLaren, D.A., 1997, 'Community involvement in the distribution and evaluation of biological control agents: Landcare and similar groups in Australia', *Biocontrol News and Information*, 18, p. 39-50.

Centre for International Economics, 2001, 'The CRC for Weed Management Systems: An impact assessment', CRC for Weed Management Systems Technical Series No. 6.

Holtkamp, R.H., Briese D.T. and Woodburn, T.L., 1997, *Distribution of biological control agents for* Onopordum *and* Carduus *thistles,* CRC for Weed Management Systems, MRC/IWS Project M. 593b.

Nordblom, T., Smyth, M., Swirepik, A., Sheppard, A. and Briese, D. 2001, 'Benefit-cost analysis for biological control of Echium weed species (Paterson's curse / salvation Jane)', Contributed paper, 45th Annual Conference of the Australian Agricultural and Resource Economics Society (AARES), Adelaide, 23–25 January 2001.

Sheppard, A., Smyth, M. and Swirepik, A., 2001, 'The impact of a root-crown weevil and pasture competition on the winter annual *Echium plantagineum'*, *Journal of Applied Ecology*, 38, pp. 291-300.

Smyth, M. and Sheppard, A., 2002, '*Longitarsus echii* and its impact on *Echium plantagineum* (Paterson's curse): the insect for the Mediterranean rainfall range of the weed?, 13th Australian Weeds Conference, Perth Sept, 8-13.

Stahle, P., 2000, *Biological control of Paterson's curse and thistles*, Business Plan for The Woolmark Company, DPS Strategy Pty Ltd.

Swirepik, A. and Smyth, M. 2001, *Effective biological control of Paterson's curse and thistles* Annual report prepared for Australian Wool Innovation and Meat and Livestock Australia (PPM1), CSIRO Entomology.

Swirepik, A. and Smyth, M., 2002, 'Biological control of broad-leafed pasture weeds (Paterson's curse, *Onopordum* and Nodding thistles). What have achieved and where to from here?', 13th Australian Weeds Conference, Perth, Sept 8-13.

Swirepik, A. and Woodburn, T. (unknown) 'A new biological control project against thistle *Onopordum acaulon* in Western Australia, CSIRO Entomology ACT and WA.

1997, PPM1 – *Effective delivery and establishment of biological control agents for Paterson's curse and thistles in temperate sheep pasture*, New IWS Project Proposal.

APPENDIX 1: QUESTIONNAIRES

GROUP 1

BACKGROUND

The Project

MLA and other research funding bodies have invested in biological weed control projects since 1987.

From the late 1980's biological control projects against the broad-leafed pasture weeds *Echium plantagineum* (Paterson's curse), *Onopordum illyricum* and *O. acanthium* (scotch and illyrian thistle) and *Carduus nutans* (nodding thistle) have been underway. Until 1996/97 Australian Wool Innovation (AWI) and MLA funded the three projects independently, with the work focusing mostly on the importation, host-specificity testing and initial establishment of agents at a small number of nursery sites. From 1997/98 the three projects were placed under one funding umbrella with a fourth project on the biocontrol of *Cirsium* thistles (run by DNRE, Victoria). The post 1997/98 project focused on the establishment, redistribution and monitoring of agents across temperate Australia, with the main objective being the fast tracking of the delivery of biocontrol to the end user.

Currently biocontrol agents have been successfully identified, reared and released against the target species and impact is being noted around release sites.

A new project is likely to be initiated in 2002/03 that will release additional agents in the current sites. This project is anticipated to speed up the delivery of benefits to landholders.

The Review

This consultancy is briefly reviewing MLA investments in the project 'Distribution of biological control agents for Paterson's curse and thistles'. This is being achieved by a desk-top review of relevant project documents, as well as interviews with key personnel from relevant research organisations and with others with knowledge of the project.

In addition, the role of MLA in biological weed control R&D is being assessed using the above project, its predecessor, and the project planned, as a case study. In this regard we are assessing whether projects of this nature will provide benefits to livestock producers and the community. Thirdly, we have been asked to recommend an investment strategy for MLA in biological weed control to ensure benefits to the livestock industries.

This external review has an elapsed time period of only 4 weeks. The first two weeks has been taken up by reviewing the documentation. We are now seeking your input regarding the project overall, the likely benefits to livestock industries, and in a wider context, your views on elements of a future investment strategy for MLA in biological weed control that ensures benefits to the industry.

QUESTIONS

1. Generally how do you think the project (Biological Control of Paterson's Curse and Thistles) has performed since July 1997:

   (b) as an R&D project?

   (c) delivering benefits to industry?

2. Are you confident that the impact by 2010 and associated financial benefits to industry will be as expected (eg. $90 million benefit per year from the control of Paterson's Curse by Crown Weevil)?

3. If not by 2010, what is a more realistic timeframe where producers will have modified their pasture management program (ie. reducing weed control costs) as a result of the impact of the program?

4. What do you see as the major risk factors that will influence the actual achievement of the stated benefits? For example

   (e) the efficacy and spread of the agents

   (f) the adoption of biological control by graziers

   (g) seasonal conditions

   (h) inappropriate management actions by graziers

5. Has extension material post 1996/97 been developed and provided to producers and landcare groups on:

   (c) management of agents, and

   (d) IWM

6. Are appropriate systems in place to monitor the impact over time on graziers' properties?

   (e) regarding the producer initiated versus natural spread of the various insects from nursery sites

   (f) regarding interactions between different agents in the field

   (g) regarding financial gains on individual properties

   (h) regarding financial gains on a regional basis within a consistent nationwide framework

7. Is there any hard evidence of impact at a paddock or farm scale e.g. reduced chemical use, change of pasture management practice due to absence of weeds, etc?

8. Do you know of any similar other biological weed control initiative (Australia or elsewhere) that has been successful and can be used as evidence of likelihood of success for this project? What about failures?

9. What do you see as the primary role of a new project (funding period 2002-2005)? How will it enhance the overall effort in weed biological control?

10. How could the impact of the agents in the field be improved?

11. What aspects of the project would you suggest could be improved upon, if this project were to be started again, say for a different group of insect agents and target weed?

12. Can the existing distribution/extension model be improved?

13. What bodies should be involved in distribution, and who should be the appropriate body/agent for coordinating the release and monitoring of the insects?

GROUP 2

BACKGROUND

The Project

MLA and other research funding bodies have invested in biological weed control projects since 1987.

From the late 1980's biological control projects against the broad-leafed pasture weeds *Echium plantagineum* (Paterson's curse), *Onopordum illyricum* and *O. acanthium* (scotch and illyrian thistle) and *Carduus nutans* (nodding thistle) have been underway. Until 1996/97 Australian Wool Innovation (AWI) and MLA funded the three projects independently, with the work focusing mostly on the importation, host-specificity testing and initial establishment of agents at a small number of nursery sites. From 1997/98 the three projects were placed under one funding umbrella with a fourth project on the biocontrol of *Cirsium* thistles (run by DNRE, Victoria). The post 1997/98 project focused on the establishment, redistribution and monitoring of agents across temperate Australia, with the main objective being the fast tracking of the delivery of biocontrol to the end user.

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QUESTIONS

1. Generally how do you think the project (Biological Control of Paterson's Curse and Thistles) has performed since July 1997:

   (a) as an R&D project?

   (b) delivering benefits to industry?

2. Are you confident that the impact by 2010 and associated financial benefits to industry will be as expected (eg $90 million benefit per year from the control of Paterson's Curse by the Crown Weevil)?

3. If not by 2010, what is a more realistic timeframe where producers will have modified their pasture management program (ie. reducing weed control costs) as a result of the impact of the program?

4. What do you see as the major risk factors that will influence the actual achievement of the stated benefits? For example

   (a) the efficacy and spread of the agents

   (b) the adoption of biological control by graziers

   (c) seasonal conditions

   (d) inappropriate management actions by graziers

5. Has extension material post 1996/97 been developed and provided to producers and landcare groups on:

   (a) management of agents, and

   (b) IWM

6. Are appropriate systems in place to monitor the impact over time on graziers' properties?

   (a) regarding the producer initiated versus natural spread of the various insects from nursery sites

   (b) regarding interactions between different agents in the field

   (c) regarding financial gains on individual properties

   (d) regarding financial gains on a regional basis within a consistent nationwide framework

7. How involved has been the Landcare Network with respect to this project? How many Landcare groups or other producer groups have been actively included in the State network (for your State)?

8. Is it correct that for *U. solsititialis* and *T. horridus* on Nodding thistle the release stage is complete? Does this mean that the producer and landcare groups are fully informed of what is required to maintain nursery site and require no more input from researchers or extension officers?

9. Is there any hard evidence of the impact at a paddock or farm scale e.g. reduced chemical use, change of pasture management practice due to absence of weeds, etc?

10. Do you know of any similar other biological weed control initiative (Australia or elsewhere) that has been successful and can be used as evidence of likelihood of success for this project? What about failures?

11. What do you see as the primary role of a new project (funding period 2002-2005)? How will it enhance the overall effort in weed biological control?

12. How could the impact of the agents in the field be improved?

13. What aspects of the project would you suggest could be improved upon, if this project were to be started again, say for a different group of insect agents and target weed?

14. Can the existing distribution/extension model be improved?

15. What bodies should be involved in distribution, and who should be the appropriate body/agent for coordinating the release and monitoring of the insects?

GROUP 3

BACKGROUND

The Project

MLA and other research funding bodies have invested in biological weed control projects since 1987.

From the late 1980's biological control projects against the broad-leafed pasture weeds *Echium plantagineum* (Paterson's curse), *Onopordum illyricum* and *O. acanthium* (scotch and illyrian thistle) and *Carduus nutans* (nodding thistle) have been underway. Until 1996/97 Australian Wool Innovation (AWI) and MLA funded the three projects independently, with the work focusing mostly on the importation, host-specificity testing and initial establishment of agents at a small number of nursery sites. From 1997/98 the three projects were placed under one funding umbrella with a fourth project on the biocontrol of *Cirsium* thistles (run by DNRE, Victoria). The post 1997/98 project focused on the establishment, redistribution and monitoring of agents across temperate Australia, with the main objective being the fast tracking of the delivery of biocontrol to the end user.

Currently biocontrol agents have been successfully identified, reared and released against the target species and impact is being noted around release sites.

A new project is likely to be initiated in 2002/03 that will release additional agents in the current sites. This project is anticipated to speed up the delivery of benefits to landholders.

The Review

This consultancy is briefly reviewing MLA investments in the project 'Distribution of biological control agents for Paterson's curse and thistles'. This is being achieved by a desk-top review of relevant project documents, as well as interviews with key personnel from relevant research organisations and with others with knowledge of the project.

In addition, the role of MLA in biological weed control R&D is being assessed using the above project, its predecessor, and the project planned, as a case study. In this regard we are assessing whether projects of this nature will provide benefits to livestock producers and the community. Thirdly, we have been asked to recommend an investment strategy for MLA in biological weed control to ensure benefits to the livestock industries.

This external review has an elapsed time period of only 4 weeks. The first two weeks has been taken up by reviewing the documentation. We are now seeking your input regarding the project overall, the likely benefits to livestock industries, and in a wider context, your views on elements of a future investment strategy for MLA in biological weed control that ensures benefits to the industry.

QUESTIONS

1. Generally how do you think the project (Biological Control of Paterson's Curse and Thistles) has performed since July 1997:

   (c) as an R&D project?

   (d) delivering benefits to industry?

2. The prediction is that by 2010 there will be $90 million per annum saved for industry through reduced weed management costs. Are you seeing benefits in reduced costs, and do you think this will be realised?

3. If not by 2010, when do you expect to see some benefit as a result of the impact of the program?

4. What do you see as the major risk factors that will influence the actual achievement of the stated benefits? For example

   (a) the efficacy and spread of the agents

   (b) the adoption of biological control by graziers

   (c) seasonal conditions

   (d) inappropriate management actions by graziers

5. Has sufficient information been prepared and distributed on Integrated Weed Management (that is biocontrol agents, in conjunction with tactical grazing, spraying and fertiliser use)? Do you/your group require further information/training on the full range of weed management strategies available and how they interact?

6. Are appropriate systems in place to monitor the impact over time on graziers' properties?

   (a) regarding the producer initiated versus natural spread of the various insects from nursery sites

   (b) regarding financial gains on individual properties (financial gains accrue from improved pasture production and reduced weed control costs)

7. Is there any hard evidence of the impact at a paddock or farm scale e.g. reduced chemical use, change of pasture management practice due to absence of weeds, etc?

8. Do you know of any similar other biological weed control initiative (Australia or elsewhere) that has been successful and can be used as evidence of likelihood of success for this project? What about failures?

9. The current project has come to a conclusion. CSIRO are proposing more releases of the agents to assist in control. Do you think the release of more agents is warranted?

10. How could the impact of the agents in the field be improved?

11. What aspects of the project would you suggest could be improved upon, if this project were to be started again, say for a different group of insect agents and target weed?

12. Can the existing distribution/extension model be improved?

13. What bodies should be involved in distribution, and who should be the appropriate body/agent for coordinating the release and monitoring of the insects?

14. Do you believe the group/yourself has an adequate understanding of the rearing and redistribution process for agents?

15. What would happen if the group/yourself received no further technical or financial support, would the group/yourself stop rearing and distributing the agents?

16. What is your/the groups understanding of the ongoing role of you/your group following the completion of the 'science' part of the project?

GROUP 4

BACKGROUND

The Project

MLA and other research funding bodies have invested in biological weed control projects since 1987.

From the late 1980's biological control projects against the broad-leafed pasture weeds *Echium plantagineum* (Paterson's curse), *Onopordum illyricum* and *O. acanthium* (scotch and illyrian thistle) and *Carduus nutans* (nodding thistle) have been underway. Until 1996/97 Australian Wool Innovation (AWI) and MLA funded the three projects independently, with the work focusing mostly on the importation, host-specificity testing and initial establishment of agents at a small number of nursery sites. From 1997/98 the three projects were placed under one funding umbrella with a fourth project on the biocontrol of *Cirsium* thistles (run by DNRE, Victoria). The post 1997/98 project focused on the establishment, redistribution and monitoring of agents across temperate Australia, with the main objective being the fast tracking of the delivery of biocontrol to the end user.

Currently biocontrol agents have been successfully identified, reared and released against the target species and impact is being noted around release sites.

A new project is likely to be initiated in 2002/03 that will release additional agents in the current sites. This project is anticipated to speed up the delivery of benefits to landholders.

The Review

This consultancy is briefly reviewing MLA investments in the project 'Distribution of biological control agents for Paterson's curse and thistles'. This is being achieved by a desk-top review of relevant project documents, as well as interviews with key personnel from relevant research organisations and with others with knowledge of the project.

In addition, the role of MLA in biological weed control R&D is being assessed using the above project, its predecessor, and the project planned, as a case study. In this regard we are assessing whether projects of this nature will provide benefits to livestock producers and the community. Thirdly, we have been asked to recommend an investment strategy for MLA in biological weed control to ensure benefits to the livestock industries.

This external review has an elapsed time period of only 4 weeks. The first two weeks has been taken up by reviewing the documentation. We are now seeking your input regarding the project overall, the likely benefits to livestock industries, and in a wider context, your views on elements of a future investment strategy for MLA in biological weed control that ensures benefits to the industry.

QUESTIONS

1. How would you rate your knowledge of the project (Biological Control of Paterson's Curse and Thistles) since July 1997 (very little, some, quite familiar)?

2. Generally how do you think the project (Biological Control of Paterson's Curse and Thistles) has performed since July 1997:

   (a) as an R&D project?

   (b) delivering benefits to industry?

3. A prediction is that by 2010 there will be $90 million per annum saved for industry through reduced weed management costs. Are you seeing benefits in reduced costs, and do you think this will be realised?

4. If not by 2010, when would you expect to see some benefit as a result of the impact of the program?

5. What do you see as the major risk factors that will influence the actual achievement of the stated benefits? For example

   (a) risk in the efficacy and spread of the agents

   (b) risk in the adoption of biological control by graziers

   (c) seasonal conditions

   (d) inappropriate management actions by graziers

6. Are you aware of any extension material post 1996/97 that has been developed and provided to producers and landcare groups on:

   (a) management of agents, and

   (b) IWM

7. Are you aware if there are appropriate systems in place to monitor the impact over time on graziers' properties?

   (a) regarding the producer initiated versus natural spread of the various insects from nursery sites

   (b) regarding financial gains on individual properties (financial gains accrue from improved pasture production and reduced weed control)

8. Are you aware of any hard evidence of impact at a paddock or farm scale e.g. reduced chemical use, change of pasture management practice due to absence of weeds etc?

9. Do you know of any similar other biological weed control initiative (Australia or elsewhere) that has been successful and can be used as evidence of likelihood of success for this project? What about failures?

10. The current project has come to a conclusion. CSIRO are proposing more releases of the agents to assist in control. Do you think the release of more agents is warranted?

11. How could the impact of the agents in the field be improved?

12. What aspects of the project would you suggest could be improved upon, if this project were to be

started again, say for a different group of insect agents and target weed?

13. Can the existing distribution/extension model be improved?

14. What bodies should be involved in distribution, and who should be the appropriate body/agent for coordinating the release and monitoring of the insects?