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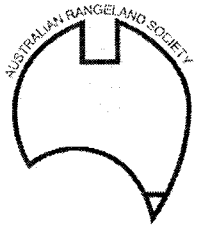

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SHRUB POPULATION REGULATION IN SEMI-ARID WOODLANDS BEFORE AND AFTER EUROPEAN SETTLEMENT

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ABSTRACT

This paper examines the historical evidence for the widely held view that vegetation communities in the semi-arid woodlands were significantly more open prior to European settlement. It is postulated that there were originally multiple stable vegetation states maintained by interactions between light grazing by native herbivores, periodic fire and browsing of post-fire shrub regeneration by medium-sized marsupials. Finally, preliminary results from research currently in progress aimed at developing integrated shrub management strategies are discussed in the context of attempting to restore a more appropriate, and productive, balance between overstorey and understorey components that also more closely resembles pre-European vegetation patterns.

INTRODUCTION

Marked changes in vegetation structure and composition have occurred in the 130 years following European settlement in the semi-arid woodlands of eastern Australia (Harrington *et al.* 1984). Of particular significance was the disappearance of much of the perennial grass component and the emergence of an understorey dominated by native shrubs. Historical accounts (e.g. Anon. 1901) have provided clear evidence that after only two decades of sedentary pastoralism, 'noxious scrub' had increased at an alarming rate over extensive areas. This change in the 'state' of the vegetation was particularly pronounced in western New South Wales and, combined with severe drought, depressed wool prices, bank collapses and waves of invading rabbits, led ultimately to the State government establishing a Royal Commission in 1900 to examine the dismal state of affairs then prevailing (Anon. 1901). The *Summary of Evidence* presented to the Commission records numerous references to encroaching scrub. P.J. Kelly, of Booroomugga Station east of Cobar, for example, described how '...Nineteen years ago it was beautiful open box country, with some large pines on it. It commenced to deteriorate twelve years ago and is now scrub country, with pine, budda, yarran, and box seedlings on it.'

This increase in shrub cover/density has been attributed primarily to changes in fire regimes, particularly fire frequency, following the introduction of domestic herbivores (Harrington *et al.* 1984). Any potential grass fuel, except in highly episodic 'wet' seasons, was largely consumed by excessive populations of domestic, and later feral and native, herbivores. The effectiveness of fire in regulating shrub numbers has since been confirmed by research demonstrating that seedlings of all problem shrub species are not only fire-sensitive (Hodgkinson and Griffin 1982), but also susceptible to competition from established perennial grasses (Harrington 1991). Despite an intensive research effort over the past two decades, there is still a need to refine our knowledge of individual species' responses to specific control strategies.

MULTIPLE STABLE STATES IN AUSTRALIAN SAVANNAS - FACT OR FICTION?

While it is generally accepted that Australian semi-arid woodlands were more open prior to European settlement, early reports by experienced stockmen and land surveyors assessing new country (e.g. Oxley 1987), frequently describe patches of dense scrub where passage, even on horseback, was severely hampered. Much of the early 'folklore' referring to open woodlands may, therefore, simply reflect landscapes where patches of dense scrub could be more readily circumvented. In 1875 G. Fortey was commissioned to examine the back country on Toorale and Dunlop stations, two large

properties north and south of Louth, New South Wales. What he described in a detailed, hand-written report of 5 pages held in the Noel Butlin Archives Centre, ANU, Canberra, was a complex mosaic of vegetation communities. He recounted how, after passing through dense mulga, he finally reached '. . . a soft plain with a little Scrub and which had evidently been cleared by fire, as I could judge by the dead timber lying about which extended for about 4 miles then into scrub for about 3 miles and camped on a small clay pan of water.'

Given that multiple disturbances are necessary to attain a stable shrub:herbage 'state', it is pertinent to ask what combinations of factors, or disturbances, were likely to have been responsible for creating and/or maintaining these mosaics of open, semi-closed and closed communities. In particular, how important were the interactions that existed between fires, herbivores and folivores, some of whom may now be locally extinct, in mediating shrub population density? Modelling studies in southern Africa (Dublin *et al.* 1990) suggest that elephant (*Loxodonta africana*) browsing, wildebeest (*Connochaetes taurinus*) grazing and fire, acting in concert, were key determinants influencing the structure of woodland communities in the Serengeti-Mara ecosystem. Increased fuel availability, especially when wildebeest numbers were low following the rinderpest epidemic of the 1890s, led to frequent fires, thereby reducing tree and shrub densities to the point where elephants could maintain some communities as grasslands, even in the absence of fire. However, based on predator-prey theory, they were unable to do so at high overstorey densities through predator satiation.

In many ways, there are striking similarities between these African studies and the fire × grazing × mesomarsupial browsing interactions postulated as originally influencing vegetation dynamics in the semi-arid woodlands of eastern Australia (Noble 1995). Because many medium-sized marsupials such as the bettongs (*Bettongia* spp.) are now locally extinct, a shrub biocontrol hypothesis based on fire, herbivory and bettong browsing interactions is sheer 'ecospeculation', despite strong circumstantial evidence in support. Essentially, this hypothesis proposes that prior to European settlement, light grazing by native herbivores and episodic fire, helped promote a grassland/woodland mosaic where some areas could be maintained as grassland by bettongs browsing regenerating shrubs, even in the absence of regular fire. Other patches rarely burnt, because high tree and shrub densities prevented sufficient grass fuel accumulating. Excessive numbers of exotic herbivores subsequently reduced fuel in grassland patches so that as fire became less frequent, shrub populations could expand laterally from dense scrub foci, aided by a decline in mesomarsupial numbers.

TOWARDS AN INTEGRATED APPROACH TO SHRUB MANAGEMENT

If the multiple stable state hypothesis is a model applicable to Australian conditions, then it is instructive to canvass those management options capable of emulating pre-European shrub regulation processes. Because of the fire-shrub nexus, prescribed fire has been proposed as the most cost-effective means of restoring a more desirable balance between shrub and herbaceous strata (Hodgkinson and Harrington 1985, MacLeod and Noble 1991). Single fires provide only short-term benefits before shrubs regenerate, either by seedling recruitment or by coppicing. While research using artificial fuel has shown that as many as 80% of a population of resprouters can be killed by two successive autumn fires, there is no likelihood of sufficient fuel being generated in such a short time to enable annual fires to be imposed under natural conditions (Noble *et al.* 1986). Consequently, recent research has concentrated on development of integrated shrub management systems based on two or more treatments, whereby secondary treatments such as chemical defoliation may follow prescribed fire to simulate the multiple fire treatments imposed experimentally (Noble *et al.* 1991).

Accordingly, an extensive research program has been underway over the past six years examining the potential for using low dosage chemical defoliation as an economically feasible, and environmentally sustainable, option when applied to shrubs regenerating from either an initial mechanical or fire treatment. The research has been organised in three discrete phases: (i) screening of several likely defoliants (initially 11 materials) applied as spot sprays over a range of concentrations to different

shrub species; (ii) determining application rates in terms of active ingredient per hectare and developing appropriate technology for applying suitable chemicals on a broad, i.e. paddock, scale; and eventually (iii) operational research at paddock and property scales to evaluate treatment efficacy by active adaptive management employing appropriate landscape process models (e.g. SEESAW) and decision support systems.

The first phase successfully identified several promising chemicals; however, subsequent research in the second phase has concentrated specifically on glyphosate (Roundup®). Not only did glyphosate give excellent results when applied at dilute concentrations to young coppices (Noble *et al.* 1992), but the material itself has desirable environmental properties including extremely low toxicity to animals, especially humans, and very low residual life in the soil. At two sites near Cobar and Bourke, 90-100% of young coppice foliage of regenerating budda (*Eremophila mitchellii*) and turpentine (*E. gilesii*) was killed by glyphosate spot-sprayed by propane-powered gas-gun at very low concentrations (e.g. down to 12.5% of the concentration normally used for killing mature shrubs of other species). Other studies demonstrated that autumn spot-spraying of glyphosate was more effective than spring application and there was little difference in terms of leaf scorching when either one- or two-year-old foliage was sprayed with glyphosate in the autumn.

Data obtained from experiments conducted in the second phase using a gas-powered, hand-held boom spray enabled dosage response curves to be established, although there was considerable interspecific variation in leaf scorching. Firebush (*Senna pleurocarpa*), for example, was quite sensitive to application rates as low as 0.5 kg glyphosate per ha when applied to one-year-old foliage. These data have enabled larger scale experiments to be conducted in New South Wales and Queensland where glyphosate has been applied from the air to communities containing several target species of regenerating shrubs, as well as non-target species, over a range of application rates (0.5-2.5 kg glyphosate per ha) and at both low volume (20 L/ha) and ultra-low volume (10 L/ha). Whilst these experiments are still currently in progress and no final conclusions can yet be drawn, preliminary results suggest that the operational research phase originally envisaged in this program is amply justified. This research would determine whether integrated shrub control strategies, such as prescribed fire followed by chemical defoliation in discrete zones, will not only lead to increased herbage productivity by encouraging greater recruitment of perennial grasses, but will also create stable vegetation mosaics similar to those existing prior to European settlement. In an ideal 'rangeland world', management of native shrubs should emphasise **control**. The real 'woody weeds' in rangelands today are the introduced feral species, whose **eradication** is a more appropriate, and pressing, management objective.

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