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AN EVALUATION OF THE POTENTIAL BENEFITS OF INTEGRATED SHRUB CONTROL STRATEGIES

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ABSTRACT

Widespread shrub encroachment following a reduction in fire frequency is a major factor limiting livestock production throughout the semi-arid woodlands of eastern Australia. The development of integrated shrub control strategies may provide an effective solution to the shrub problem by overcoming two major obstacles to a greater level of landholder acceptance of prescribed fire technology: control of resprouting shrubs and lack of fuel.

It is proposed that prescribed fire be used to provide the initial defoliation in those areas where there are adequate fuel loads. Because follow-up treatment must be undertaken within one or two years, secondary defoliation might be applied using sub-lethal concentrations of selective and environmentally acceptable chemicals. Economic effectiveness may be enhanced by using aerial operational procedures to rapidly treat those areas within individual paddocks which can provide maximum response in terms of increased herbage and animal productivity. This integrated approach, aided by decision support systems, may offer landholders a cost-effective means of applying shrub control over entire properties.

INTRODUCTION

Shrub encroachment is a serious impediment to livestock production in the semi-arid woodlands of eastern Australia (1,2,3). In New South Wales alone, it has been estimated that some 30 million hectares, approximately 25 per cent of the State's area, are affected by, or liable to, such infestation (4). The increasing shrub cover has led to diminished livestock production potential and placed the economic viability of properties at risk.

The actual level of economic loss caused by the shrub problem has not been subjected to rigorous analysis. One exploratory study provided an estimate of economic loss to the wool industry in the western regions of New South Wales and Queensland to be in the order of $6.0 million per annum (5). Other studies place the potential annual loss closer to $40.0 million (6,7). While there is clearly a substantial level of uncertainty concerning the real economic magnitude of shrub-induced income losses, it has been identified as a serious problem requiring address.

The increase in shrub cover, like that for savannas elsewhere in the world (8), has been attributed primarily to a change in fire regimes subsequent to European pastoral settlement. The frequency of both natural and man-induced fire decreased markedly as potential grass fuel was consumed by domestic and feral grazing animals and increased numbers of native herbivores (9). Seedlings of all problem shrub species are fire sensitive, and in past times were controlled by periodic fire events as well as by competition from vigorous perennial grasses (10,11). Shrub seedling establishment and herbage fuel production are strongly linked to above-average rainfall seasons which are highly episodic and unpredictable. Much herbage fuel is quite ephemeral, lasting little more than six months after senescence, so that the opportunity for prescribed fire is heavily constrained by fuel availability (12).

Most problem shrub species are natives comprising those that re-seed after fire such as the hopbushes (*Dodonaea* spp.), and those that resprout, especially species of *Eremophila* such as budda (*E. mitchellii*) and turkey bush (*E. gilesii*). Only rarely do introduced shrubs reach problem proportions such as Acacia nilotica in western Queensland (13,14). Consequently, there is little potential for biological control of the major species (15).

Extensive investigations over the past decade have examined numerous options for controlling shrub populations and restoring herbage productivity (16,17). Landholders have been reticent to apply this technology, partly through inexperience in using some techniques on a broad scale and partly because they are not convinced of the economic benefits accruing from such measures (18,19,20).

This paper discusses management options for shrub control. Practical and economic merits of integrating two potentially useful control techniques appear to offer solutions to overcoming weaknesses inherent in single-treatment measures.

CONTROL TECHNOLOGY

Because shrub encroachment has largely been attributed to a reduction in fire frequency following heavy grazing, an obvious remedy has involved the deliberate use of fire in conjunction with strategic grazing management (21). Experimental trials at both small plot and field scales have demonstrated the effectiveness of prescribed fire (9,16,22). Economic studies have pointed to potentially high cumulative net benefits accruing if such herbage responses were to be observed after prescribed fire (19,23).

A major limitation to the widespread adoption of prescribed fire has been the difficulty in achieving success at a practical scale due to insufficient fuel, both spatially and over time. Some parts of a paddock may carry substantial fuel loads while intervening areas may have minimal fuel. This discontinuous distribution severely restricts fire spread.

Research has indicated that single fires provide only short-term control (12). Prescriptions of two to three fires are required to prevent regenerating seedlings and coppicing shrubs becoming sexually mature and recharging the soil seed bank. While the most difficult shrubs to control are the resprouting species, up to 80 percent of budda (*Eremophila mitchellii*) can be killed when completely defoliated by fire using artificial fuel in two successive autumns (24). A similar response to repeated autumn defoliation has been demonstrated for resprouting mallee eucalypts (25). One major barrier preventing serial imposition of autumn defoliations under extensive field conditions, is the short time available for herbage fuel to accumulate.

Economic considerations weigh heavily against practical consideration of control strategies based on conventional agronomic approaches. Mechanical methods and chemical arboricides have been tested in recent years (26,27,28,29) yet high labour, fuel and material costs have effectively restricted their application to the higher-rainfall fringes of the semi-arid zone where cash cropping becomes a viable means of recouping the high capital investment incurred (30,31). A lack of appropriate cultivars and low-cost pasture establishment techniques for semi-arid rangelands is preventing the development of pasture reseeding options to produce feed/fuel and increase livestock productivity in the short term (17).

Blade ploughing has been tested for shrub control, however, the high initial treatment cost relative to potential future production gains would seem to effectively restrict the application of these mechanical techniques to small areas where specific management objectives, such as clear vision or easier stock movement, are required (20). Like single fire treatments, a 'once off' mechanical treatment is unlikely to provide a long-term effect. Regeneration of shrub populations through seedling recruitment or root suckering would inevitably mean a follow-up treatment is required for a lasting result (32)

INTEGRATED SHRUB CONTROL SYSTEMS

Technical and economic limitations of single-treatment approaches have inevitably led to discussions on how the best features of alternative control methods might be most effectively and economically combined. Such considerations have also been germane in America where research has led to the development of integrated brush management systems (IBMS). Here two or more control methods are combined in a logical sequence in order to complement, or reinforce, the beneficial impact of preceding treatments (33,34,35).

Scifres *et al.* (33) found herbicide-fire combinations offered the most promise for improving range condition in country infested with mesquite (*Prosopis* spp.). Prescribed fire in the winter applied 30 months after aerial spraying in the spring with 1.1 kg/ha of 2,4,5-T + picloram, followed by a second prescribed fire five years later, provided a greater reduction in mesquite canopy than either spraying or prescribed fire alone. Economic analyses have demonstrated the profitability of such procedures (36).

Similarly, a prescribed fire-chemical defoliation combination is proposed for Australian semi-arid woodlands. Chemical defoliants would be used in the autumn at sub-lethal rates, i.e. at concentrations of 10-25% less than normally specified, to simply defoliate resprouting coppice after fire. This strategy, if successful, would overcome the delay involved in waiting for natural fuel accumulation so fire can be reimposed.

Initially potential chemical agents need to be screened over a range of concentrations of active ingredients. Such chemicals would be sprayed onto coppice regrowth of target species. Coppice application is seen, a priori, to be more efficient because there is less leaf surface area to be treated compared with a mature canopy chemicals may also be more physiologically effective when applied to young leaves.

If successful, large-scale testing of defoliation treatments would logically follow. Large paddock size may dictate the need for appropriate operational procedures. This may involve both aerial ignition (22) and aerial spraying to optimise treatment application.

An important consideration of successful fire-chemical defoliation strategies prior to their adoption on a broad scale, will be their economic feasibility. Whilst present consideration of economic factors must remain speculative rather than definitive, a guide to the potential scope for integrated shrub control is provided by a benefit-cost analysis (20) based on the synthesis and modification of two recent approaches examining the independent value of prescribed fire (19) and chemical treatments (30). (Details of the analysis can be obtained on application to N.D. MacLeod).

Using heuristic data derived from rangeland personnel workers, a 20 year partial budget was constructed to examine the net benefits that might accrue from serial autumn fire treatment (years 0 and 5) supported by chemical defoliation (year 1) to a heavily encroached 4000 hectare paddock grazed by a self-replacing flock of Merinos. Prices and costs are based on published data (37), and a brief listing of assumptions on productivity before and after treatment is shown in Table 1. Because the chemicals and application

Table 1.

Area: 4000 hectares

Fire 1 = year 0, Fire 2 = year 5.
Chemical defoliation. year 1.

	Nil-fire		Post-fire					
Year(s)	0	20	0	1	2-4	5	6	20
Stocking rate (ha:dse)	6.0	8.0	-	6.1	6.3	-	5.5	5.0
Wool Cut (kg/hd)	4.5	4.0	-	4.7	5.0	-	5.4	5.5
Lambing (%)	45.0	30.0	-	50.0	55.0	-	65.0	70.0
Mortality (%)	6.0	8.0	-	5.5	5.0	-	5.0	5.0
Wool Price ($/kg)	3.33	3.33	-	3.33	3.33	-	3.33	3.33
Sheep price ($/hd)	14.00	14.00	-	14.00	14.00	-	14.00	14.00
Fire Cost ($/ha):		-	0.57	-	-	0.44	-	-
Aerial Spray ($/ha)*		-	-	0.10	-	-	-	-
Gross margin ($/dse)	7.46	5.09	-	8.41	9.75	-	11.00	11.62
Gross margin ($/ha)	1.24	0.64	-	1.40	1.60	-	2.00	2.32
Stock handling ($/ha)	0.23	0.28	0.31	0.18	0.11	0.13	0.08	0.08

Pre-treatment value of land and improvements (8.0 ha/dse) ($/ha) = 3.75
Post-treatment value of land and improvements (5.0 ha/dse) ($/ha) = 9.00

* Cost includes aircraft spray operation and ferrying to site from base. Cost of the chemical agent is not included. Ferrying cost is assumed to be shared between 4 landholders.

rates, are not specified, the analysis identifies the approximate cost per hectare for chemicals beyond which treatment would no longer be profitable.

Net present value (NPV) of the combined flows of benefits and costs, excluding the cost of chemical agents but including aerial application costs, was calculated to be of the order of $8.25 per hectare. On the basis of the assumptions used, this figure represents the maximum justifiable cost that might be incurred if chemical treatment is to remain profitable. Were the increases in post-treatment productivity to be lower than those assumed for the budgets, this sum would obviously be smaller. The opposite conclusion would hold should the assumptions prove to be pessimistic. Until research has proceeded further, these conclusions must remain speculative. At this time, many commercially available arboricides would cost well in excess of the break-even' limit if applied at, or close to, present registration strengths. The challenge remains to identify agents and application rates that are cost-effective in the longer term.

DECISION SUPPORT SYSTEMS

Given the difficulty of making informed decisions on optimal combinations and sequences of treatments to apply for integrated shrub control, land managers are finding decision support systems (DSS) increasingly useful (38). DSS are microcomputer-based advisory programs designed to guide decision-makers to that set of information or "expert knowledge" specifically relevant to their particular problem. In addition to qualitative "human expertise" (33), DSS also include "hard-data" based on research results. Such information can be applied by the DSS through relational data-bases including geographical information systems and simulation models.

A DSS called SHRUBKILL has been developed to provide advice on the use of prescribed fire to control shrubs (39). This DSS provides advice and information on on the ecological and economic issues of using prescribed fire. SHRUBKILL is being used mostly by extension personnel new in the region or for detailed consultations with graziers with shrub problems. Because of its modular structure, SHRUBKILL has been easily modified to provide another DSS for fire management in mallee country (40). These early DSS models will provide the base for building a comprehensive DSS for integrated shrub control in Australian rangelands.

REFERENCES

1. Anon. (1969). Report of the Inter-Departmental Committee on Scrub and Timber Growth in the Cobar-Byrock District and other Areas of The Western Division of New South Wales, New South Wales Government Printer, Sydney.

2. Harrington, G N, Oxley, R E & Tongway, D J (1979). The effects of European settlement and domestic livestock on biological systems in poplar box (*Eucalyptus populnea*) lands. Aust. Rangel. J. 1, 271-9.

3. Booth, C A (1986). Woody weeds - their ecology and control. New South Wales Soil Conservation Service Bulletin.

4. Hassall and Associates (1982). An economic study of the Western Division of New South Wales. Report commissioned by the N.S.W. Western Lands Commission, Sydney.

5. Sloane Cook and King Pty Ltd (1988). The economic impact of pasture weeds, pests, and disease on the Australian wool industry. Australian Wool Corporation, Melbourne.

6. Hodgkinson, K C and B eeston, G R (1982). The biology of Australian weeds: 10. *Eremophila mitchellii* Benth. J Aust. Inst. Agric. Sci. 48, 200-8.

7. MacLeod, N D (1989). The economic cost of shrub encroachment in western New South Wales. Proc. Conf. on Weeds, Invertebrate Pests and Diseases of Australian Sheep Pasture, Ballarat. Aust. Wool Corp. (in press).

8. Busby, F E and Noble, J C (1986). Fire in arid and semi-arid regions. In Rangelands: A Resource Under Siege. (Eds P.J. Joss, P.W. Lynch and O.B. Williams) p.573. Aust. Acad. Sci., Canberra.

9. Hodgkinson, K C and Harrington, G N (1985). The case for prescribed burning to control shrubs in eastern semi-arid woodlands. Aust. Rangel. J. 7, 64-74.

10. Hodgkinson, K C and Griffin, G F (1982). Adaptation of shrub species to fires in the arid zone. In Evolution of the Flora and Fauna of Arid Australia. (Eds W.R. Barker and P.J.M. Greenslade) pp. 145 52. Peacock Public., Adelaide.

11. Harrington, G N and Hodgkinson, K C (1986). Shrub-grass dynamics in mulga communities of eastern Australia. In Rangelands: A Resource Under Siege.(Eds P.J. Joss, P.W. Lynch and O.B. Williams) pp. 26 8. Aust. Acad. Sci., Canberra.

12. Noble, J C, Harrington, G N and Hodgkinson, K C (1986). The ecological significance of irregular fire in Australian rangelands. In Rangelands: A Resource Under Siege (Eds P.J. Joss, P.W. Lynch and O.B. Williams) pp.577 80. Aust. Acad. Sci., Canberra.

13. Burrows, W H, Carter, J O, Anderson E R and Bolton M P (1986). Prickly Acacia (*Acacia nilotica*). Invasion of mitchell Grass (*Astrebla* spp) Plains in Central and North-West Queensland. Contributed Paper.

14. Carter, J O (1989). Prickly Acacia (*Acacia nilotica* subsp. indica) - extent of spread in Australia and implications for the grazing industry. Proceedings of Conference "Weeds, Diseases and Invertebrate Pests of Australian Sheep Pastures". Aust. Wool. Res. Trust. Fund. Prod. Res. Advisory Committee, Ballarat, (in press).

15. Moore, R M (1971). Weeds and weed control in Australia. J. Aust. Inst. Agric. Sci. 37, 181-91.

16. Hodgkinson, K C, Harrington, G N, Griffin, G F, Noble, J C and Young, M D (1984). Management of vegetation with fire. In Management of Australia's Rangelands. (Eds. G.N. Harrington, A.D. Wilson & M.D. Young) pp. 141-57. CSIRO, Melbounre.

17. Noble, J C Cunningham , G M & Mulham, W E (1984). Rehabilitation of degraded land. In (Eds. G N Harrington, A D Wilson & M D Young). Management of Australia's Rangelands, pp. 171 88. CSIRO, Melbourne

18. O'Shea R H & Harrington G N (1986). Grazier reluctance to prescribed burning in the semi-arid woodland of northwest New South Wales and the results of large scale paddock burns. Proceedings of 4th Bienn. Conf. Aust. Rangel. Soc. Armidale, New South Wales, 24-27 August, pp. 138-41.

19. Burgess, D M D (1988). The economics of prescribed burning for shrub control in the semi-arid woodlands of north-west New South Wales. Aust. Rangel. J. 10, 48-59.

20. MacLeod, N D & Johnston B J (1990). An economic framework for the evaluation of rangeland restoration projects. Aust. Rangel. J. 12, 40-53.

21. Moore, C W E (1969). Application of ecology to the management of pastoral leases in northwestern New South Wales, Proc. Ecol. Soc. Aust. 4, 39-54.

22. Noble, JC (1986). Prescribed fire in mallee rangelands and the potential role of aerial ignition. Aust. Rangel. J. 8, 118-30.

23. Macleod, N D & Noble, J C (1990). An economic evaluation of the impact of prescribed fire on pastoral leases in the mallee shrublands of southwestern New South Wales. Environ. Int. 16, (in press).

24. Hodgkinson, K C (1989). Prescribed fire for shrub control in sheep rangelands. Proceedings of the conference "Weeds, Invertebrate Pests and Diseases of Australian Sheep Pastures". Aust. Wool Res. Trust Fund Prod. Res. Advisory Committee, Ballarat (in press).

25. Noble, J C (1984). Mallee. In Management of Australia's Rangelands. (G N Harrington, A D Wilson & M D Young) pp. 223-41. CSIRO Melbourne.

26. Batianoff, G N & Burrows W H (1973). Studies in the dynamics and control of woody weeds in semi-arid Queensland 2. *Cassia* and *C. artemisioides*. Qld. Agric. Anim. Sci. 30: 65-71.

27. Burrows, W H (1973). Studies in the dynamics and control of woody weeds in semi-arid Queensland 1. *Eremophila gilesii*. Qld. Agric. Anim. Sci. 30, 57 64.

28. Robertson, J A & Beeston, J R (1981). Methods of clearing and woody weed control in the poplar box (*Eucalyptus populnea*) lands. Aust. Rangel. J. 3, 39-44.

29. Campbell, D & Gammie, R (1980). Does dryland cropping have a place in the Western Division? Agric. Gaz. NSW 91, 3-5.

30. Burgess, D M D and Murphy, J (1989). An Economic Perspective on Chemicals for Shrub Control in the Western Division. 2nd Edition, New South Wales Department of Agriculture and Fisheries, Farm Business Notes No. 48.

31. Johnston, B J, MacLeod, N D & Young, M D (1990). An economic perspective on future research directions for the Australian sheep-grazed rangelands. Aust. Rangel. J. (in press).

32. Harrington, G N (1979). The effects of feral goats and sheep on the shrub populations in a semi-arid woodland. Aust. Rangeland. J. 1: 334-45.

33. Scifres, C J (1987). Decision analysis approach to brush management planning: Ramifications for integrated range resources management. J. Range Manage, 40, 482-91.

34. Scifres, C J, & Mutz, J L Rasmussan, G A & Smith, R P (1983). Integrated brush management systems (IBMS): Concepts and potential technologies for running mesquite and whitebrush. Texas Agricultural Experimental Station Bulletin 1450.

35. Scifres, C J, Hamilton, W T, Connor, J R, Ingliss, J M, Rasmussen, G A, Smith, R P, Stuth J W & Welch, T G (1985). Integrated brush management systems for south Texas: Development and Implementation. Texas Agricultural Experiment Station Bulletin 1493.

36. Ethridge, D E, Dahl, B E and Sosebee, R E (1984). Economic evaluation of chemical mesquite control using 2,4,5-T. J. Range. Manage. 37, 152-6.

37. Murphy, J (1990). Crop and livestock budgets - 1990: Cobar and Bourke Shires, New South Wales Department of Agriculture and Fisheries Agdex 821, Sydney.

38. Ludwig, J A (1988). Expert advice for shrub control. Aust. Rangel. J. 10, 100-5.

39. Ludwig, J A (1990). SHRUBKILL: a decision support system for management burns in Australian savannas. J. Biogeogr. 17, (in press).

40. Ludwig, J A, MacLeod, N D and Noble, J C (1990). An expert system for fire management in mallee reserves. In The Mallee Lands: A Conservation Perspective. (Eds J C Noble, P J Joss and G K Jones). CSIRO Melbourne (in press).