



Branched Broomrape Eradication Program 1992-2011



Front cover:

The 'Operation CleanSweep' badging in the header was developed by John Lamb Consulting and used throughout the program.

Photos show Branched Broomrape plants in the field and hosting on a carrot in the laboratory

The Branched Broomrape Eradication Program

Table of Contents

1. Introduction
2. Background
 - 2.1 Branched broomrape, its impact distribution and host range
 - 2.2 Justifying eradication
 - 2.3 The program structure and national perspectives
 - 2.3.1 National arrangements
 - 2.3.2 Structural changes at the state level
 - 2.3.3 The Legislative Backing
 - 2.4 National and state funding arrangements
3. The eradication program begins
 - 3.1 Research finds control solutions
 - 3.2 The code
 - 3.3 Decontamination
 - 3.4 The community
4. Eradication
 - 4.1 Discovery
 - 4.1.1 Discovery Victoria
 - 4.1.2 Detector dog
 - 4.2 Release from quarantine
 - 4.2.1 Preventing seed set
 - 4.2.2 Adoption of control measures
 - 4.2.3 Financial assistance for on farm management
 - 4.2.4 Eradication by host denial
 - 4.3 Seed bank destruction
 - 4.3.1 DNA detection

4.3.2 Eradication by seed destruction

4.3.3 Methyl bromide fumigation

Roadsides

Arable land

4.3.4 Basamid

4.3.5 Pine oil

Pine oil by air

4.4 Host denial via herbicides

4.4.1 Aerial operations

5. Delivering the program

5.1 People

5.2 Program structure

5.2.1 Industry guidance of the program

6. Eradication Ends

6.1 The Final Word

APPENDIX

The history of branched broomrape in South Australia

ATTACHMENT

Summary of outputs, methods and budgets for each project in the Branched Broomrape Eradication Program 1 July 2009 - 30 June 2012

Author

References

Acknowledgement

THE BRANCHED BROOMRAPE ERADICATION PROGRAM

1. Introduction

Initially the Branched Broomrape Eradication Program was predicated on the classification of the plant by the State Herbarium of South Australia as *Orobanche ramosa*. This classification was based on the best available information and indicated that the presence of this weed had serious negative production and marketing implications.

Branched broomrape was identified at a single location around 30 km east of Murray Bridge in South Australia. A small-scale, State funded eradication program began in 1992. In response to increasing numbers of discoveries national funding was provided for an extensive delimitation survey during 1999. Following two annual delimitation surveys national funding through the Primary Industries Ministerial Council process was provided for an eradication program in 2001 and a quarantine area declared utilising provisions of the *Fruit and Plant Protection Act, 1992*.

Around \$42 million was spent over ten years from 2003 to 2011 in a program aimed at eradicating the weed. Despite this being a well-funded program the weed was not able to be eradicated, due to various factors including its distribution across many properties, difficulty in detecting and destroying individual plants and long-lived seedbank. This is a unfortunately similar scenario for many weed eradication programs, which can be very difficult to achieve if the weed is not found early.

2. Background

2.1 Branched broomrape, its impact, distribution and host range

At the start of the program, the risk profile of the branched broomrape found in South Australia was assessed with this information: -

Branched broomrape is a parasitic weed of a wide range of plant hosts. The species is a true parasite and has no chlorophyll of its own. Plants can only survive by attaching themselves to the root systems of the host plants. Seeds of branched broomrape are primed to germinate (i.e. 'conditioned') when they are kept moist within a certain temperature range. However they will only then germinate if they receive a chemical trigger from the root of a nearby host plant. After a period of underground growth plants are only visible when the short, leafless, pale flowering shoot emerges in spring from an underground tuber. Dust-like seeds are shed from fruiting capsules in late-spring to early summer as the flowering stem dies.

The impact of branched broomrape on host crops varies from a benign association to causing significant yield loss or plant death. Even if crop yield is not affected, the quality of the produce can be severely affected rendering it unsaleable due to the parasite consuming host sugars. This is particularly a problem with vegetable crops such as carrots.

Branched broomrape is native to the Eastern Mediterranean, and is now endemic throughout the Mediterranean Basin, Europe, Central Asia, the Middle East, South Africa and the Americas. Branched broomrape has the potential to spread to all major horticultural and cropping areas in Australia (see Figure 1) but is restricted to an area of approximately 70 km x 70 km in South Australia (see Figure 2). Risk mapping for South Australia based on the landform properties of infested areas indicated that around 40% of the lower rainfall, 400 mm average, agricultural area of South Australia was at risk.

The major industries judged to be threatened by branched broomrape in Australia included oilseeds, faba beans, lupins, vetch, pasture legumes and vegetables (e.g. Brassica crops, carrots). Host testing in South Australia found this broomrape can host on more than 80 crop, pasture, vegetable, ornamental and weed species found locally. Testing of native and ornamental plants further extended the original host list with 32 native species in the total host list of 98 species.

Branched broomrape does not host on grasses, including cereals, and is non-toxic to livestock.

A further major threat for Australian agriculture is the impact that contamination of products with branched broomrape seed could have on export markets, particularly the grain export markets and hay markets. Many trading partners are free of branched broomrape and may use its presence in Australia as a trade barrier. In 1999 it was estimated that the value of at-risk crops was approximately \$2.3 billion.

Figure 1. *CLIMATE* model of potential distribution for branched broomrape (red indicates highest climate match)

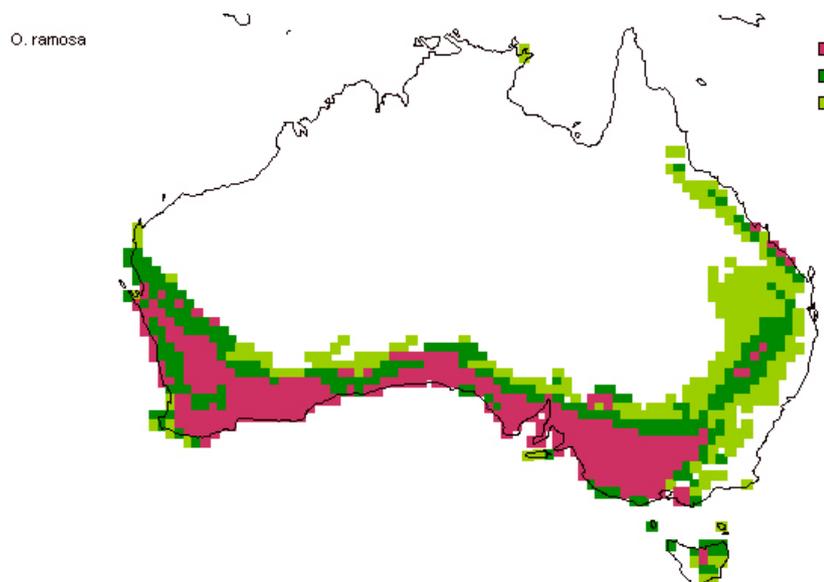
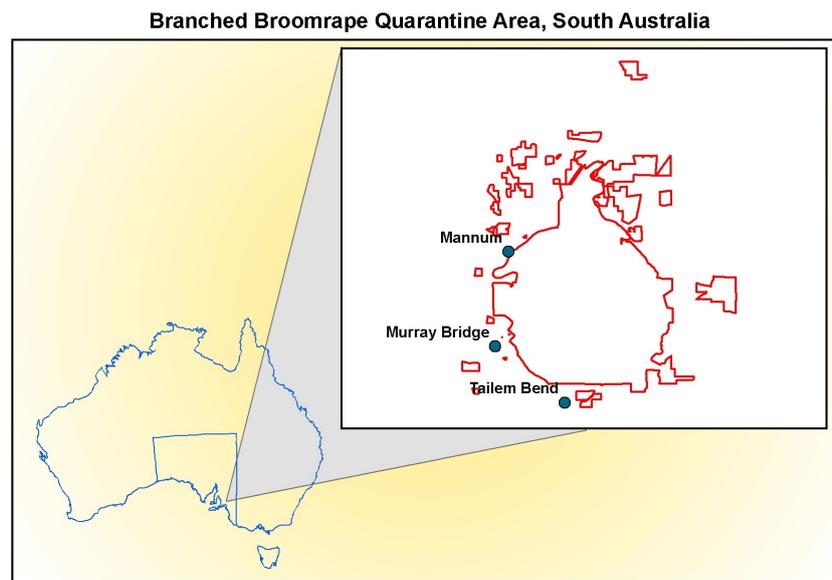


Figure 2. Location map for the branched broomrape quarantine area



2.2 Justifying Eradication

Justification for the eradication program was based on the weed being a form of *Orobanche ramosa*, known internationally as branched broomrape. The State Herbarium classifies it as *O. ramosa* ssp *mutelli*. This parasitic species has a wide host range and will reduce yields of commercial vegetables. Its seed was prohibited in imported produce in many of Australia's trading partners for example, Japan and China. This included as a contaminant of cereal grain even though cereals are not hosts of branched broomrape. There was the potential to reduce crop production and disrupt the smooth marketing of Australian agricultural produce, especially to markets with nil tolerance to the presence of branched broomrape.

The host range of this locally naturalised form of branched broomrape was validated through laboratory testing and field observation. However, significant crop yield losses were never observed during the eradication program – occasional instances were found of branched broomrape parasitising canola plants but otherwise it was mostly found on daisy weeds. The most common host encountered during the program was Cretan weed (*Hedypnois rhagadioloides*) which is common in sandy areas within the quarantine area.

Economic justification for the eradication program came from: -

- Extrapolating the potential to spread across most of the agricultural areas of Australia producing substantial yield reductions across a wide range of host crops.
- The threat to international markets that have zero tolerance to broomrape seed in grain and other produce.

The Adelaide consultants, EconSearch, gathered the available information and prepared an analysis to assist decision making. Based on 2001 production information, the Net Present Value of future losses was estimated at \$243 million. In a separate paper EconSearch showed substantial benefits to the Murray region would accrue from the eradication program.

2.3 The Program Structure and National Perspective

There were significant changes in terms of decision making structures at both the National and State levels during the program. These are summarised as follows;

2.3.1 National Arrangements

Ministers of Agriculture and Resource Management meet around twice per year as a grouping of Ministers (the Council) and Chief Executives (the Standing Committee). The naming of the Standing Committee follows that of the Council.

The changes were:

Prior to 1991 – Australian Agricultural Council (AAC)

1991 – Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ)

2001 – ARMCANZ split into the Primary Industries Ministerial Council and the Natural Resource Management Ministerial Council

2010 – Ministerial Council revised as Standing Council on Primary Industries (SCoPI), with an officers' committee entitled Primary Industries Standing Committee (PISC).

2.3.2 Structural Changes at the State Level

The team managing the Eradication Program remained Animal and Plant Control Group within the South Australian Government for the term of the eradication program. This Group moved to different organisations as follows:

Prior to 1992 – Within the Natural Resources Division in the Department of Agriculture

1992 to 2002 – Initially within the separate groups of Primary Industries SA (PISA) and the SA Research and Development Institute (SARDI), which were amalgamated to form Primary Industries and Resources in 1997 and then to Primary Industries and Regions in 1997.

2002 to 2010 – The Group was transferred to the newly formed Department of Water Land and Biodiversity Conservation.

2010 onwards -A group within Biosecurity SA that is part of Primary Industries and Regions.

2.3.3 The Legislative Backing

Between 1992 and 1999 the Branched Broomrape program was managed under the Animal and Plant Control Act. The reason for doing this was the significant reduction in consultation required to place the restrictions in place. Responsibility for this act was with the Animal and Plant Control Commission.

In 1999 when the plant was found to be widely distributed the Minister wanted a quarantine area created around the infected areas. It was easier to quarantine the area under the Fruit and Plant Protection Act. Therefore the line of responsibility moved from the Commission to the Agency and the group responsible for administering this Act.

2.4 National and State Funding Arrangements

Emergency responses to national incursions of livestock diseases and plant pests are through two Deeds agreed between governments and industries, the Emergency Animal Disease Response Agreement and the Emergency Plant Pest Response Deed. However, at the commencement of the Branched Broomrape Eradication Program in 1992 there was no such deed that covered incursions of new weeds and other invasive species. Other national responses not covered by a deed included red imported fire ants, electric ants and a number of tropical weeds. In time a third Deed for invasive species came about, the National Environmental Biosecurity Response Agreement. However, it could not be retrospectively applied to existing response programs. 'Off-deed' arrangements had to be made outside of the existing response arrangements, including cost-sharing. These off-Deed programs were often significant in terms of funding requirements and were long-term in nature. As there were no agreed cost sharing arrangements in place, negotiations could be difficult between the Commonwealth, States and Territories.

Following the detection of Branched Broomrape there was quick response from the State Government led by Rob Kerin, the Minister of Agriculture. It was decided to manage the eradication program under the Plant Protection Act rather than the Animal and Plant Control Act due to the greater provisions in the former Act. A management group was established and Chaired by the Executive Director of Natural Resources, Roger Wickes. This group was tasked with developing the response program including costing.

The branched broomrape eradication funding sought was substantially greater than were available at the State level and required the development and negotiation of a cost sharing arrangement between the Commonwealth, State and Territory governments. The decision making was complicated by ultimately unsuccessful moves at the time to have weed responses included within the Plant Health Deed. Reluctance for cost sharing of the program arose on each occasion funding arrangements needed to be renegotiated. There was also the complicating situation of the massive cost to governments associated with the Red Imported Fire Ant program in South-East Queensland.

In February 2002, a State election was held with the outcome balanced. To remain in Government, the Labor Party offered the speaker's position to the Honourable Peter Lewis, the Liberal Party Member for Hammond, whose rural electorate included the quarantine area. Peter Lewis had a substantial personal interest in the program and negotiated \$1million per year for three years in State funding for the program as part of the deal. Peter would appear as a passionate advocate at farmer's meetings in the early stages of the program. The government continued this additional funding for the life of the program.

The threat to all States was evaluated and they contributed according to this estimate with funds matched by the Commonwealth. These multiple funding sources meant South Australia, the Commonwealth and all other States contributed a total of \$4.2 million per year to the program for the next decade from March 2002. This adequate amount provided opportunities for research and extension as well as the tasks of containment and eradication. The eradication program also had its own

funding lines in State budgets. These diverse funding sources meant that the program was relatively independent within the Animal and Plant Control Group and its State Department. Useful, as the Animal and Plant Control Group moved from Primary Industries and Resources South Australia, PIRSA, to the Department of Water, Land and Biodiversity Conservation, DWLBC, and back to Biosecurity SA within Primary Industries and Regions, PIRSA, during its operation.

The grains industry, through the Grains Research and Development Corporation, the GRDC, provided substantial support for research in the first three years of the eradication program. Grains industry and grain marketers were involved in the Community Focus Group discussion. In 2008, a Review Team felt that there was not a clear commitment to the eradication programs from the industry sectors. This in part was due to the explicit exclusion of the broomrape program, and weeds more generally, from the Emergency Plant Pest Response Deed. It was also due to the varying impacts of the programs on a range of industry sectors whereby no single industry had a majority interest.

**Branched Broomrape
Eradication Program**

PIMC 14 November 2008

Item 4.C

Funding June 2009 - June 2012 - All Sources less savings plus carryover

Commonwealth and States	ARMCANZ 19 Proportions	2009/2010	20010/2011	2011/2012	Total
Commonwealth	50.00%	1,230,400	1,263,550	1,297,600	3,791,550
New South Wales	7.10%	174,717	179,424	184,259	538,400
Queensland	9.90%	243,619	250,183	256,925	750,727
South Australia	8.50%	209,168	214,804	220,592	644,564
Tasmania	3.50%	86,128	88,449	90,832	265,409
Victoria	15.00%	369,120	379,065	389,280	1,137,465
Western Australia	6.00%	147,648	151,626	155,712	454,986
PIMC	100.00%	\$2,460,800	\$2,527,100	\$2,595,200	7,583,101
South Australia initiatives		1,745,000	1,955,000	1,955,000	5,655,000
Funds available to the Program		\$4,205,800	\$4,482,100	\$4,550,200	\$13,238,100
Other Funding:					
GRDC					
In Kind Contributions: (est.)					
CRC for Aust Weed Mgt					
Vic & S.A. Departments		250,000	250,000	250,000	750,000
Landholders		369,000	369,000	369,000	
		\$5,039,800	\$5,106,100	\$5,174,200	\$14,213,101

Funding was provided by all States according to their proportion of the risks of the future effect of branched broomrape establishment on marketing and production.

The Commonwealth matched State funds as indicated by the following summary, the last eradication financial plan.

The Eradication Program from 1992 to 2012 and the Transition to Management project is summarized in Appendix 1” **The History of Branched Broomrape in South Australia**” Some national issues about managing pest incursions that remain to the present, year 2022, are mentioned.

3. The Eradication Program Begins

The first delimitation survey was undertaken in 1999 from the Etterick Hall, near Murray Bridge, with the Operations Centre organized as for an emergency response with Mr Paul Jupp, of the Animal and Plant Control Commission, as leader. Conditions applied to the use of the hall. Thursday night was dance club. So, the Operations Centre was moved to the walls while the locals danced. This Hall was the venue for an evening meeting at which the quarantine area was declared with several hundred landowners filling the hall, the porch and listening at the windows. They took the message relatively calmly.

Subsequently a Community Reference Group was formed with open membership and a real role in the management of the program. This was critical to the program’s acceptance and positive progress.

The Etterick hall’s limitations of location, size and security became apparent as the program grew and during 2000 Mr Rob Matthias, the Department’s Emergency Management Coordinator, was able to secure access to the operations room and facilities at the State Emergency Services Centre in Murray Bridge. The loan and sharing of these facilities continued for a decade.

Figure 4



Each marker indicates a branched broomrape plant growing on weeds

3.1 Research Finds Control Solutions

Solutions to broomrape control and eradication in this Mallee environment for the varying land uses that range from broadacre farming, irrigated horticulture, and dairying to hobby farms and neglected land were not available in 2001. A small research group with Dr John Matthews of the University of Adelaide as research leader and Mr Darryl Miegel as Technical Officer was set up. They utilized part of a paddock leased from the Dabinett family as a research site. Their work primarily focused on herbicide options, host and false host crops to stimulate seed germination, and other broad scale control measures in crops and pastures. This is the early research funded by the GRDC. Ms Emma Ginman completed her Masters thesis on dispersal of branched broomrape seed at the site, including viable seed passage through the sheep gut, seed adherence in wool and wind dispersal. A second research site was developed in the Jervois area in the second half of the program.

Research was also done by the Animal and Plant Control Group in PIRSA/DWLBC during the life of the eradication program, led by Dr John Virtue with Dr Anna Williams and then Dr Jane Prider, and technicians Mr Che De Dear and Mr Andrew Craig. This research included decontamination, host range, fumigation, life cycle and seedbank longevity. Laboratory research was undertaken at the Waite Campus in its quarantine facility.

Dr Alan McKay also led a team in the South Australian Research Institute, SARDI, that produced a DNA probe to detect branched broomrape seed, which was used in research to detect treatment effects on the soil seedbank. Eradication modelling work was undertaken through the Weeds Cooperative Research Centre and CSIRO. Farm trials led by Rural Solutions in PIRSA also looked at measures to increase pasture productivity in the region whilst still controlling broomrape.

Research continued until the end of the program. The various discoveries were critical in providing tools to prevent branched broomrape emergence in this Mallee region's farming systems. A Compendium of the branched broomrape research undertaken is provided in 13 volumes online only at

<https://data.environment.sa.gov.au/Plants-and-Animals/Pests-Biosecurity/Pages/Biosecurity.aspx>

Fortunately, good, high input farming practices promoted the total suppression of branched broomrape. As part of the transition to management, Rural Solutions South Australia was engaged to produce a handbook in 2013 of best management practice for the majority of enterprises in the quarantine area. This, coupled with a project that engaged directly with farmers to improve production practices had benefits that outlasted the eradication program. This project was often referred to by producers as helping them become better farmers.

Practical, on farm management was brought together into a manual for the on-farm management of the weed that was used as a training aid and edited annually. At the end of the program, in 2013, this was published as a best practice manual for the On Property Management of Branched Broomrape. The manual was produced in July 2013 and published by the Government of South Australia, Biosecurity SA.

3.2 The Code

The quarantine Area was declared using provisions of the *Fruit and Plant Protection Act, 1992*. All landowners in the quarantine area were required by regulation to prevent the spread of branched broomrape seed. All produce and machinery that could carry contaminated soil was subject to regulated movement under a Ministerial Code. Technically, all produce from the quarantine area was moved under direction and machinery decontaminated as it moved from infested paddocks. The Code – Control of Branched Broomrape provided information and protocols on the movement restrictions and certification requirements for the branched broomrape quarantine zone. The Code was a regulation under the Act that could be varied without Ministerial approval.

A permit system facilitated the movement of produce and material from the quarantine area. Efficiency of administration was improved with the appointment of the program manager as a Chief Inspector under the Act with powers limited to Branched Broomrape.

3.3 Decontamination

Research found that certain quaternary ammonium compounds destroyed branched broomrape seed by dissolving the lipids in their seed coat. A commercially available product, Nipro Quat® was used, in 5% solution, to wash down machinery and

equipment to prevent the spread of seed. Machinery and vehicles were disinfected as they left an infested paddock. This wash down, utilizing high pressure equipment, was a service delivered by the program on a 24/7 basis and provided valuable local employment for a long line of casual staff.

Figure 5



Decontaminating fencing equipment

Figure 6



A survey team decontaminates equipment as it leaves a paddock. The bike was utilized to speed the survey process

3.4 The Community

A Community Focus Group was formed as the Eradication Program began to provide real consultation and effective feedback to program management. Membership of the group was open and it was first chaired by Mr Peter Dabinett, the local Soil Board Chair, whose farm was not within the quarantine area at that time. Chairs were then drawn from within the Animal and Plant Control Commission and eventually independent Chairs, Mr Geoff Thomas then Mr John Berger, were appointed. Initially, several tens of concerned locals attended and as the system became settled a core group maintained support. This Group met regularly on a bi-monthly basis and continued for the entire program. The Community Focus Group was important in its role as the voice of the people in assisting the program as a sounding board for regulation and extension.

4. Eradication

Eradication was the aim. Five conditions had to be met to achieve this.

- 1) Discovery of all infested sites,
- 2) Prevent seed set by host denial, destruction of broomrape plants attached to hosts and killing emerged plants,
- 3) Diminution of the seed bank through natural decay or by destruction,
- 4) Containment through preventing seed dispersal in produce or soil by quarantine measures.
- 5) Evidence that meets 'Proof of absence' of the pest.

A paddock was the unit of quarantine with eradication measures undertaken at the paddock level rather than infested site.

4.1 Discovery

Each year in spring, following emergence of broomrape, every paddock on every property within the quarantine area and a proportion of paddocks outside it were surveyed, as were the roadsides within and nearby. Just over 350,000 ha and around 7,800 paddocks were surveyed each year.

Central to the program was a large data base to record survey results and manage histories of the paddocks. Individual infestations were mapped and a comprehensive paddock history kept for each paddock that included stock and crop movements as well as treatments. To create a record the centroid or central position of each paddock was taken and mapped using the computerized mapping systems ArcView and ArcGis. This code was the key locator of each paddock. There were 17,800 detailed paddock records on the data base.

Paddocks were sampled by teams of two people in a pattern formulated to optimize discovery by Ray Correll, a Statistician from CSIRO. Around 17 teams were employed to complete this task during broomrape flowering and before the vegetation dried during spring and early summer.

Figure 7



This sign was attached to each gate on every infested paddock

Employing, training and equipping then tasking and recording survey results is a major undertaking and requires a support group of at least six people.

To alleviate the pain of wearing rubber boots and plasticised overalls in the Mallee heat survey team members were competing for the award of broomrape of the year. The award went to the surveyor who discovered the most broomrape infestations in the season and included a fudge factor to prevent the same person winning the award too often. Competition for this award that was presented at the annual Christmas function was fierce.

Figure 8



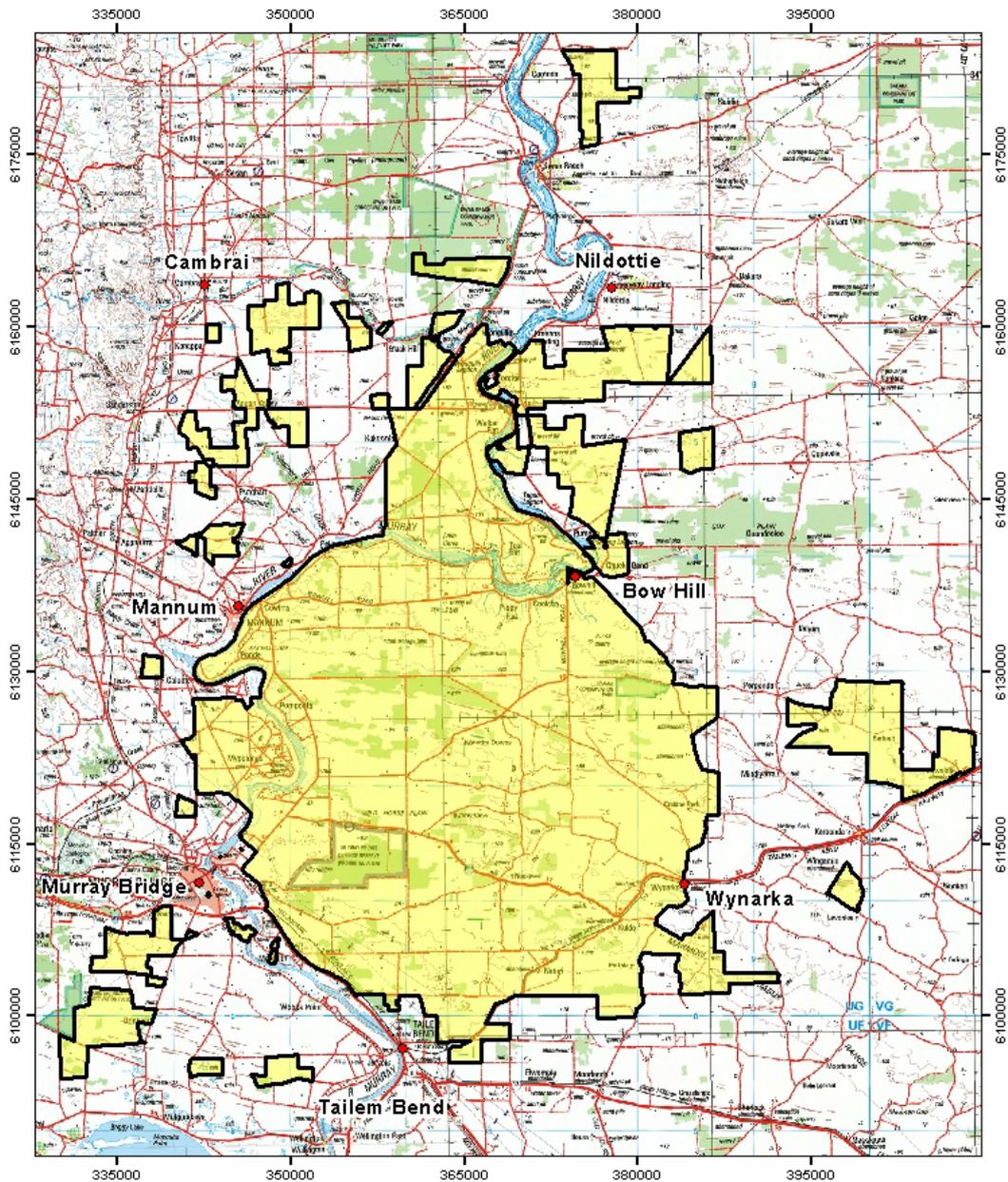
Senior Project Officer, Nick Secomb, Fiona Flavell, broomrape of the year and Senior Compliance Officer, Lance Holberton

Each year there were more discoveries in the region. With the consequence that the South Australian quarantine area grew both in size and numbers of infestation sites. Following the last major survey in 2010 the quarantine area was eventually 210,000 ha, entirely within the Murray Mallee region of South Australia. There were 824 infested paddocks on 294 properties and 67 roadside sites identified from a survey of 349,000 hectares.

Figure 9

The quarantine area was at its largest in January 2012.

January 2012- Branched Broomrape Quarantine Area



**Branched Broomrape
Quarantine Area - January 2012**

2011 Quarantine Area

Cartography by Branched Broomrape Eradication Program, Biosecurity SA.



The accuracy of topographic and cadastral data is not guaranteed.

4.1.1 Discovery Victoria

At-risk sites were identified in Victoria. There were 34 properties across Victoria and 20,900 ha linked by produce, livestock and machinery sales or ownership to farms in the Branched Broomrape quarantine zone. The Victorian Department of Primary

Industries undertook discovery surveys of high risk area for several years. Following multiple surveys no branched broomrape was found.

4.1.2 Detector Dog

A chocolate Labrador dog named Fudge was trained by a member of the police dog squad to detect branched broomrape with a view to utilizing scent detection to better delimit new infestations discovered by surveyors and to do some of her own discovering. Fudge was partially successful due to management difficulties and her unreliable strike rate. She would ignore plants to indicate on others. She also had epilepsy and was medicated. Fudge was retired.

Figure 10



Fudge indicating a broomrape plant

4.2 Release from Quarantine

If no branched broomrape was found in a paddock after 12 years of annual surveys then it was to be released from quarantine. This would result in the quarantine area having a 'Swiss Cheese' appearance. This was possible as there was a continuous history of individual paddocks.

Given the long-term nature of the Program, it was felt that the community would become increasingly reluctant to continue its support without tangible indicators of progress. The change of paddock status to 'provisional' after seven years with no emergence helped to maintain support and suggested that the Program was making progress. Restrictions were reduced on provisional paddocks.

Using false hosts, sacrifice hosts and increasing fumigation to increase the decline of the branched broomrape seedbank and change the time until eradication from an individual paddock were investigated through research trials. However none were adopted as they as each strategy had significant drawbacks including cost or reliability.

4.2.1 Preventing Seed Set

Preventing seed set of a parasitic plant that spends the majority of its life underground is a challenge achieved by: -

- Denying the parasite hosts, as in weed control in cereal crops.
- Destroying the host and attached parasite, as in weed control in pastures.
- Destroying emerged plants.

At the commencement of the program there was limited information available about how to prevent seed set in the wide range of host plant situations in the Mallee. Herbicide regimes to achieve these objectives were worked out by the research group.

4.2.2 Adoption of Control measures

Landholders were responsible for branched broomrape eradication on their properties.

Adopting control measures was not so hard for high tech croppers but was increasingly difficult for those with other management foci or economic imperatives.

Fortunately, broomrape control aligned with good farming practice. Rural Solutions South Australia, the extension branch of PIRSA, with a group led by Tanja Morgan, prepared a guidebook of control measures named “On Property Management of Branched Broomrape.” This was the reference material for a range of technology transfer and management improvement projects through the life of the program. Farmers would comment that they were better producers, overall, as a result of these projects.

4.2.3 Financial Assistance for On Farm Management

The Branched Broomrape Eradication Program operated two grant schemes. The Herbicide Grants Scheme provided reimbursement for herbicide used by landholders to control hosts of branched broomrape above that used in normal crop weed control. The Farm Plan Scheme provided financial support to landholders to implement a farm plan that prevents the emergence of the weed and to meet compliance arrangements to prevent the spread of the weed. These schemes were managed by the branch of PIRSA responsible for rural assistance and met the government audit requirements.. Around \$1m in grants were approved, annually.

4.2.4 Eradication by Host Denial

Timing is everything. Branched broomrape seed bank reduction is optimized if its hosts are controlled when the parasitic has attached to their roots and before broomrape flowering stems emerge from the soil and set seed. This is a narrow window. The research group identified this window with a growing degree day model for branched broomrape based on the break of season autumn rainfall and average daily temperature.

Spraying emerged branched broomrape plants is futile as seed set occurs within a few days post emergence. Herbicides or pine oil treatment did not sufficiently stop seed set or render seed non-viable. Hence post-emergence control of branched broomrape was not a significant strategy of the eradication program.

4.3 Seed Bank Destruction

4.3.1 DNA detection

Once an infestation is observed, can the quantity of seed in the soil be measured? Quantifying the seed bank will inform decay time and indicate treatments for eradication. Polymerase chain reaction DNA technology for branched broomrape was developed by South Australian Research and Development Institute, SARDI, plant pathology laboratories, led by Dr Alan Mackay. Statistics applied to the reaction enabled an estimate of the number of seed in the sample.

4.3.2 Eradication by seed destruction – fumigation and drenching

Soil fumigants (Basamid ®, pine oil and methyl bromide) were deployed by the program as a means to target specific area of branched broomrape infestation.

4.3.3 Methyl Bromide Fumigation

Methyl bromide is an ozone depleting gas and a controlled substance. In Australia it can only be used as a fumigant for quarantine and pre-shipment purposes, unless the Australian Government has given permission for another use. Penalties apply for misuse. The scale of methyl bromide fumigation in the program is, thus, quite remarkable, although, at the time it was still being used in horticulture.

Roadsides

Initially, when it was thought that there was a limited distribution of branched broomrape and seed destruction by fumigation was to play a big role in eradication. It is impossible to fumigate rocky areas, including roadsides, so a rock mulcher was contracted that turned rock into gravel. Expense and the discovery of kilometres of infested roadside resulted in fumigation being dropped in favour of herbicide application to control hosts.

Arable land

Swathes of paddocks were wrapped in plastic as part of a large fumigation program using methyl bromide. The characteristics of this chemical are well known and it is used in intensive agriculture and quarantine with known efficacy and risks. For a couple of years the program was a significant user of methyl bromide. This large scale treatment was phased out in 2007 and then only used for areas of a few square metres.

Figure 11



Contractors treating a paddock with methyl bromide

Figure 12



Sometimes nature makes a day worthwhile. Morning mist enhances the first runs of plastic covered methyl bromide treatment through a cultivated paddock.

4.3.4 Basamid

Research found that at low concentration the active chemical in the soil fumigant Basamid (methyl isothiocyanate) was found to induce branched broomrape into suicidal germination. At higher concentration it would kill imbibed seed.

The Agrow drill was the first implement used to apply granular Basamid. Its mechanism was not suited to Basamid® that has the characteristic of absorbing moisture. This caused erratic flow and blockage problems in the drill mechanism.

Figure 13



Steve Lamey examines the workings of the drill used for Basamid

Figure 14



The drill in operation. Most probably halted to attempt to get the hygroscopic Basamid to feed through the mechanism

Figure 15



The successful Basamid fumigation combination

The Agrow was replaced by a locally built Horwood Bagshaw air seeder with winged tynes from Canada that distributed the fumigant evenly across the swathe. This air seeder design had a mechanical feed that enables accurate metering of product. Basamid ® was replaced with Dazomet®, another brand of methyl isothiocyanate, in one tonne bags.

4.3.5 Pine oil

A by-product of milling pine trees, a soil drench of diluted pine oil had the potential advantage of being able to be applied to non-crop areas and for treating small areas of emerged plants. Pine oil was commercially available as Interceptor®, a product sourced from New Zealand. It worked in a similar manner to Nipro Quat ® by dissolving lipids in cell walls of broomrape seed.

Pine oil by air

Aerial application can be fast, flexible in regards to terrain and will not pick up soil or seeds from treated areas. Early trials utilizing a bucket slung from a helicopter showed that accurate placement was not achievable with this method and the volume of material required, 20,000 L/ha meant the application rate was too slow and expensive. A different method had to be developed.

Figure 16



Applying pine oil with a helicopter and bucket. Exciting but not feasible

A large purpose built spray unit with flood nozzles was developed by the South Australian company, Spray Shop to deliver the 20,000 l/ha of 5% pine oil solution to selected areas. Measurements of infiltration showed a wetting depth of 10-15mm was achieved with this volume in the Mallee soils.

Figure 17



The pine oil rig; built in Adelaide to accurately apply 20,000 litres of spray per hectare

Figure 18



A trailer spray rig that applied pine oil to small areas was also built locally under supervision

During the 2008 season, 330 ha were treated with Basamid or pine oil at a cost of \$1.192 million. However, field based research showed that both pine oil and Basamid fumigants were less than 100% effective. At a range of sites up to 75% reduction in branched broomrape seed was shown with Basamid but only a 30% reduction with pine oil.

4.4 Host Denial via herbicides

4.4.1 Aerial Operations

The narrow spraying window to treat hosts prior to broomrape emergence meant large tracts of land had to be sprayed with herbicide in a couple of weeks. Local spray operators were too busy with existing work commitments so the program undertook a significant aerial spraying program of pasture, range land and difficult terrain partly funded by landholders through cost assistance diversion. Fixed wing planes, provided by the South Australian based Aerotech, and County Helicopters from Victoria were utilized. The program also undertook control on roadsides and areas where circumstances dictated boom or hand held application.

Figure 19



Figure 20



Rather than move to airstrips close to targets aerial Operations were settled at the Pallamanna airfield, close to Murray Bridge, as the most efficient way to operate. It avoided events like becoming bogged on the runway at the Army Range on a cold day in August.

5. Delivering the Program

5.1 People

Many levels of management guided this program. The intricate nature of its composition and substantial size of its funding required all levels of management of the departments in which the program become knowledgeable about it. The closer the manager to the program the more intimate their knowledge of and greater their time commitment to it. The actual day to day running of the program was headed by the Mr Phil Warren, Manager, Branched Broomrape Eradication Program.

Other people important to the operations of the program included, Mr Nick Secomb, Senior Project Officer Mr Bob Manouge, Program Administrator, , Mr Steve Lamey, Project Eight Officer, Mr Lance Holberton, Senior Compliance Officer and Operations Centre staff Mrs Veronica Ward, Mr Charlie Caruana, Mr Luke Wilson, Mr Rob Selfe and Mrs Su Johns.

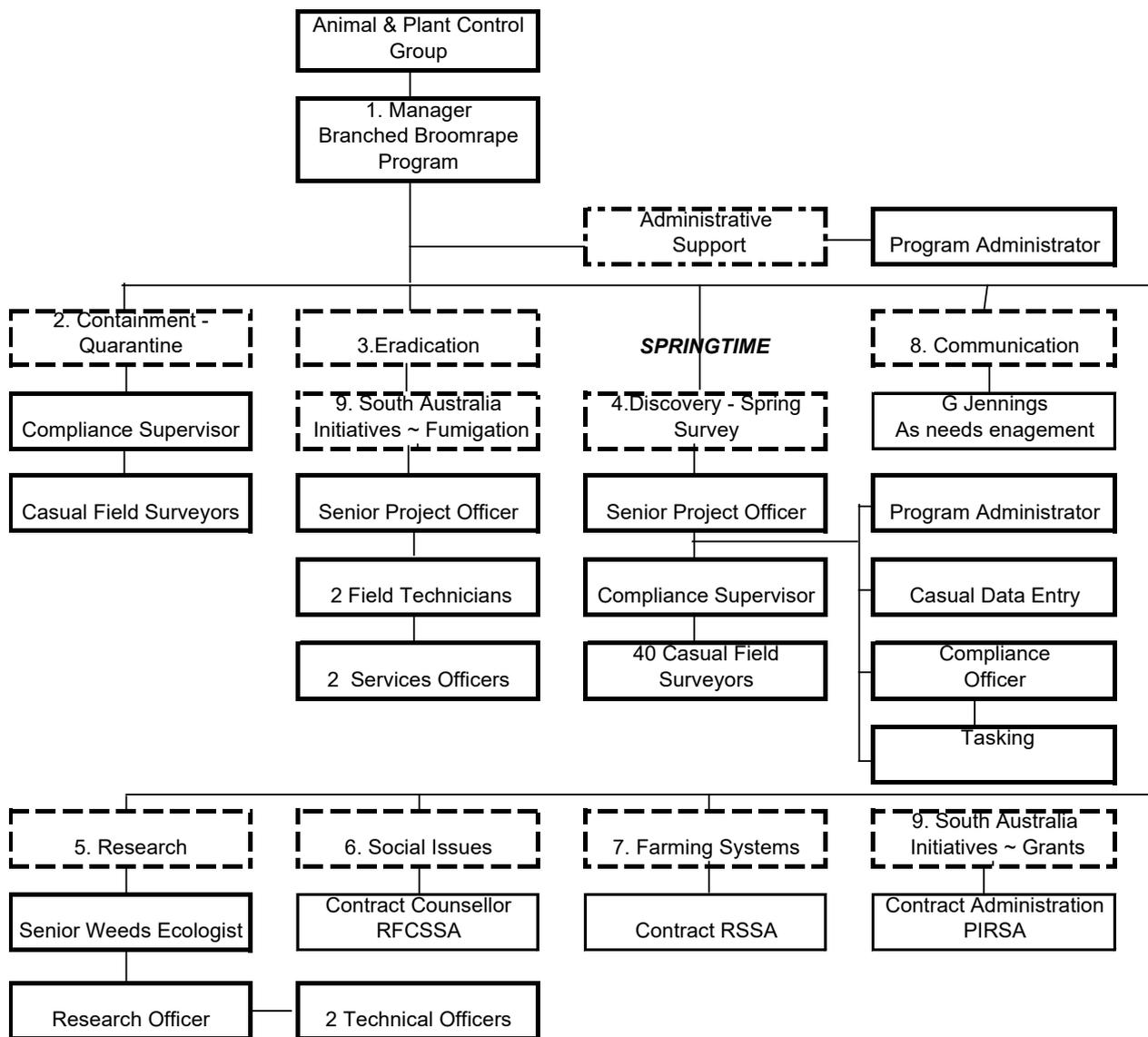
Those who helped run the program include Mr Peter Allen, Mr Mark Ramsey, Mr John Virtue, Managers of the Animal and Plant Control Commission or Group. Everyone involved did more than play their part.

A core group of around 20 people were employed full time. During peak times in the spring surveys when every paddock in the quarantine area plus a sample of surrounding paddocks was surveyed and additional 40 casuals were employed. Just over 200 people were directly employed during the eleven years of the eradication program. In addition more than 24 landholders consistently assisted the program through the Community Focus Group. In all, more than 360 people were employed on or belonged to program committees.

5.2 Program Structure

The program comprised nine projects. Both the projects and the program structure were consistent throughout as per this chart from 2008.

BRANCHED BROOMRAPE PROGRAM ~ STRUCTURE 2008



Jan-2008

RFCSSA = Rural Financial Counselling Service South Australia

RSSA = Rural Solutions South Australia

PIRSA = Primary Industries and Resources South Australia

5.2.1 Industry Guidance of the Program

At a distance from the daily management of the program, the Branched Broomrape Steering Committee had members from organisations with a strong South Australian presence such as the South Australian Farmers Federation, with Dale Perkins, Chairman of the South Australian Farmers Federation showing keen support of the program in its initial phase. Membership was drawn from Local Councils, and Grain marketing companies and Rural Counselling. The Committee oversaw the program’s progress and ratified policy, meeting regularly. The national view was represented through an External Management Committee with membership of weed experts from

government departments and research bodies. This body met less regularly as the program progressed.

Figure 21



From the left John Berger, Chair of the Community Focus Group, Greg Fraser, then Plant Health Australia CEO and a member of the review committee, Phil Warren, Program Manager and Mark Ramsey, Manager of the Animal and Plant Control Commission in the Operations Centre at Thomas Street, Murray Bridge

6. Eradication Ends

The quarantine area continued to enlarge with discoveries of new infestations outside the previous boundaries. In January 2011 the status of the extent of branched broomrape infestations was summarised in the following table.

Table 1

Cumulative Data to 2010 Year 12

Area Surveyed (ha)	Infested Properties	Infested Paddocks (level 4)	Area of Infested Paddocks	Area Infested	Road verges	Road verges distance (metres)	Quarantine area (ha)
349,992	294	824	58,381	7,535	67	60,000	209,685

In March 2011 genetic analysis in Europe identified the South Australian form of branched broomrape as *Phelipanche mutellii* (= *Orobanche mutelli* = *Orobanche ramosa* spp. *mutelli*), which is not considered to be as 'aggressive' as *Orobanche ramosa* (= *Phelipanche ramosa*). In its native range throughout the Mediterranean, *Phelipanche mutellii* is mainly a parasite of various herbaceous plants in the daisy family, which aligned with it commonly being seen on weedy daisy hosts in South

Australia. Overseas it has lesser economic impacts on crops than the related but different *O. ramosa*. This taxonomic revision and a perceived change in host risk profile was a consideration in ending the eradication program.

Program research showed that seed will survive in the Mallee soils for decades, making eradication a very long term proposition. There is a high level of on-farm control of infestations with only 11.5% of known infested paddocks having flowering plants emerge. However, this was above the target figure of 8%.

These and other factors were considered in a national, independent review of the branched broomrape program that concluded that eradication is no longer technically feasible within the financial constraints facing the program.

In August 2011 the National Management Group for Weeds endorsed the review recommendations and established a National Steering Committee to oversee the development of a plan for the transition to ongoing management of branched broomrape.

6.1 The Final Word

At the end of the program in 2012 there was, still, no national framework to manage weeds such as branched broomrape. The Emergency Plant Pest Response Deed is a legal instrument (EPPRD) that currently excludes weeds and therefore cannot be used for the Branched Broomrape type responses. Therefore the draft National Environmental Biosecurity Response Agreement was used as an overarching framework for the response.

The program had a lot going for it. It was adequately funded, supported by all levels of management and the diverse funding sources meant it had a high degree of autonomy so it could react to changing circumstances, quickly. Most people involved, particularly landholders were supportive and had a go. The story of this program suggests that by the time “the authorities” become aware and then react it is difficult to impossible to eradicate an unwanted biological intruder like branched broomrape. It had already spread across many properties, was difficult to detect and kill all individual plants, and had a long-lived seedbank. Effective quarantine is the most cost-effective approach to prevent such weeds.

APPENDIX

The History of Branched Broomrape in South Australia

Initial Discovery

1911 - Branched broomrape is recorded at Glenelg in South Australia. State Herbarium of South Australia. Details are: "S. Dixon (Herb. J.M. Black)" s.n., Prior to or in 1911, South Australia, Southern Lofty region. "Sandhills nr. Glenelg. Observed by him during the last year or two. Grows near *Orobanche australiana*. Sent to Kew, Oct. 1911 "Annotations by Black in his detailed dissection notes include: "corolla lilac (light)" Sheet number AD 97306334.

Two other species of broomrape also occur in Australia: *O. cernua* var. *australiana* which is a native species and the introduced *O. minor* (clover broomrape) which is common in pastures; however, neither of these species are considered to be significant pests.

There are no further herbarium records of branched broomrape from Glenelg but in the early 2000's survey teams did find it on the roadside around the intersection of West Beach and Military Road.

1992 – Branched broomrape, identified as *Orobanche ramosa*, was found on farmland near Bowhill in the Mallee region of South Australia. Surveys showed that the infestation was restricted to a few properties. A State-funded eradication program was undertaken from 1992. The infestation was fumigated with methyl bromide and monitored.

1994-97 – Several small outbreaks were found in the same area and similarly treated by the South Australian Government.

1998/99 – Known area infested increases to 16 sites across ten properties, covering 160 hectares.

NATIONAL ERADICATION PROGRAM COMMENCES

August 1999 – Following the discovery of additional infestations, the Standing Committee on Agriculture and Resource Management (SCARM) agreed to fund a national management and delimitation program.

September/October 1999 - Further surveys were undertaken in spring to confirm the distribution of the weed. Results indicated that the number of individual infestations (paddocks) had reached 116, affecting 55 properties and spread over 1300 hectares. The results also demonstrated that livestock grazing of pastures and the use of herbicides in crops masked the presence of the weed.

12 November 1999 – A quarantine area, set up under the *Fruit and Plant Protection Act, 1992* that included all known branched broomrape infestations was declared, to contain the weed with a view to eradication. The containment program was planned to continue until at least March 2001 to enable:

- improved knowledge on distribution of the weed in Australia;
- studies to be undertaken on the host range and the plant's ecology and biology;
- an evaluation of its economic impact;
- the development of field sampling methods and management strategies for the weed.

March 2000 – SCARM noted the change in direction of the program due to the much higher level of infestation, but agreed to fund the containment/surveillance program and the assessment of the eradication program.

The outcome was agreement to provide a total of \$2.2 m, cost-shared between governments, to implement the eradication program between November 1999 and June 2001. Further funding would be based on results of surveys undertaken in 2000.

There was no formal mechanism for industry to participate in cost sharing for weed response programs. However, industry has been involved in supporting eradication research, and South Australian industry leaders and affected properties have made significant in-kind contributions.

Spring 2000 – A survey was conducted in the quarantine area and on properties in other areas with links to infested properties. A total of 220 linked properties were surveyed, some located on Yorke Peninsula and in Victoria.

A total of 118 new infestations were found in spring 2000, to give a total of 236 infestations on 130 properties in South Australia. The total area of paddocks infested was now about 11,000 ha, and infestations were also found along 19 km of road verges. All infestations were confined to an area of about 70 km x 70 km in and around the quarantine area. No infestations were found on linked properties outside this area.

March 2001 – SCARM agreed in principle with the continuation of an eradication program with the objective of eradicating branched broomrape in the long term. The eradication program was established by Ministers at the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) meeting 19 (Resolution No 3B). The total budget is more than \$4.2m for the three year period.

Research funding was also approved for 2001-05, totaling about \$1.94 m. This was committed by Grains Research and Development Corporation and Horticulture Australia Ltd as well as the Weeds Cooperative Research Centre to develop systems for the on farm management of branched broomrape.

December 2002 – The South Australian Government commits to invest in a 10 year program seeking to eradicate branched broomrape as part of an agreement with the independent Member of Parliament the Hon Peter Lewis MP. The compact provides additional state funding of around \$2.0 m annually and an expanded farm grant scheme is introduced during 2003. The grants schemes supported farmers with the additional costs of herbicides and costs associated with implementing farm plans above normal operations.

Autumn 2003 and 2004 – Fumigation with methyl bromide of 40 hectares in an exercise costing around \$0.7m. Paddock trials of pine oil begin with 30 hectares treated and a Basamid, ® with the active methylisothiocyanate, trial shows this product is effective but methyl bromide remains the superior fumigant.

Spring 2004 – Discovery surveys outside the quarantine area mean the entire 70 x 70 km zone has been surveyed at least once.

2005 – Dr Ray Correll of CSIRO begins a range of risk analyses that influence quarantine standards under the eradication program. Ready control with herbicides of broad leaf weed hosts in crops is evident. Poor control in pastures is recognised as the significant constraint to achieving eradication.

A small infestation at Swan Reach, on a property 14 km north of the existing quarantine area that was probably related to machinery movement was discovered. This showed the need for links surveys between properties and for the machinery decontamination provisions of the quarantine Code.

2007 – A temperature-based growing degree day model is developed to predict annual emergence time of branched broomrape flowers and assist time of spraying. Models predicting the pathway to eradication, named the Return Rate Model, provide a measure of the long time horizon for this program. The performance of the fumigants Basamid and pine oil are assessed as requiring improvement if they are to be used as an eradication tool.

2003, 2004, 2005 and 2008 – Independent reviews of the program consistently recommended that eradication was technically feasible and an appropriate response to Branched Broomrape. In November 2008 the Primary Industries Ministerial Council continued to support the program and, at its 14th meeting, agreed national funding of \$7.583 million for a further three years until June 2012.

ERADICATION ENDS

January 2011 – The quarantine area continues to enlarge with discoveries of new infestations outside the previous boundaries. Current status of the extent of branched broomrape infestations is given in the following table.

Table 1

Cumulative Data to 2010 Year 12

Area Surveyed (ha)	Infested Properties	Infested Paddocks (level 4)	Area of Infested Paddocks	Area Infested	Road verges	Road verges distance (metres)	Quarantine area (ha)
349,992	294	824	58,381	7,535	67	60,000	209,685

March 2011 – Following DNA analysis in Europe, the South Australian species is classified as *Phelipanche mutellii* (= *Orobancha mutellii*) and is not considered to be as 'aggressive' as *Orobancha ramosa*. Program research shows that seed will survive in the Mallee soils for decades, making eradication a very long term proposition. There is a high level of on-farm control of infestations with only 11.5% of

known infested paddocks having flowering plants emerge. However, this is above the target figure of 8%.

A national independent review of the branched broomrape program concludes that eradication is no longer technically feasible within the financial constraints facing the program.

August 2011 – The National Management Group for Weeds endorses the review recommendations and establishes a National Steering Committee to oversee the development of a plan for the transition to ongoing management of branched broomrape. It is also agreed that the existing national funding of \$2.6 million and State initiatives of \$1.95 million will continue until 30 June 2012 to support elements of the current program and provide for this transition.

December 2011 – The eradication program completes operations and surveys of the quarantine area (209,685 Ha) in 2011. The surveys discovered 28 new infested paddocks (total infested 852) and 5 new infested patches on roadsides (total infested 72) within the quarantine area.

March 2012 – A two-year transition to management program to June 2014 was approved by the Primary Industries Standing Committee, to be funded by the Australian and South Australian Governments.

June 2014 – Two year transition to management plan is fully implemented, allowing time for industries and individuals to develop and implement their own farm biosecurity plans. In the first year, Biosecurity SA maintained quarantine restrictions on properties where branched broomrape occurred but released all properties where branched broomrape had never been detected and those where twelve years had elapsed since it was last found. For properties remaining in quarantine, movement of high risk products and machinery was restricted and crop surveys were conducted to confirm product freedom from branched broomrape. Commodity markets were consulted on the change. Australian grain standards were revised to have a tolerance for branched broomrape that aligned with other weed seed contamination. A [best practice manual for the on-property management of branched broomrape](#) was produced that, in 2022, is available via the PIRSA website.

In the second year, all remaining properties were released from quarantine and Biosecurity SA made arrangements to finalise the program, including archiving operational material, completing and publishing scientific research, and transferring the database and other compliance information to the South Australian Murray Darling Basin Natural Resources Management Board. Workshops and telephone surveys were done with land holders to assist the adoption of best practice management.

2022 – There has been no evidence of domestic or international market issues arising from the transition out of quarantine. [Branched broomrape remains a declared plant](#) under the *Landscape South Australia Act 2019*, with legal requirements to prevent its entry and spread and to undertake control. There have been no detections of branched broomrape in other regions of South Australia.

ATTACHMENT

Summary of outputs, methods and budgets for each project in the Branched Broomrape Eradication Program 1 July 2009 - 30 June 2012

1. PROGRAM MANAGEMENT

Aim

- The program is managed and directed so that other project outcomes are achieved and State and National management and administrative requirements are met.

Budget \$289,000

2. COMMUNICATIONS

Aims

- An increased understanding of the program amongst target audiences such as other government and industry organisations, landowners and the public.
- Reinforced market confidence through awareness of the program amongst marketeers.
- Improved adoption in the community of appropriate technologies to move towards eradication and adopt best farming practice.

Budget \$27,000

3. CONTAINMENT – Quarantine

Aims

- Branched broomrape is contained to its present boundaries.
- High levels of confidence in Australian and South Australian produce in international and national markets are promoted by minimising the opportunity for branched broomrape seed to contaminate produce.

By:

- Using a two-tiered quarantine system that has a quarantine area encompassing all infestations to contain branched broomrape, plus stringent quarantine requirements for individual paddocks with known infestations.

Budget \$1.2 m

4. DISCOVERY – Surveys

Aim

- An increased confidence of knowing the full distribution of branched broomrape in Australia to maintain access to international and national markets and provide sound information for targeting quarantine and eradication strategies

By:

- Surveying all paddocks in the quarantine area
- Re-surveying all high-risk properties within 7.5km of an infestation.
- Surveying 10% of linked properties each year to confirm that the current distribution is accurate.

- Tracing the movement of branched broomrape vectors from newly discovered infested properties to other areas of SA and interstate.

Budget \$318,000

5. ERADICATION BY ATTRITION – Grants

Aim

- Seed reserves on properties are depleted in the long-term while the properties remain commercially viable.

By:

- In accordance with the government initiative, aid the implementation of integrated weed management plans aimed at depleting seed reserves with a view to eventual eradication of branched broomrape by affected grain, livestock and horticultural growers.
- Optimising the containment of branched broomrape and rate of eradication by providing financial assistance to landowners for containment costs through grants schemes that assist with the implementation of farm plans.
- Ensuring the attrition of seed reserves by supporting landholders and providing for costs of certain herbicides that specifically control host plants in all land use situations.

Budget Grants \$700,000

Spray Contracts 475,000

Containment costs Assistance \$200,000

The State initiatives funding is balanced between eradication by attrition and seed destruction with a small portion to fund research. Grants to support attrition take priority.

6. ERADICATION BY ATTRITION - Skilling in Farming Systems

Aim

- Seed reserves on properties are depleted in the long-term while the properties remain commercially viable.

By:

- Working directly with all landholders with infested pastures to ensure adoption of eradication measures on their pastures by.

Budget \$444,000

7. ERADICATION BY SEED DESTRUCTION

Aim

- Seed reserves in high-risk infestations (eg along road reserves and in satellite infestations) with a high chance of successfully establishing new infestations are eradicated.

By:

- Supporting eradication in the long-term through the removal of the major seed load in infested paddocks and roadsides.

Budget \$170,000

8. PROJECT 8 - Cooperate and Participate to Eliminate

Aims

- Landholders access grants and lodge plans (compliance, farm plans and herbicide grants.)
- Emerged branched broomrape is treated in spring with herbicides or pine oil.
- Plans are audited and treatment carried out if necessary..

Budget \$96,400

9. RESEARCH

Aim

- Research is focused on three key areas – effectiveness of fumigation treatments, branched broomrape physiology and seed bank decline, and modelling of risk associated with removing produce from the quarantine zone.

Results from a seed bank decline field experiment started in 2003. In 2008, under host free conditions the number of viable seeds present four years after the start of the experiment on a loamy soil was nearly equal to the original starting population, while at a second site on a sandy rise moderate decline was present after 3 years, but in the 4th year numbers appeared to rise. The results provide significant cause for concern as the anticipated 12 year time to 100% seed bank loss would not be achievable given the field results, and a time frame of 15-20 years will stretch the timeline for eradication to 2035.

Branched broomrape germination was observed in both summer and autumn which indicates that temperature control of germination is unlikely. This observation would be consistent with the widespread occurrence of branched broomrape on tomatoes which are normally a summer crop in Mediterranean regions.

Budget \$191,000

Author: Philip Warren, Program Manager

References:

Most material is drawn from the reviews prepared for the Australian Weeds Committee in 2002, 2005, 2008 and 2011. Photos are from program archives held within PIRSA or by individuals.

Acknowledgement:

Dr John Virtue, who undertook research into branched broomrape and was later the line manager immediately above the Program Manager, had important editorial input. Mr Steve Lamey provided photos.

Mr Roger Wickes, Executive Director, Natural Resource Management, PIRSA, provided comment about the national arrangements.