

The Biological Control of Noogoora Burr (*Xanthium occidentale*) in Queensland: An Economic Perspective

John F. Chippendale (deceased)¹

Alan Fletcher Research Station, PO Box 36, Sherwood, Queensland 4075, Australia

Australian Wool Corporation records indicate that Noogoora burr (*Xanthium occidentale*) contaminated 0.6% of the total Queensland wool clip in the 9 yrs between 1982/83-0/91, compared to >4% in the 11 yrs between 1953-65. The difference is thought to be due to the effects of *Puccinia xanthii* (discovered in Queensland in 1975) and *Epiblema strenuana* (released in December 1983). This view is supported by a 1989 survey of Queensland's Regional Inspectors. The cost of the biological control research program is estimated to have been A\$7.2 million, while the present value of benefits are in excess of A\$16.7 million.

Introduction

The era of the information-based organisation has arrived (Drucker 1988). As such, the measurement of efficiency and effectiveness of programs in terms of outcomes has become the core performance criterion directing the flow of financial and human resources within organisations. Thus, *ex post* evaluations of programs have taken on a new aura of importance. The following paper is an *ex post* study of the biological research program aimed at the control of Noogoora burr, *Xanthium occidentale* Bertol. (Asteraceae). The aim of the paper is to provide evidence that biological control agents have significantly reduced the impact of Noogoora burr on the Queensland wool industry and to estimate costs and benefits of the program.

Noogoora Burr in Australia—A Brief History

Noogoora burr was introduced with cotton seed imported from the Southern States of America in the 1860s (Liddle 1986). First official records are found in "Reports of the Chief Inspector of Stock 1879-1889" (Marks 1972). In 1879 the Chief Inspector of Stock, P.R. Gordon, sent The Board of Inquiry into Diseases of Livestock and

Plants a bundle of botanical specimens that were suspected of killing dairy cattle. These plants were identified by the Board's Botanist as *Xanthium strumarium* L. (*occidentale*). The plant was reported to be spreading rapidly, covering just over 200 ha around the Noogoora Estate near Ipswich in Queensland. Tests by the Government Chemist confirmed the toxicity of the burr and recommendations were made that immediate attention should be given to its control. In 1880 it was again noted in official records that the burr was spreading rapidly along waterways and that people were carting burrs around with their produce. It was strongly recommended that the plant be brought under the operation of the *Burr and Thistle Act*, with the notation that "... its spread in the pastures of the Colony would be nothing short of a calamity" (Marks 1972). It was not until 1926 that Noogoora burr was declared a noxious weed in Queensland (Williams 1944). By 1930 the majority of the State's river systems were infested (White-Haney 1930).

Pest Status

From the 1930s-60s Noogoora burr was regarded as Queensland's worst weed (Currie

¹ Please address reprint requests to Dr. Rachel E. Cruttwell McFadyen, Alan Fletcher Research Station.

1936, Williams 1944, Allen 1947, Anonymous 1949, Kenny, Everist & Sutherland 1950, Anonymous 1955, Everist 1960, Anonymous 1962). Despite having this infamous position, little attention was paid to quantifying the total damage being inflicted by the weed, although a few guesses appeared over the years. The highest estimate was \$200,000,000 p.a. for Australia (Anonymous 1963). Currie (1936) estimated the loss in wool value to Queensland to be >A\$50,000/yr. Dodd (1947) calculated yearly losses in Queensland wool values through the years 1941-6 to be as high as A\$474,000 (Table 1). Martin and Carnahan (1982) calculated losses from Noogoora burr wool penalties in Queensland to be \$1,232,500 for 1978-9. An Australian Wool Corporation (AWC) survey in 1988 placed Noogoora burr 18th on a list of 22 of the most important weeds of the Australian wool industry, estimating losses to Australia of A\$700,000/yr (Anonymous 1988). These figures represent the extreme minimum cost of Noogoora burr. To all these estimates must be added costs pertaining to other damage, control costs, and the cost of Government intervention (Wapshere 1974, Condon and Alchin 1981). The true cost of Noogoora burr to Queensland will never be known.

Table 1. Deductions for Noogoora burr content in Queensland wool (Dodd 1947).

Year	Dollars
1941-42	474,000
1942-43	143,000
1943-44	191,800
1944-45	247,400
1945-46	155,000

Physical and Chemical Control

Physical and chemical control of the pest plant proved very difficult. Originally, graziers treated large areas with arsenic pentoxide to control the burr. One grazier, a Mr. Elliott, reported 123 head of stock lost from arsenic poisoning (Anonymous 1952). By 1947 the Graziers' Association considered that it was impractical for individuals on larger holdings to cope with the destruction of Noogoora burr (Allen 1947).

With the discovery that 2,4-D provided cost-effective control, a Co-ordinating Board was set up in 1947 to oversee the eradication of the plant. The objective was to enforce land holders and Councils to simultaneously destroy burr plants on any land under their jurisdiction. In conjunction with these schemes, and under recommendations of the Board, the Queensland Government in 1948 began supplying knapsacks, power sprayers and hormone weedicides at cost price, free of freight to the nearest railway station, to local authorities and individual land holders. The scheme continued in earnest until the early 1950's from whence it apparently died a slow death. Benefits from the scheme were never quantified and due to the fragmented nature of accounting at the time it is impossible to place a figure on its total cost. Despite favourable newspaper articles at the time (Anonymous 1951*b*), the scheme has never been given credit for substantially reducing the burr population.

Biological Control Program

The biological control research program commenced around 1930 and continued through into the mid-1970s (Williams 1944, Wilson 1960, Wapshere 1974, Donnelly, G.P., personal communication, 1991). Despite the release of 3 separate agents during this period, there was little, if any, controlling impact on the weed (Julien 1987).

In 1968, the Commonwealth Scientific and Industrial Research Organization (CSIRO) began investigating the suitability of a rust disease, *Puccinia xanthii* Schw. (Uredinales), for the control of Noogoora burr (Wapshere 1968). The rust was suggested for introduction subject to the results of further research (Hasan 1973). However, no formal introduction was made due to doubts about its host-specificity (Tomley 1978). Subsequently, the disease was recorded on Noogoora burr in Australia in 1974 (Julien 1987). The mode of entry is unknown (Tomley 1978). By February 1976 the rust had been reported devastating Noogoora burr on Toomba station, 20 km west of Charters Towers (Anonymous 1976). Although the rust spread mainly by natural means, some funds were allocated by the Co-ordinating Board in 1978 for

the distribution of the disease to areas within Queensland that were not already affected (Tomley 1978). By 1978 there were general observations from land holders that the rust was having an impact on the weed in the field (McFadyen, R.E., personal communication, 1991). Julien, Broadbent and Matthews (1979) concluded that the overall effects of *P. xanthii* may achieve control of *X. strumarium* (*occidentale*) in the field.

Epiblema strenuana (Walker) (Lepidoptera: Gelechiidae) from Mexico was released in Queensland in December 1982 for the control of *Parthenium hysterophorus* L. (Asteraceae). Initial research had shown that it also attacked *Xanthium* spp. in the Americas. First observations that it was attacking Noogoora burr in Australia were made by McFadyen in 1984 (McFadyen, R.E., personal communication, 1989). Subsequent reports by field staff indicated that *E. strenuana* was spreading rapidly, and having a considerable detrimental effect on Noogoora burr plants (McFadyen 1987).

Cost of the Biological Control Program

Because of the large time period involved, and the fragmented spatial nature of the biological control program, the exact quantification of program costs was impossible. A diary of research operations, with associated personnel and locations, was drawn up from discussions with long serving research scientists (Diatloff, G., personal communication, 1991, Donnelly, G.P., personal communication, 1991). Included was the work of Taylor, Hitchcock, Mundell, Mann, Smith, Stride, Wapshere, Kassulke, Balloch, Hasan, and miscellaneous persons associated with rearing, collecting and releasing in Australia. Values, in 1991 dollars, were then imputed at three times the scientific officers' estimated salary equivalent, to include operational and overhead costs including an assistant. Overseas research was costed at \$150,000 p.a., the current cost of running an overseas field station (Diatloff, G., personal communication, 1991). Costs were summed to give an approximate cost of the program in 1991 dollars. This methodology was used in place of indices because (1) the exact yearly costs could

not be determined and (2) indices are inadequate to measure change over such a large time period (Yamane 1969). Using this methodology, the cost of the biological control program to Australia is estimated to be around A\$7.2 million.

Quantifying the Effects of the Biological Control Agents on Noogoora Burr

Local Authority Survey

In 1989 a mail survey was distributed through 18 Land's Department Regional Inspectors to cover 131 Local Government Authorities (LGAs) in Queensland. The Inspectors were instructed to complete questions in consultation with local Weed Inspectors and other persons with expert knowledge of Noogoora burr. Questions were included regarding the importance of Noogoora burr as a weed, population changes since the 1960s, and the role that climate, land use changes and biological control agents were playing in bringing about any changes in the Noogoora burr population levels.

Results from 4 different scaling instruments indicated that Noogoora burr was regarded as of nil to low importance over most of Queensland. This finding is supported by the Australian Wool Corporation's research (Anonymous 1988) quoted above. It was evident that there was less Noogoora burr present than in the 1960s; only 3% of the LGAs were thought to have experienced an increase in population size. As would be expected, climate was identified as an important variable associated with this change, while land use changes were viewed as relatively unimportant. Apart from climatic factors, respondents identified a significant association between the reduction in the burr population and the importance of *P. xanthii* as a controlling agent. No such relationship with *E. strenuana* was observed, although the insect was recognized as having an effect on the plant in the field. The association between rust and changes in the Noogoora burr population was further supported by a corresponding reduction in the reliance on chemical control of the weed. From 1979-89 the respondents perceived a general reduction in the use of chemicals, with a corresponding increase in the reliance on

biological control. Chemical control is still being undertaken in certain regions. The cost of this control, and other detrimental effects of the burr, will be elicited in a future survey.

Percentage of Noogoora Burr in Queensland Wool

Bales of greasy wool containing Noogoora burr and Bathurst burr are specifically marked in sales catalogues. Because Bathurst burr contamination in Queensland wool is light (Martin and Carnahan 1982), and as the majority of wool in Queensland is marketed through one auction centre, a rather unique opportunity exists to obtain a population index for Noogoora burr over an extended period of time. To facilitate this, a literature search was undertaken to find the percentage of Noogoora burr in the Queensland wool clip over past

years, based on sales catalogue data. A request was also made to the AWC to supply current data. The percentage of the Queensland wool clip infested with Noogoora burr from 1935/36 to 1990/91 (Anonymous 1951a, Dodd 1947, Wapshere, A.J, personal communication, 1991, Foden, C.A.F & McDonald, M. personal communication, 1988-91) is graphed in Fig. 1. Unfortunately there is a gap in the data series over the critical period in the late 1970s to early 1980s, the period when *P. xanthii* first impacted on the Noogoora burr population. This gap has resulted from difficulties in accessing computerised historical data within the AWC. It is intended to pursue the manual extraction of this data in the future. Fig. 1 also shows rainfall over the same period, the series representing annual rainfall averaged for a North-South cross section of Queensland's sheep region. The weather stations included

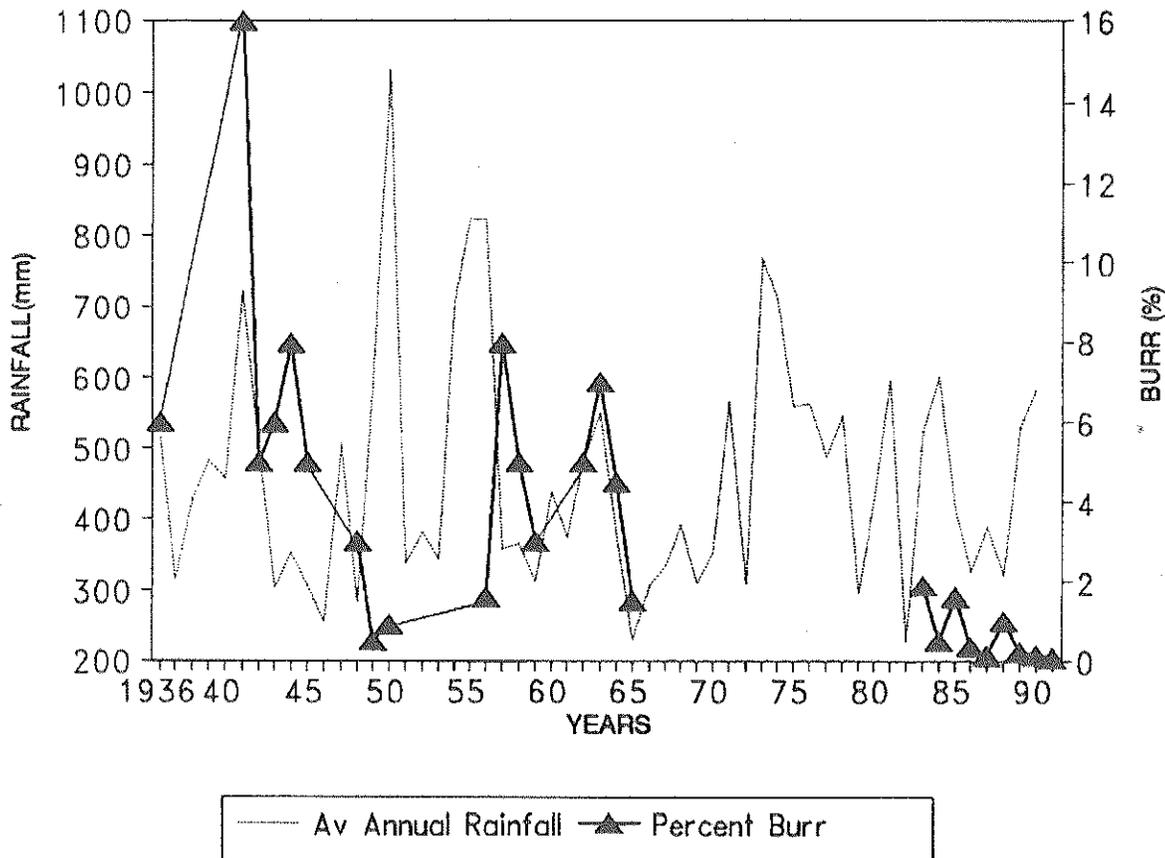


Figure 1. The percentage of the Queensland wool clip contaminated with Noogoora burr grouped against the average annual rainfall of 5 weather stations scattered throughout the wool growing region.

were: Hughenden, Winton, Barcaldine, Charleville and Cunnamulla (Clarkson, N., personal communication, 1991).

Fig. 1 shows that the percentage of burr in Queensland wool prior to the arrival of *P. xanthii* fluctuated greatly. These fluctuations are positively correlated to annual rainfall except during the 1949-56 period. This period corresponds to the main thrust of the Government's Simultaneous Destruction Scheme. Given the rainfall pattern during this period one would have expected the percentage of Noogoora burr in the wool to be much higher. Dodd (1956) states that Queensland had experienced a run of good seasons and that "it is certain that the proportion of burry wool (in 1956) is now higher than 16%", when in fact it was <2% (Fig. 1). The period 1955-57 shows up as a key point in the history of Noogoora burr, being associated with: (1) major flooding, (2) political upheaval in the Lands Department, (3) the end of the Labour Government in Queensland, (4) an increasing focus on the development of the brigalow region, (5) the growing belief that biological control was the answer to control, with an entomologist working in USA and India, and consequently, (6) scientific staff being withdrawn from field supervision of the Simultaneous Destruction Scheme (McFadyen 1991, Diatloff, G., personal communication, 1991). Thus, there is strong support for the conclusion that active intervention during the period was effective in holding the Noogoora burr population at unnaturally low levels.

Letters from Shire Clerks indicate that the burr populations associated with the 1974 floods (Fig. 1) were at record levels (Wehlew 1975, Horn 1975, Smith 1975, Choveaux 1975, Shelton 1975). These letters are supported by a Queensland Department of Primary Industry's survey carried out by W.H. Hazard in 1975. The survey identified Noogoora burr as by far the most important annual weed in the Central Highlands (Pope, V., personal communication, 1989). Thus, even though the series is incomplete, it would appear that changes in the Noogoora burr population were directly correlated to the rainfall pattern up until this stage. In comparison, once *P. xanthii* had

become established over a wide area, Noogoora burr contamination reduced to an extremely low level and showed markedly dampened fluctuations, yet there had been no corresponding change in the annual rainfall pattern (Fig. 1). It appears that the rapid success of *P. xanthii*, in bringing Noogoora burr under control, can be largely attributed to the corresponding favourable rainfall pattern which existed from 1974-1978. This period was the largest block of wet weather experienced since 1936 (Fig. 1).

Fluctuations in the Noogoora burr population since the widespread distribution of *E. strenuana* around 1987 (McFadyen, R.E., personal communication, 1991) would appear to have become even further dampened (Fig. 1).

Benefits of Biological Control

Linear regression was used to investigate the relationship between annual rainfall and the percentage of burr in wool in the periods 1936-45 and 1957-65. These periods were selected to remove the influence of the mass control schemes as much as possible. A significant positive correlation was found between annual rainfall and the percentage of Noogoora burr in wool, ($F^2=0.64$, $P<0.001$). The model was then used to estimate the percentage of burr in the Queensland wool clip for the entire time series (Table 2). The benefit of biological control is represented by the difference between the actual and the estimates, post-1983. This difference was converted into bales of greasy wool (Table 3). The reduction in price due to vegetable fault (Currie 1936, Wapshere 1974, Bamma, Curran, and Gilmour 1985) is estimated to average out around 20 cents/kg of greasy wool, 1987-88 prices (Hector, Roberts and Crackel 1990). The benefit from higher wool prices is given in Table 4. The total benefit from the reduction in the Noogoora burr population for the 8 yrs commencing 1982-83 is >A\$6,700,000 (1991 dollars). This is an average annual benefit >A\$837,000. Assuming an equivalent annual flow of benefits into infinity, and a 5% discount rate, this gives a present value >A\$16,750,000.

Table 2. Percentage of Noogoora burr in the Queensland wool clip 1936-91 compared to estimates predicted by average annual rainfall.

Wool Year Ending	Actual ¹	Estimate
1936	6	8 ²
1941	16	13
1942	5	8
1943	6	4
1944	8	5
1945	5	4
1948	3	4
1949	0.5	10 ³
1950	0.9	19
1956	1.6	1.5
1957	8	5
1958	5	5
1959	3	4
1962	5	8
1963	7	9
1964	4.5	6
1965	1.5	2
1983	1.9	9 ⁴
1984	0.5	10
1985	1.6	6
1986	0.3	4
1987	0.1	6 ⁵
1988	1	4
1989	0.2	9
1990	0.1	10
1991	0.05	N/A

¹From the Australian Wool Corporation.

²Pre-*P. xanthii*

³Simultaneous Destruction Scheme and 2,4-D [(2,4-dichlorophenoxy) acetic acid] in use.

⁴Post-*P. xanthii*.

⁵Post-*E. strenuana*

Conclusion

There is strong quantitative evidence that the general Noogoora burr population in Queensland has been reduced substantially over the last 9 yrs. General field observations support the conclusion that this change has resulted from the impact of *P. xanthii*, which arrived in Queensland in 1975, and *E. strenuana*, which was released into the field in December 1983. The total cost of the associated biological research program was

estimated to be in the vicinity of A\$7.2 million (1991 dollars), while the present value of benefits from such a reduction is estimated at >A\$16,750,000 (1991 dollars). Work is continuing to complete the Noogoora burr in wool series represented in Fig. 1, and to elicit other costs of Noogoora on properties which still have a problem.

Table 3. Number of extra bales of greasy wool in Queensland during 1983-90 that should have contained Noogoora burr, given annual rainfall in each year.

Wool Year Ending	Total Clip (Bales) ¹	Reduction (%)	Bales
1983	317,264	7.1	22,526
1984	351,377	9.5	33,381
1985	377,765	4.4	16,622
1986	298,477	3.7	11,044
1987	400,990	5.9	23,658
1988	358,031	4.0	14,321
1989	376,120	8.8	33,098
1990	518,742	9.9	51,355

¹Data from the Australian Wool Corporation.

Table 4. Savings in vegetable matter penalties, calculated at \$0.20/kg greasy wool.

Wool Year Ending	Dollars (A\$ 1991) ¹
1983	980,000
1984	1,280,000
1985	574,000
1986	366,000 ²
1987	759,000
1988	425,000
1989	918,000
1990	1,397,000
Total	6,700,000

¹ABARE Prices Paid Index, Queensland.

Acknowledgments

I wish to acknowledge the contribution of C.A.F. Foden & M. McDonald of the AWC for supplying current and historical data on the percentage of Noogoora burr in Queensland Wool. Also to A.J. Wapshere for passing on unpublished AWC data on the percentage of Noogoora burr in wool between 1953 and 1965.

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