Harry Stobbs Memorial Lecture, 2002

Seeing the wood(land) for the trees — An individual perspective of Queensland woodland studies (1965–2005)

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Abstract

A range of studies undertaken in Queensland woodlands since 1965 are reviewed from a personal perspective. The review does not claim to be comprehensive and references linking a rapidly growing source of ecological and management information are also included. It is suggested that there is strong evidence for an altered structure in grazed woodland remnants as a result of the introduction of domestic livestock and associated changed fire regimes. Some implications for the on-going utilisation of this huge woodland resource (c. 60 M ha) on lands assigned for agricultural production (grazing) purposes are discussed. The need for better understanding of the role of fire in keeping these woodlands 'open' is emphasised, with the impact of fire on the establishment and survival of woody seedlings requiring most attention.

Preamble

When I commenced studying Queensland's grazed woodlands in 1965, after a short dally with tropical pastures in the previous year, one could have typed all relevant reference citations on a single A4 page. Hence, "seeing the wood(land) for the trees" was the pro forma title of this talk — as it certainly seemed to this young graduate that the majority of our agricultural scientists at that time, could not "see" the huge grazed woodland resource in this State that desperately needed research and development (R&D) for its management. (There was also an apparent blindness to the worth of our native pastures in those years — but that's another story). Fortunately, since those days a growing compendium of workshop proceedings, books and special journal issues detailing progress in our knowledge and understanding of the woodlands has appeared. So much has been published that it is impossible to do this work justice in one short address, and I have not attempted to do so. For example, there are proceedings of two mulga lands symposia [*Tropical Grasslands* 7(1), 1973; Royal Society of Queensland, Sattler 1986], *Native Pastures in Queensland: The resources and their management* (Burrows *et al*. 1988), "State and transition models for rangelands" [*Tropical Grasslands* 28(4), 1994], *The Future of Tropical Savannas: An Australian Perspective* (Ash 1996), "Sustainable management of Queensland's landscapes: linking the science and action" [*The Rangeland Journal* 24(1), 2002], as well as less Queensland-specific but nevertheless highly relevant works such as Eric Rolls' *A Million Wild Acres* (Rolls 1981), Stephen Pyne's *Burning Bush — A Fire History of Australia* (Pyne 1991), *Savanna burning — understanding and use of fire in northern Australia* (Dyer *et al*. 2001) and "Measuring and imagining: exploring centuries of Australian landscape change" [*Australian Journal of Botany* 50(4), 2002], amongst many other compilations and specialist papers. Given the overwhelming nature of these compendia and reports, I have decided to concentrate in this talk on some of the insights I personally obtained in my journey in woodland R&D since 1965.

Harry Stobbs — A personal memoir

I came to know Harry when he was the Honorary Editor of *Tropical Grasslands*. In the early-mid

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The views expressed herein are those of the author and do not represent a policy position of the Queensland Goverment or of the Department of Primary Industries.

1960s, the Department of Agriculture and Stock (now Department of Primary Industries — DPI) under Ross Humphreys as Chief Agrostologist, finally acknowledged the enormous contribution that the western half of Queensland made to pastoral production by, for the first time, permanently stationing graduate research staff and/or agricultural advisers in Richmond, Blackall and Charleville. The Charleville group secured good R&D support from the Australian Wool Corporation (AWC) and by 1967, a growing band of pasture agronomists and Sheep and Wool husbandry staff formed the nucleus of the Charleville Pastoral Laboratory.

Dr Joe Ebersöhn (DPI) and Dr George Moule (AWC) were very strong mentors and supporters of the young graduates. This support, coupled with Ebersöhn's innate sense to establish a critical mass of staff to work in this difficult environment, led to 7 of the researchers based in Charleville between 1967–1974 completing Masters and PhD degrees at 7 different universities in the UK, the USA and Australia.

Most of the R&D work focussed on mulga lands and the growing knowledge and confidence of the staff led them to convene an Australia-wide Symposium in 1972 to discuss mulga and mulga lands management for the pastoral industries. To ensure there would be a permanent record of the meeting, we approached Harry Stobbs, as editor of *Tropical Grasslands*, with the idea of having a special issue of the Journal devoted to the Symposium proceedings. Harry took up the suggestion enthusiastically, as he did most things in life.

Tropical Grasslands has always prided itself in the rigour and professionalism of its published papers. While Harry did not resile from this standard, which he was foremost in maintaining, I recall with deep appreciation the helpful way he encouraged and cajoled several of the young contributors to the Symposium into improving their papers to the professional level he required.

This special issue of the Journal was seminal, not only in being the first to devote all of its contributions to the one broad topic, but also in providing a distinctive break with the "improved pasture-leguminosis" tradition of journal papers at the time. Harry not only helped us to put some rigour into our contributions, but importantly also introduced the Journal and its readership to the broader natural resource-management issues which so dominate our profession today.

Tree-grass relationships

Undoubtedly, the most widely cited paper from that special issue of *Tropical Grasslands* was the contribution by Ian Beale on "Tree density effects on yields of herbage and tree components in south-west Queensland mulga scrub" (Beale 1973). The presentation of these results coincided with the publication of analogous work by Joe Walker, Milton Moore and Jock Robertson from CSIRO's Cunningham Laboratory reporting "Herbage response to tree and shrub thinning in *Eucalyptus populnea* shrub woodlands" (Walker *et al.* 1972) at Talwood in the Goondiwindi district, Queensland. Interestingly, Beale, in contradistinction to the CSIRO authors, followed the foresters' path by measuring tree competition in terms of stem basal area. This is an integrative and robust measure employed in most of the tree-grass studies that have subsequently appeared in the literature.

The plethora of these studies (Figures 1a; 1b) is an indication of the importance placed on the competitive interaction between trees and grass by landholder and researcher alike. Joe Scanlan has recently synthesised the considerable data now existing for Queensland woodland communities and in this paper (Scanlan 2002), and his earlier contributions referred to therein, developed ecological theory (*e.g.* Scanlan 1992) which helps further explain the nexus between trees and grass in this State's pastoral environment.

Joe's paper appeared in the latest issue of *The Rangeland Journal* [Vol 24(1) 2002] which is devoted to papers examining 'Sustainable management of Queensland's landscapes' — especially in relation to tree clearing legislation in this State. I commend this issue to anyone with particular interest in this subject. Earlier I had attempted to summarise the vexing questions facing landholders and the wider community as a consequence of tree clearing for pastoralism, in 2 invited plenary papers presented at the XVII and XIX International Grassland Congress (IGC), respectively (Burrows 1993; 2001).

Of course, by knowing where we are on the '*x*' axis in these tree-grass competition curves, we can easily derive estimates of potential pasture production and livestock carrying capacity. Importantly, if we also know the flux in tree-shrub basal area over time we have a useful predictor, all things being equal, of future carrying capacity as well. Steven Bray and colleagues

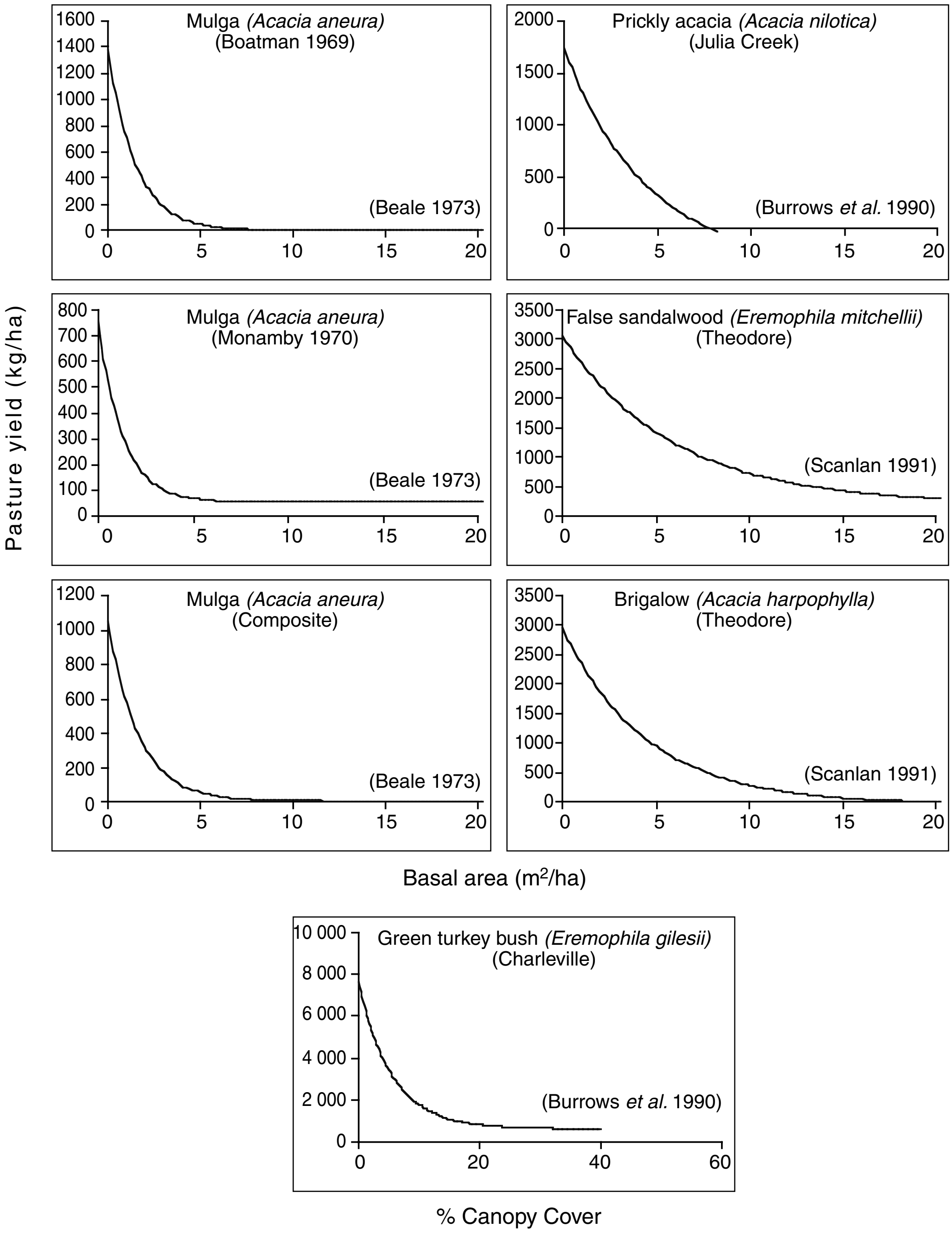

Figure 1a. Tree-pasture relationships for a range of woodland study sites in Queensland and north-west New South Wales. Note the differing units expressing tree competition on the 'x' axes. See individual graph citations for further details.

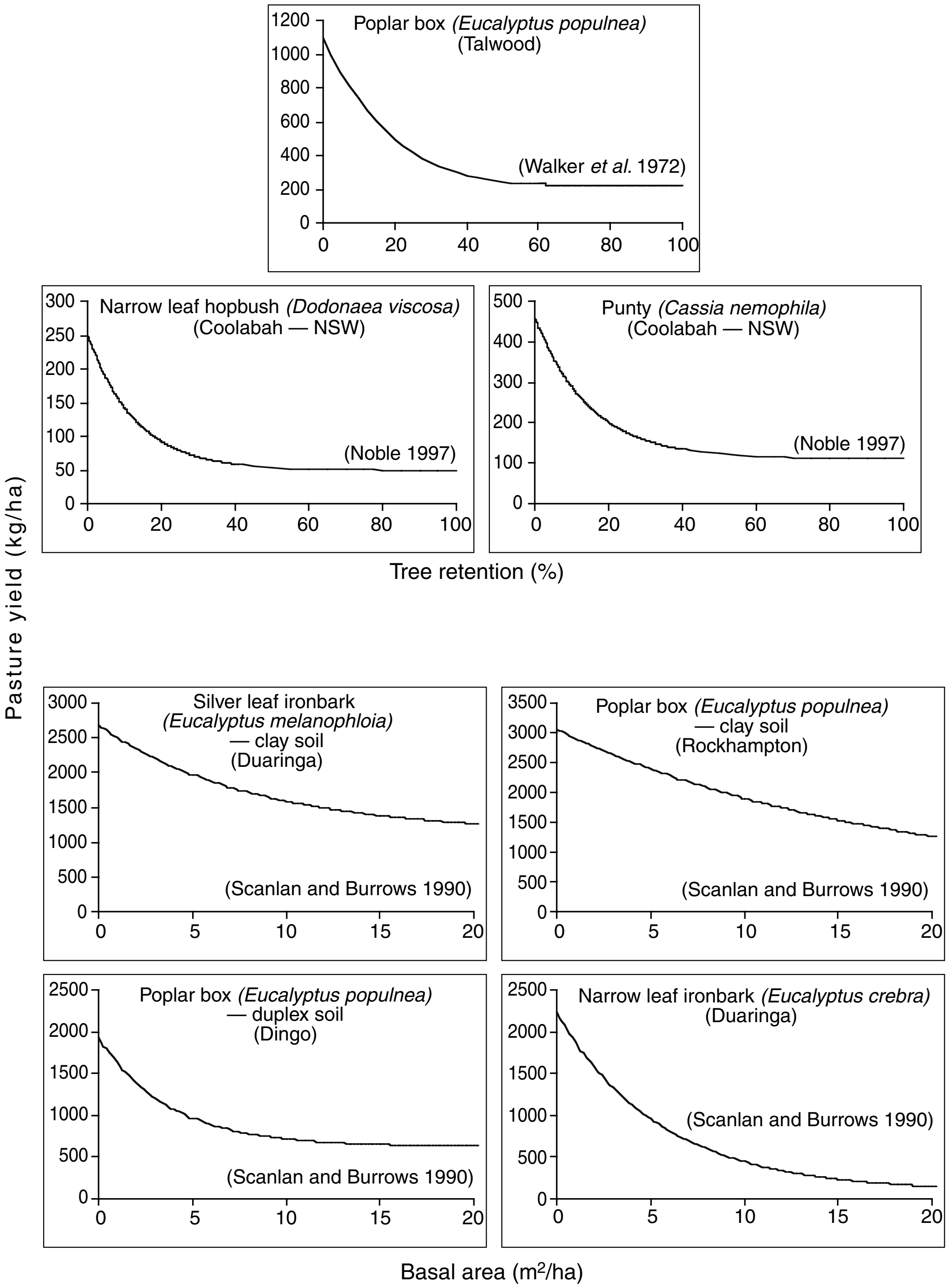

Figure 1b. Tree-pasture relationships for a range of woodland study sites in Queensland and north-west New South Wales. Note the differing units expressing tree competition on the 'x' axes. See individual graph citations for further details.

(Bray *et al*. 2002) have recently gone through this exercise for a poplar box community in central Queensland (Table 1).

Table 1. Prospective loss in potential pasture production as woody plants thicken up on a notional poplar box (*Eucalyptus populnea*) woodland site in central Queensland. Pasture yields are based on Scanlan and Burrows (1990) and tree basal area increment is derived from Burrows *et al*. (2002). See Bray *et al*. (2002) for further details.

Year	Tree basal area (m^2/ha at 30cm)	Pasture production (kg/ha)
1	4.0	1070
20	5.9	890
40	9.0	740

Tree-shrub dynamics

There is a widespread reluctance amongst government regulators and conservationists to openly acknowledge the general negative effect that tree-grass competition has on pastoralism; in particular, that the woodland communities now protected from clearing could in time lose their livestock production capacity, with serious impacts on management of the remaining pasture on the landholding. This is a consequence of continued thickening up of tree and shrub populations under grazing, along with the implications of Bray *et al.*'s findings.

To appreciate this point, we need to know the rate of change in tree-shrub basal area over time. Yet, even after 150+ years of pastoralism, this subject still arouses considerable debate, despite a wide range of evidence indicating that there has been significant structural change in most woodland communities since livestock grazing commenced. Unfortunately, I consider that vested interests have clouded perspectives — especially amongst many who see pastoralism as an affront on Queensland's landscape, or amongst those who do not have any comprehension of differing woody plant–pasture responses under livestock grazing.

Ingress of trees and shrubs into rangeland areas grazed by domestic livestock is not a uniquely Queensland or Australian phenomenon. It seems to be a universal consequence of Europeans and their domestic livestock displacing most hunter-gatherer societies, as clearly outlined in Steve Archer's Harry Stobbs address in 1993 (Archer 1995a) and summarised by him with Bob Scholes in the *Annual Review of Ecology and Systematics* in 1997 (Scholes and Archer 1997). Archer maintains a very useful web site containing an extensive bibliography of woody plant-proliferation references — which should convince even the most committed sceptic of the ubiquitousness of the response. Visit: http://rangeweb.tamu.edu/archer/ (accessed 22 October 2002).

Again a timely, must-read compendium has recently been published [*Australian Journal of Botany* 50(4), 2002] which brings together much of the evidence for vegetation change in Australia since European occupation. The co-ordinator of this volume, David Bowman, notes in his introduction that there is no single approach to study landscape change because the available historical records and techniques to interpret natural archives all have specific constraints, differing levels of precision and sensitivities to environmental signals. This may be so, but to this reader at least, the collective evidence for vegetation change in our woodland communities (other than through land clearing) is both compelling and overwhelming.

Once applied ecologists became aware of the close relationship between tree basal area and pasture production, it was a logical step to attempt to better understand the speed and direction of change (if any) in our woody plant populations. The most quantitative, although labour-intensive method, for doing this is to utilise permanent monitoring plots.

Such plots, mainly in the form of permanently positioned vegetation transects, are now represented in most of the State's important grazed woodland communities. This network is a lasting legacy of the foresight of Dr Joe Ebersöhn. Joe was a strong proponent of long-term ecological studies in our rangelands. When I expressed an interest in the ecology of woody plants, he immediately encouraged me to follow that line — but warned that anyone choosing such a discipline would have to be content with posthumous fame, given the long life cycle of most of our trees and shrubs! Well, at age 23, it was easy to assume one was bulletproof and would live forever, so posthumous fame was not a concern then, and surprisingly concerns me even less now.

Ebersöhn did nothing by halves, so the first transects we established in south-west Queensland totalled 64 km in length as we reported (Burrows and Beale 1969) in the *Australian Journal of Botany* in 1969. On transferring to central Queensland in 1980, I was very fortunate to become a colleague of Eric Anderson, Joe Scanlan, Paul Back and John Carter. Rather ambitiously we decided to extend a modified version of the Ebersöhn transect methodology — soon to be known as TRAPS (**t**ransect **r**ecording **a**nd **p**rocessing **s**ystem — Back *et al.* 1997; 1999) to cover most of the state's grazed woodland communities (or "forest country", as it is referred to by most landholders); not a minor ambition, as such communities account for c. 60 M ha or one-third of Queensland's land mass! (Figure 2).

There are now about 130 recording sites, the oldest of which have been in place for 20 years. The sites overall provide convincing evidence of a gradual but inexorable increase in stand basal

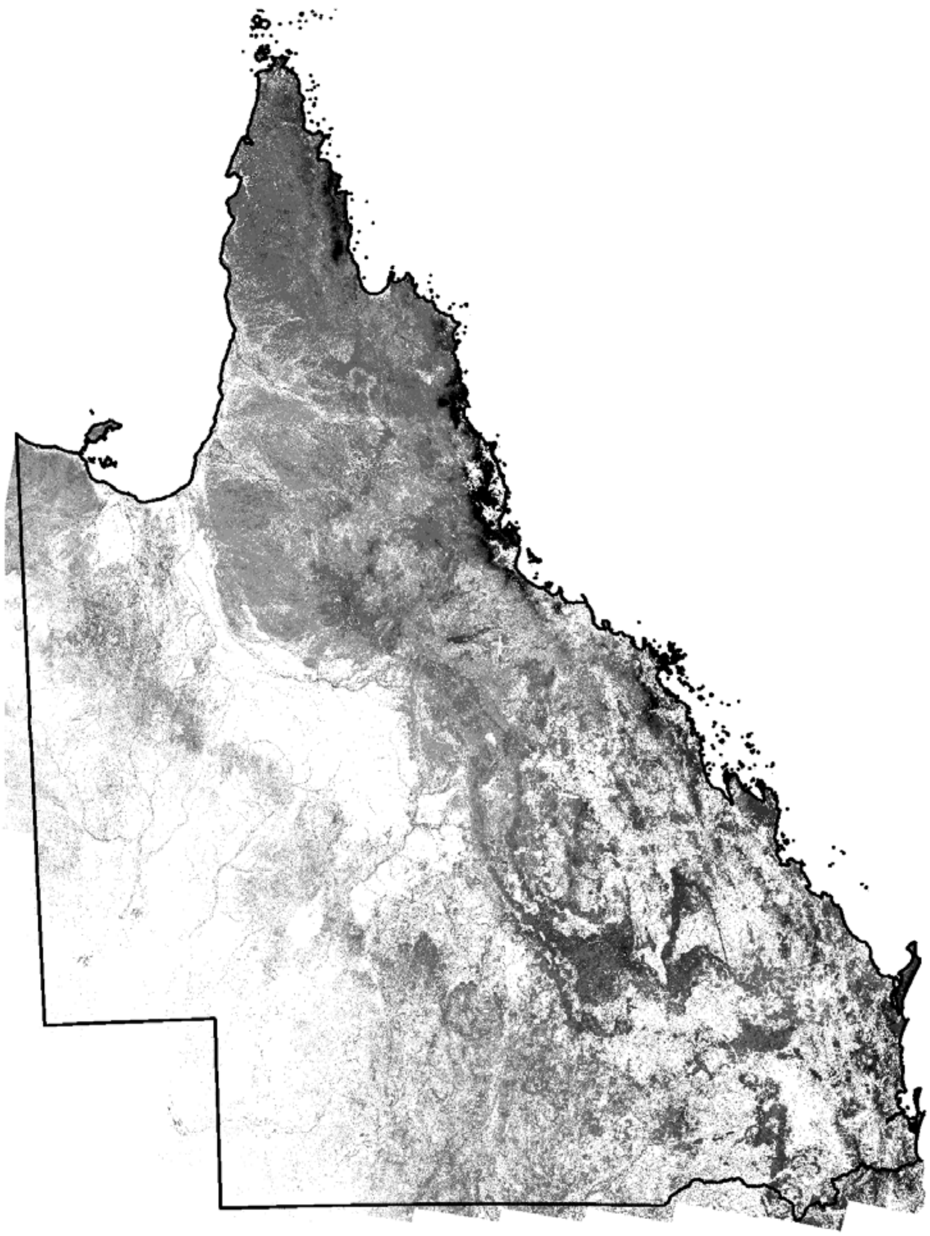

Figure 2. Indicative forest and woodland cover in Queensland – based on Landsat TM imagery. See Henry et al. 2002 for more details. (reproduced with permission of Australian Rangeland Society).

area and understorey shrub populations (*e.g.* Figure 3). A recent analysis carried out with colleagues in DPI and the Department of Natural Resources and Mines (DNR&M) (Burrows *et al.* 2002) showed that, when these fluxes were converted to above-ground woody plant biomass, and hence carbon content, there is a huge unreported C sink present in the grazed eucalypt woodlands — even when significant tree deaths recorded during the drought of the late 1980s–early 1990s were taken into account.

Measuring changes in plant structure along permanent transect lines may provide extreme accuracy but is labour- and time-intensive and

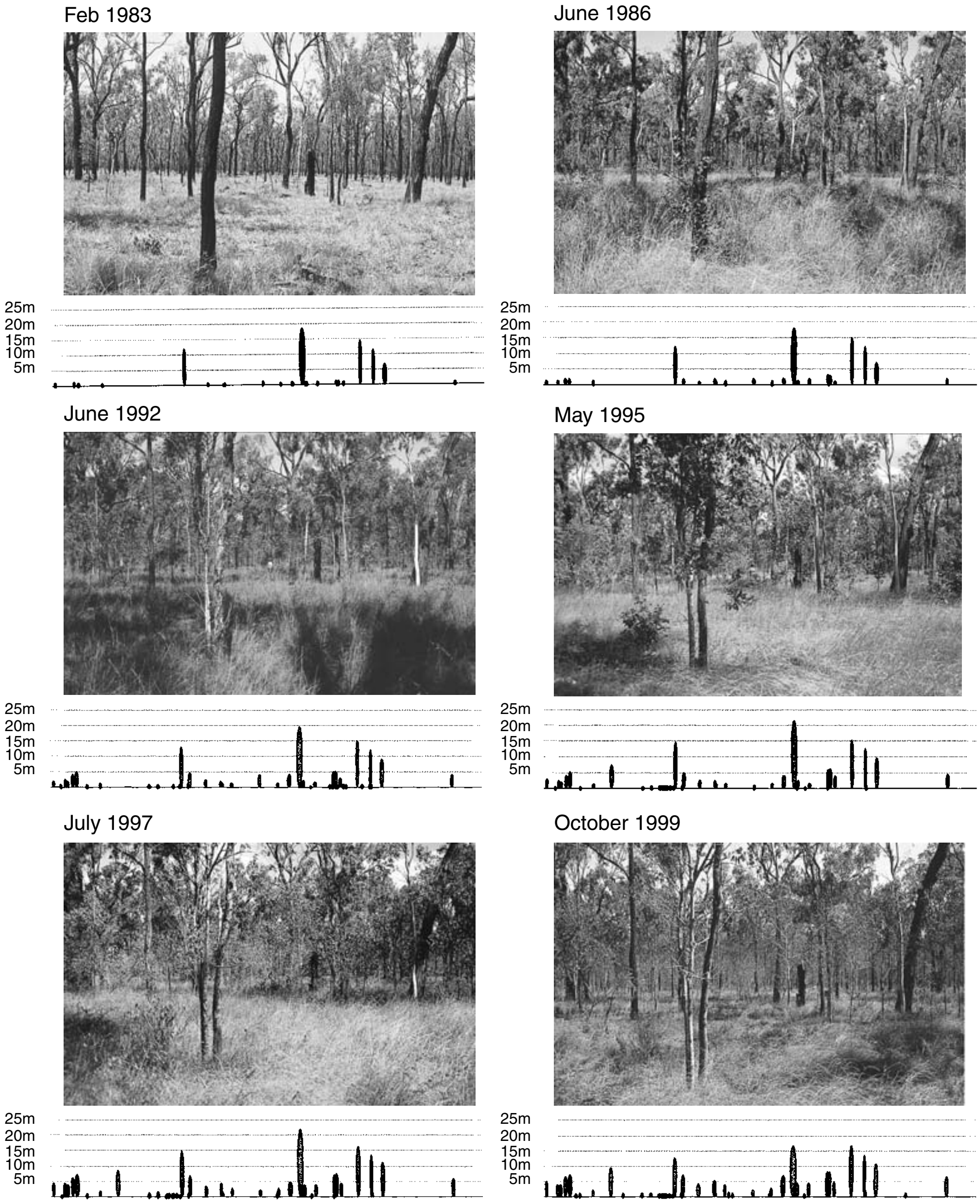

Figure 3. Photographic record of changes in a narrow leaf ironbark (*Eucalyptus crebra*) transect in central Queensland. TRAPS-generated graphic beneath each photo depicts the height and number of plants recorded within the particular transect band; reduced height in some trees from July 1997 to October 1999 resulted from a wind storm — see Back *et al.* (1997; 1999) for methodological details.

transects need to be carefully selected if the dynamics recorded on them are to truly represent broader community changes (see Figure 3 in Burrows *et al.* 2002). Moreover, it would be foolish to dismiss simpler or more widely applicable methodologies for following change, just because they may lack the individual plant detail provided by permanent transects.

Our initial indications of change were based on analyses of early explorers' and anecdotal records. Such information was put together tellingly by Eric Rolls (1981) in his award-winning book *A Million Wild Acres* which examined the history of the Pilliga Scrub in New South Wales. A timely compilation of early explorers' and settlers' observations of the vegetation by Dave Ryan *et al*. (1995) was challenged by Benson and Redpath (1997) of Sydney's Royal Botanic Gardens and Herbarium and this riposte was in turn questioned by Tim Flannery (1998). Recently, Tom Griffiths (2002) has suggested that much of this debate centres on different interpretations of 'forest' and 'open' landscapes as used in the early settlers' vernacular. However, there is no doubt in my mind that conservationists have seen any acknowledgement of the claim that most woodland communities were more open at settlement, as threatening their push for more and more stringent tree clearing controls. Indeed, Paul Sattler and Rebecca Williams' lengthy tome alludes to remarkable hindsight by detailing the conservation status of Queensland's regional ecosystems (R.E.), with such classification based on the % remaining of each R.E. compared with that allegedly present in 1788! (Sattler and Williams 1999, p. 1/11).

I consider that those seeking to deny the reality of past vegetation 'flips' on grazing lands should read and absorb the ecological theory developed by Imanuel Noy-Meir, Brian Walker and Mark Westoby (*e.g.* Westoby 1980; Walker and Noy-Meir 1982; Westoby *et al.* 1989). In addition, sceptics would also benefit by digesting the 1901 Royal Commission into the Condition of the Crown Tenants in the Western Division of New South Wales (Royal Commission 1901). A typical quote from this commission refers to the Cobar-Byrock district and states: "Generally speaking it was originally open box-forest country with currajong and an occasional pine tree upon it. The overstocking of the country, coupled with the rabbits prevented the growth of grass to anything like its former extent and so causes a cessation of bush fires which formerly had occurred periodically. This afforded the noxious scrub a chance of making headway". This study was followed up by another enquiry in 1969 (Inter-Departmental Committee 1969) and both have been drawn upon in Jim Noble's entertaining read — *The Delicate and Noxious Scrub* (Noble 1997). Present day scrublands of the Cobar-Byrock region are a prominent feature in all contemporary satellite images of Australia. They attest to the persistency of such flips to woody plant dominance, given the changes were wrought >100 years earlier.

The special issue of *Tropical Grasslands* [Vol. 28 (4) — 1994] detailing State and Transition theory and examples of State and Transition models for Queensland's vegetation communities provides more than enough additional background for understanding the processes that have favoured woody plant increases in our pastoral lands. When I commenced work at Charleville in 1964, Joe Ebersöhn explained to me that there was so little grass in the mulga lands because this country was predominantly grazed by sheep, rather than cattle. British breed cattle (*Bos taurus*), he went on to explain, had the "decency to die" before the grass did, whereas sheep did not! This made sense to me, but it was also left unsaid that the presence of mulga guaranteed year-long feed supplies even in the most severe of droughts; while the ubiquitous artesian bore drains ensured stock grazing pressure in this arid area was never effectively reduced. In this light, the apparent speed with which the Cobar peneplain converted to shrub dominance following the introduction of sheep (and rabbit) grazing should be of no surprise.

Yet, the surprising fact is that many landholders and conservationists have failed to appreciate that the conversion of the northern cattle herd to predominantly *Bos indicus* since the 1960s, along with the widespread use of dry season supplements (especially urea-molasses), has in many respects paralleled the earlier influence of sheep and mulga feeding on vegetation structure in south-western Queensland and north-western NSW. While British cattle could traditionally exert little sustained grazing pressure in the monsoon north, because of its long 'dry' season, coupled with stock unadapted to the harsh environment, Brahman cattle supported by modern infrastructure and dry season supplements certainly can. This should lead to lower fire incidence in this region compared with the past. There is already strong subjective evidence for this, suggesting the extent of fires is currently much lower in north-east cf. north-west Australia (see Fig 1.1 in Dyer *et al*. 2001) — such that several authors associate the current ingress of trees into traditional grasslands of Cape York Peninsula with reduced fire incidence (Neldner *et al.* 1997; Crowley and Garnett 1998).

Satellite imagery has obvious appeal in following vegetation change because of the completeness and frequency of its coverage — and all Queenslanders should be proud of the professional capabilities of the DNR&M's Statewide Landcover and Tree Study team (*e.g.* Department of Natural Resources 2000). Likewise radar and laser altimetry have a rapidly evolving place in monitoring woodland resources. However, we are still some way from obtaining the individual plant detail that population biologists require (Fensham *et al*. 2002). For these reasons, I agree with Fensham and Fairfax (2002) that aerial photo interpretation (API) is an underrated medium for assessment of vegetation dynamics. One advantage of aerial photos over satellite imagery is the longer time scales for which data are available. For example, Rod Fensham and coworkers (R. Fensham, personal communication) claim to have accurately quantified by API an average basal area increment of 21% in uncleared eucalypt woodland remnants in central Queensland from 1952–1991. Nevertheless, this technique is itself obviously limited by the lack of aerial photography before WWII, whereas the explorers' and anecdotal records are less time-constrained.

Probably the most under-utilised tool available for quantifying and interpreting vegetation change in the tropics and subtropics is the analysis of stable soil carbon isotopes. This technique is based on the different carbon isotope signatures (see Tieszen and Archer 1990) displayed by plants exhibiting the C_3 and C_4 photosynthetic pathway (or broadleaf plants and tropical grasses, respectively). Interestingly, once these distinctive signatures were discovered, they were quickly seized upon and widely utilised by animal nutritionists interested in estimating the proportion of grass or legume in the diet of cattle consuming tropical pasture.

However, it was some time before plant ecologists recognised the potential of the technique for interpreting the extent and even rate of change of flips between tropical grass and woody vegetation. Steve Archer's group at Texas A & M University has been especially prominent in showing how the invasion of *Prosopis* spp. into the desert grasslands of south-western USA can be quantified with $\delta^{13}C$ methodology (*e.g.* Archer 1995b; Boutton *et al*. 1998, 1999; Archer *et al*. 2001).

We have undertaken exploratory analyses of $\delta^{13}C$ profiles under many woodland communities in Queensland (Burrows *et al*. 1998). These strongly suggest that there have been widespread increases in woody plant presence in our grazing lands. A more comprehensive study is current with colleagues in the CRC for Greenhouse Accounting. I am confident that the output of this research will lead to a major re-analysis of assumptions about the structure of the grazed woodlands at European settlement, and herein lies a conservation dilemma. For example, there is compelling evidence that Cypress pine has extended its range and thickened up considerably since European settlement (Binnington 1997) and that gidgee and other *Acacia* spp. are expanding into Mitchell grasslands (McCallum 1999, Figure 4). Does this mean that we should be clearing these invaded areas of such native trees to protect their Regional Ecosystem status? What implications does a detailed $\delta^{13}C$ study of soil carbon beneath remnant eucalypt woodlands have for the present tree clearing debate, if it is concluded that these woodlands were definitely more open when domestic livestock grazing commenced?

Attribution of change

It is one thing to acknowledge extensive change in the structure of the woodlands but another to provide attribution for it. Beverly Henry and coworkers (Henry *et al*. 2002) have sought to do this in their recent *Rangeland Journal* paper. CO_2 fertilisation, climate variation, introduction of domestic livestock and change in fire regimes have all been invoked at various times to explain observed changes in woodland structure. We reached the following conclusions in a recent *Global Change Biology* paper (Burrows *et al.* 2002):

"Increase in woody biomass in savannas most likely requires a change in growth conditions brought about by a combination of factors that directly or indirectly affect ecosystem function. Reported examples of change in vegetation

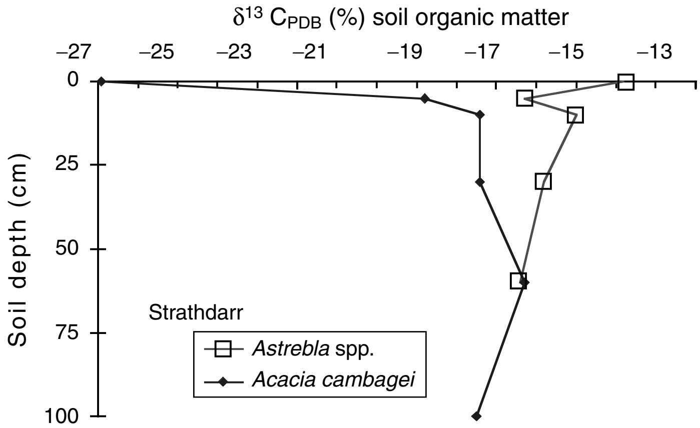

Figure 4. δ^{13}C of soil organic matter for soil profiles beneath gidgee (*Acacia cambagei*) and adjacent Mitchell grassland (*Astrebla* spp.) at 'Strathdarr', Longreach. Values are means of 6 cores for each depth interval. Data are highly suggestive that the gidgee has recently invaded the Mitchell grassland. See Tieszen and Archer (1990) for more details on the technique. (W.H. Burrows and J.O. Skjemstad, unpublished data).

structure with change in local conditions (including fenceline comparisons) provide evidence that while atmospheric CO_2 concentration or climate (especially rainfall) affect growth and establishment of woody plants in arid and semi-arid savannas, imposed management, particularly intensification of grazing and change in fire regimes, are more likely the trigger for increase in woody plant cover and biomass (Scholes and Archer 1997; van Auken 2000). Climatic conditions, particularly above average rainfall, that would favour growth may not result in an increase in growth and establishment of woody plants because the same conditions should promote competition from strong grass growth, as well as increasing the likelihood of subsequent fire. However, domestic livestock grazing may alter the balance towards successful establishment of woody plants and competitive advantage for existing trees and shrubs by reducing grass cover and fine fuel for fire, and by management for active fire suppression".

Fire

Ever since that evocative term 'fire stick farming' was coined by Rhys Jones (1969), there has been increasing acknowledgement that aboriginal burning practices had a major role in determining the structure of Australian vegetation prior to the arrival of Europeans and their domestic (and feral) livestock. Indeed, as early as 1911, Karl Domin concluded that, in all parts of Queensland, the open 'forests' are not a natural association, but a secondary one changed through the influence of the aboriginal inhabitants, mostly by means of bush fires (Domin 1911). Given the nature of the country, it is not surprising that there has been a plethora of papers, conferences and books written on the subject — so admirably pulled together in Stephen Pyne's comprehensively referenced *Burning Bush — A Fire History of Australia* (Pyne 1991), and popularised in Eric Rolls' *A Million Wild Acres* (Rolls 1981) and Tim Flannery's *The Future Eaters* (Flannery 1994). Such discussion seems endless with other examples including Bird Rose (1995), Grice and Slatter (1997) and Dyer *et al*. (2001). Often overlooked is the foresight shown by Brian Roberts in organising his fire research workshop series through the 1980s and 1990s (Roberts 1980–89). Yet, for all the attention the topic of fire management has received, the planned use of fire to manage vegetation structure or tree-grass balance in our grazing lands is rare; and the timing, frequency and intensity of planned burns to achieve vegetation management objectives are little understood. Paul Back's studies into the use of fire to control native woody weeds, especially wattles and currant bush, are notable exceptions (Back 1998; Burrows and Back 2000; Bebawi and Campbell 2002).

Woody weeds

The focus of this review is on native woody plants and their management in a grazing lands context. Yet, amidst today's changing societal values, it would be surprising for some people to learn, and remiss of this reviewer to not mention, that most of the early studies of native trees and shrubs in this State centred on the control of what many viewed as woody weeds. Genera which attracted particular attention in the 1960s included *Acacia*, *Eucalyptus, Eremophila* and *Senna* (*Cassia*). While people such as Neil Young and Denis Purcell (DPI) and Jock Robertson (CSIRO) were responsible for most of the field control trials, detailed ecological studies were also carried out with a view to more effectively managing brigalow (Johnson 1964), false sandalwood (Beeston and Webb 1977), mulga (Pressland 1975; 1976) and green turkey bush (Burrows 1972; 1973; 1974). Bob Johnson was of course a great scientist and future Government Botanist, while Beeston was also a prominent botanist in the Queensland Herbarium at the time of his *Eremophila* studies. In fact, I vividly recall a time when that most gentlemanly and scholarly of botanists, Les Pedley, was sent out to a small central Queensland farm to show my father and his boys how to stem inject eucalypts with 2, 4, 5-T! Given these recollections, I sometimes believe that the rightful, if not evangelical conservation ethos, of modern day Queensland Herbarium staff is also partly masking an attempt to exorcise themselves of past demons!

Yet, there can be no denying that we need to take stock of the extent of land clearing in Queensland. In my review for the XIX IGC in 2001 entitled 'Deforestation for pasture development — has it been worth it?' (Burrows 2001), I concluded, in agreement with Adilson Serrao *et al.* (1996), that intensification of livestock raising should be on already deforested lands — and that governments and the world community should now reduce the rates of deforestation in the interests of conserving our remaining forest resources. These comments were made in an international context.

For Queensland, there are two very important provisos. Firstly, landholders should be allowed to at least maintain conserved areas on their properties at current basal areas. This does not necessarily endorse selective thinning as the optimum pathway to reach this objective, since our long running, eucalypt clearing options trial at 'Wandobah', Dingo has clearly shown that, in the absence of commercial timber harvest, selective thinning to maintain pasture production does not pay (Table 2). Secondly, the landholder should not be further constrained on what pasture species he can sow on his land, provided these are not declared plants. For example, there is ample evidence that both buffel grass and leucaena have made important contributions to livestock production and economic development in this State. Yet, there is a growing conservation chorus who see such economically important introduced species as an affront to their sensibilities.

Agricultural researchers and primary producers should not cave in to such broad-ranging demands. Agriculturalists are forever battling with native and exotic weeds and pest organisms that threaten their livelihood. As a citizen and biologist, I am totally supportive of the need for government to ensure that the biological diversity of this nation is maintained. However, as a taxpayer I'm also of the view that government should pay to 'protect' areas of conservation interest, just as the farmer has to protect his crops and livestock from pests and diseases. The farmer and grazier should not be responsible for the total landscape. Many years ago I chanced upon the trite saying that "the only sustainable agriculture is profitable agriculture" (Ainesworth 1989). No one has yet convinced me that this observation is incorrect. While of course it does not follow that profitable enterprises are always sustainable, those increasingly regulating agricultural land use should also be aware that their actions may be the catalyst for unsustainable practices that make their original objectives self-defeating.

Table 2. Response relative to control of various tree clearing treatments on a poplar box (*Eucalyptus populnea*) woodland site in central Queensland. Assumptions — paddock size 1000 ha; stocking rates are determined by the GRASSMAN model (Scanlan and McKeon 1990) — tree basal area resulting from each treatment (actual field data) determines potential native pasture production (Scanlan and Burrows 1990) which is stocked to consume 30% of the pasture on offer; steers enter paddock at 180 kg, leave at 450 kg; average rainfall is assumed for each year of a modelled 15-year time frame; Net Present Value (NPV) is based on the 15-year time span and a 6% discount rate; interest on herd capital is charged at 10%. [See Burrows (2001) for further details].

Clearing method	NPV/ha
NPV = Net Present Value after 15 years from clearing	
Control (intact woodland – initial tree basal area $10 m^2/ha$)	
Retain 20% trees scattered over paddock, stem inject remainder	($21.00)[1]
Retain 20% trees in intact woodland strips — pull and burn remainder	$47.00
Retain 20% trees in intact woodland strips — treat remainder with tebuthiuron (1.5kg a.i./ha)	$40.00
Retain 20% trees in intact woodland strips — treat remainder with tebuthiuron (1.0kg a.i./ha)	$63.60

[1]Negative value.

Biodiversity, Salinity and Greenhouse

Biodiversity loss and salinity hazard have increasingly become the call to arms of all those seeking to constrain responsible development of this State's woodland resources — matching the alacrity with which Australia's greenhouse emissions problems were largely sheeted home to tree clearing, rather than fossil fuel use. Of course, as in most arguments, there are genuine concerns; but typically it is difficult to refute exaggerated claims, because scientific mores are largely ignored in favour of emotive outbursts on TV or other media.

Again I have addressed some of the broader issues confronting land clearing in my IGC reviews (Burrows 1993; 2001) and in an article in *Search* (Burrows 1991). On rereading the latter article, in which I reiterated responsible guidelines for woodland development on agricultural land in Queensland, I noted the following observation: "Obviously, if conservationists promote the fear of regulation actively enough, a self-fulfilling prophecy of panic clearing and subsequent regulation will eventuate — not a bad tactic I guess, if you believe that the end justifies the means". Enough said — given Queensland's recent experience.

I conclude this discussion with 3 rhetorical questions. Why, as Donald Franklin (1999) reports, has there been a decline in the granivorous bird assemblages of northern Australia, coinciding with the pastoral era **prior** to clearing? Why are our subsurface ground water supplies at an all time low? Finally, why does Australia fail to include the enormous sink in Queensland's grazed woodlands in its National Greenhouse Gas Inventory? Could I suggest that a common thread, in the obviously many faceted answers to these questions, may be the proliferation of woody plants in our remnant woodlands?

What of the Future?

While Joe Ebersöhn advised of posthumous fame, my 39 years as a public servant have increasingly suggested to me that government seems less and less capable of planning very far ahead. In keeping with the 40-year theme of this meeting, I will conclude by focussing on the immediate future for woodland management.

First of all, since the passing of the Lands Act 1994 and Vegetation Management Act 1999, all 'endangered' and a huge area of 'of concern' regional woodland ecosystems are now protected under Queensland statute. Frankly, I consider that we would all benefit by concentrating in the future on educating, rather than further regulating rural landholders. Foremost amongst these lessons would be the need for more thought to be given by those clearing land to pre-clearing planning and post clearing management, rather than the clearing operation itself. Implicit in such planning, as I outlined in my XVII IGC review (Burrows 1993), is the avoidance of the critical biodiversity loss and salinisation problems before they occur, and promotion of management which aims to minimise regrowth and overstocking after clearing.

There are many unanswered research questions concerning the management of our vast woodland resource. Few would argue that it is the role of fire and the impact of changed fire regimes on the structure of our major woodland systems, since livestock grazing commenced, that is deserving of most attention. While reduction in fire frequency and/or intensity seems to easily explain the expansion of fire-susceptible species such as *Callitris* spp. (Binnington 1997), the same logic begs the question why fire-resistant species such as eucalypts also apparently formed open woodland communities when fire was more frequent. For example, accounts of the poplar box region by early explorers indicate that the dominant trees had a spacing of between 50 and 100m with little understorey (Leichhardt 1847, Figure 5). I consider that the answer is that, while adults and saplings of eucalypts are very resistant to fire, their seedlings are not. Therefore, research and modelling exercises need to focus on the frequency of establishment events and subsequent fire frequency which would be necessary to prevent the seedlings reaching a fire-resistant stage of development.

The corollary of the above is that simply encouraging or re-introducing fire into our current woodlands will do little to change the structure of the existing stands, *i.e.* strategic fire could limit future population increases but it will not prevent the basal area of existing stands from increasing, and so further reduce pasture production. Additionally, while ever domestic livestock remain consumers of woodland pastures, fine fuel loads can never equate with their potential reached under Aboriginal management.

The management of domestic livestock is thus a very important variable in grazed woodland systems [*e.g.* Ash *et al.* (2001)]. A synthesis of recent studies (Hall *et al.* 1998) suggests that conservative stocking rates (resulting in <30% utilisation of annual pasture production) offer the best option for sustainable management of our grazing land. Such utilisation levels should provide sufficient fuel, in conjunction with woody plant litter (Burrows *et al.* 1990), for seasonal burns to be employed to keep woody regrowth in

Figure 5. A poplar box (*Eucalyptus populnea*) woodland near Dingo, central Queensland. The large standing dead and fallen trunks were trees ringbarked c. 1935. These trees clearly pre-dated commencement of livestock grazing. Smaller live trees represent subsequent regrowth. Compare the distance apart and size of the dead trees with that of the regrowth. Also notable is the absence of fire scars on the dead tree trunks.

check and/or limit successful establishment of new woody seedlings. In my experience, this utilisation level approximates the grazing pressure where 'patch grazing' starts to become obvious in tussock grasslands, other than Mitchell grass. Fire can also be a useful tool to move the location of patches before they become entrenched (Winter 1987).

Burrows *et al.* (2002) recently pointed out that above-ground growth in eucalypt woodlands represents a significant greenhouse sink. When coupled with apparent huge overestimates of soil carbon loss on forest conversion to native pasture (30% of 70t/ha in the top 30 cm assumed, *cf.* <10% of 40t/ha in the top 30 cm more likely — Guo and Gifford 2002; Harms *et al.* 2002; Jackson *et al.* 2002), it is highly probable that Australia's Land Use Change and Forestry sector was a net sink, and not a net source of emissions in 1990. This could have serious implications for Australia as it would then theoretically make this country ineligible to avail itself of Article 3.7 of the Kyoto Protocol, under the United Nations Framework Convention on Climate Change. To avoid this awkward problem, I understand that Australia has now obtained approval from Kyoto signatories to allow it to calculate its targets in the first commitment period (should it ratify the protocol), assuming that this country had met Article 3.7 conditions.

One potential benefit of the on-going post Kyoto negotiations is that grazing land management is now recognised as an acceptable 'additional activity' under Article 3.4 of the Protocol. This has the potential to make the huge sink identified in the grazed woodlands available for credit under the Protocol and also for trading as 'carbon offsets' if Australia ratifies. While any such sink has to be measured under net — net rules, Burrows *et al*. (2002 — Figure 7 therein) have shown that the above-ground biomass increment (t dry matter/ha/yr) increases as stand basal area increases across the likely values of measurement. I would therefore optimistically conclude that carbon offsets could become available for the credit of Queensland landholders at some future date. Should this occur, it could provide a financial incentive for landholders to retain trees on their land and so meet wider community objectives in a more equitable manner than is current — without the need for regulation or the oft promised mirage of compensation payments for pasture production and/or development foregone.

Post script

Well, what would Harry Stobbs have thought of this potted personal year history of woodland studies in Queensland? I suspect that he would have been pleased that a person he helped so much to get the Proceedings of the Mulga Lands Symposium published in *Tropical Grasslands*, some 30 years ago, had now presented his memorial address. But with a twinkle in his eye and an infectious laugh he would have added — but your presentation could never reach the standard I set in my time as editor of this journal!

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