PROCEEDINGS OF THE AUSTRALIAN RANGELAND SOCIETY BIENNIAL CONFERENCE

Official publication of The Australian Rangeland Society

Form of Reference

The reference for this article should be in this general form;
Author family name, initials (year). Title. *In*: Proceedings of the nth Australian Rangeland Society Biennial Conference. Pages. (Australian Rangeland Society: Australia).
For example:
Anderson, L., van Klinken, R. D., and Shepherd, D. (2008). Aerially surveying Mesquite *(Prosopis* spp.) in the Pilbara. *In*: 'A Climate of Change in the Rangelands. Proceedings of the 15th Australian Rangeland Society Biennial Conference'. (Ed. D. Orr) 4 pages. (Australian Rangeland Society: Australia).

The Australian Rangeland Society

MONITORING QUEENSLAND'S GRAZED WOODLANDS - IMPLICATIONS FOR GREENHOUSE AND PASTORAL INDUSTRIES

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ABSTRACT

A woodland monitoring network has been progressively established within the 60 Mha of Queensland's grazed woodlands since 1982. A subset of monitoring sites within this network has been demonstrated to represent a study area of 27 Mha of eucalypt woodlands. The results from monitoring this study area have shown that the woody biomass stocks are increasing. This woody plant proliferation or thickening is providing a large carbon sink of 18 Mt C/yr in the 27 Mha study area. If extrapolated over the 60 Mha of grazed woodlands in Queensland, the carbon sink is approximately 35 Mt C/yr, which is equivalent to 25% of Australia's net emissions in 1999. This sink is not currently included in Australia's greenhouse gas inventory. The woody plant proliferation is also reducing pasture growth affecting the productivity and viability of livestock producing properties.

WHY START MONITORING QUEENSLANDS WOODLANDS?

Large areas of Queensland (approximately 60 Mha) are covered by grassy woodlands, which are used for grazing domestic livestock. These woodlands provide a significant resource, which contribute to individual grazing property profitability as well as the social well□being of rural communities surrounding these grazing enterprises.

The woodlands are subjected to many pressures including:

- Grazing of the grass layer by domestic stock and native animals
- Changed fire regimes
- Clearing, thinning and wood product harvesting
- Variable climate including drought and wet periods

These pressures appear to be interacting and resulting in the proliferation (thickening) of woody vegetation. This thickening often results in less grass growth, which can be utilised by grazing animals (e.g. Beale, 1973; Scanlan and Burrows, 1990) and increased costs for mustering and management. The effect of woodland thickening on the native wildlife and understorey flora, resulting from changing the communities from open woodlands to closed woodlands, is largely unknown.

The TRAPS - Transect Recording And Processing System (Back et al., 1997; 1999) woodland monitoring program was initiated in 1982, to develop an understanding of the changing vegetation structure and population dynamics of Queensland's woodlands and to address the lack of reliable data on which to base the development of sound management strategies for the grazed woodlands.

Results from the TRAPS woodland monitoring program have potential to be used for many purposes, including:

- research into the ecology and recruitment of woody plants, their life cycle and community dynamics
- following the process of clearing, suckering, regrowth and re-clearing.
- monitoring the spread of exotic woody weeds
- documenting changes in vegetation biomass (carbon stocks)
- calibration and ground truthing of remote sensing technologies and computer models.

Long-term repeat sampling of monitoring sites facilitates measurement of the effects of episodic events such as droughts, big fires, string of wet seasons, etc., but also averages out short-term events so the long-term trends can be determined.

HOW WERE THE WOODLANDS MONITORED?

The woody plant composition and structure of representative woodland stands were monitored using the TRAPS methodology developed by the Queensland Department of Primary Industries (Back et al., 1997; 1999).

The permanently positioned sites were not randomly selected but have been progressively established on rural landholdings since 1982, to provide a broad cover of vegetation communities, prehistory and geographical location across Queensland's grazed woodlands. TRAPS sites are generally set up in a "representative" woodland stand for a district. The actual monitoring site is typically a 100 m x 100 m area surrounded by a 100 m buffer zone of similar vegetation. Areas of disturbance such as roads, creeks, fences and watering points are avoided.

A TRAPS monitoring site usually consists of 5 parallel, 100 m long belt transects, 4 m wide, with the centre of each belt 25 m apart. The length of the transects can be increased if mature trees are sparse. The sites are permanently marked with steel fence posts every 50 m along the transects. All woody plants within the belt transect are identified and their position recorded to be relocatable within a notional 10 cm grid. The location accuracy allows individual plants to be positively identified and remeasured at subsequent samplings. The minimum data recorded for each woody plant includes: species, plant height, stem number and stem circumference or diameter at 30 cm above ground level. Stem circumference or diameter is measured at 30 cm to avoid buttressing and fluting at ground level and allow the measurement of smaller trees and shrubs which would not be measured at 130cm or breast height. Other recordings include canopy size for shrubby bushes and defoliation ratings following fires or other disturbance. Photographs are taken from fixed photo points looking along each transect line at each recording event. The sites are generally reassessed every 2 to 5 years.

Initially only live woody plants were measured within the monitoring system. But subsequently, the monitoring of standing dead trees and recently, coarse woody debris, has been recognized as important for carbon accounting and environmental habitat values. The regular assessment of projected foliage cover along transect lines is currently under consideration. This will provide better linkage with remote sensing techniques. The monitoring system needs to be robust enough to allow measurement and incorporation of "new" attributes into the recording system.

The TRAPS sites are also used to monitor the ground layer plants. The QGRAZE monitoring system (see Cliffe and Hoffmann, 1999) is used to record herbage species frequency along the transects.

VALIDATING THE MONITORING TECHNIQUE AND DESIGN

In point based monitoring, a relatively small number of sites are assumed to represent large areas. For example, 57 monitoring sites have been used to document growth in woody vegetation in a study area containing 27 Mha of woodland dominated by Eucalyptus/Corymbia species (herein referred to as eucalypt woodland) in Queensland (Burrows et al., 2002). To justify extrapolation, the sites must be shown to represent the environment, climate history and tree community structure of the study area.

In the above case, the sites were assessed for representativeness in relation to rainfall in the wettest quarter, temperature in the wettest quarter, soil texture class, climate history and stand basal area. Analysis of the environmental variables (rainfall and temperature) showed that 71% of the study area was represented by at least one TRAPS monitoring site (Figure 1). Soil texture classes found in the study area were also well represented. Analysis of climate history showed that rainfall experienced by the longer established sites (9-17 years) was generally low compared to the hundred year historical record, while recently established sites (1-3 years) had been subjected to periods of above average rainfall. Stand basal area for the TRAPS sites was compared to values measured in the Statewide Landcover And Trees Study (SLATS) project (Danaher et al., 1992). Again the TRAPS sites were shown to closely represent the overall structure of eucalypt woodlands within the study area.

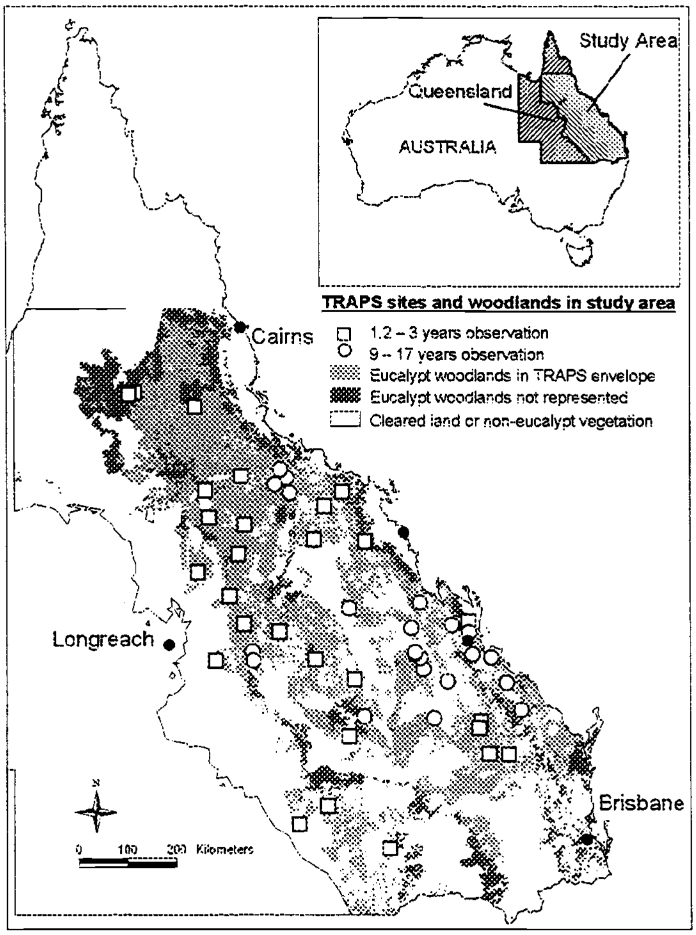

Figure 1 Map of 27 Mha of Eucalyptus/Corymbia woodlands and associated TRAPS sites within the study area. 71% of these woodlands (light grey) are represented by at least one TRAPS site based on rainfall and temperature in the wettest quarter. Unshaded areas within the study zone have been cleared or support vegetation dominated by other species. (adapted from Burrows et al., 2002).

HOW ARE THE MONITORING RESULTS USED?

To date the monitoring results have been used to document the occurrence and extent of woodland thickening, validate terrestrial biomass and land cover vegetation models, ground truth remote sensing technologies and enable analysis of woodland structure and dynamics.

The results of monitoring, in particular the documenting of woodland thickening, have been used to address global through to local issues. Aspects of the global problem of greenhouse have been addressed by demonstrating the presence of a large carbon sink within Queensland's woodlands, which may impact on international and national policy. Property and regional scale issues are being addressed by highlighting the problem of reduced pasture production in the woodlands in concert with increased tree/shrub basal area, in areas not subject to clearing. The reduced pasture production has implications for individual property profitability and surrounding rural community viability.

IMPLICATION OF THE RESULTS FOR GREENHOUSE

The TRAPS monitoring data has been used to document a significant carbon sink in 27 Mha of Queensland's eucalypt woodlands (Burrows et al., 2002). Fifty-seven TRAPS sites dominated by eucalypts were selected for analysis of woody vegetation growth and carbon stock change. These included 30 long-term sites (mean 14 years) and 27 short-term sites (mean 2.1 years). Other sites subjected to tree clearing, woodland harvesting or thinning during the period of observation and sites regrowing from tree clearing within the previous 20 years were excluded from the analysis.

Landholder information and field inspection were used to determine which sites were excluded on this basis.

Standing carbon stocks were calculated by applying allometric relationships to tree circumference measured during TRAPS monitoring (Burrows et al., 2000). The mean total standing carbon stocks increased from 38.2 t C/ha to 43.7 t C/ha over the average observation period of 14 years for the long-term sites. On average 98% of the initial carbon stock and 93% of the final carbon stock was in the live trees. The mean annual carbon increment of 0.37 t C/ha/yr over this period was significantly greater than zero ($P<0.001$) and was made up of 0.21 t C/ha/yr increase of live woody above ground biomass and 0.16 t C/ha/yr in standing dead above ground biomass. Of the 30 long-term sites, 26 showed a net positive carbon increment over the observation period.

The carbon stocks in short-term sites increased from 37.0 t C/ha to 38.6 t C/ha over an average of 2.1 years. The mean annual carbon increment was 0.7 t C/ha/yr, with the increase in the live woody above ground biomass being 0.3 t C/ha/yr. The higher growth rate, compared to the long-term sites may reflect the above average rainfall during the measurement period.

The mean total carbon stock increase for the 57 sites was 0.53 t C/ha/yr, which equates to 14.3 Mt C/yr over the 27Mha of eucalypt woodlands in the study area. Adding below ground biomass to 1m depth (root:shoot ratio of 0.26) the total carbon sequestration rate is 18 Mt C/yr over the 27 Mha. If similar figures are extrapolated across the 60Mha of grazed woodlands in Queensland the annual carbon sink is approximately 35 Mt C/yr. This sink is not currently included in greenhouse gas accounting in Australia (AGO 2001), but is equivalent to 25% of the total estimated national net emissions in 1999.

A significant issue in the national greenhouse gas accounting debate is whether this carbon sink is due to natural or anthropogenic (human induced) causes. Questions have been raised about whether the woodlands used for extensive grazing are actively managed with suggestions that the thickening would have occurred naturally as part of natural cycles, regardless of the grazing management. But, increasingly strong evidence exists from around the world, indicating that woody plant thickening in woodlands (savannas) is linked to the introduction of domestic livestock for grazing and altered fire regimes (see Archer, 1995; Henry et al., 2002; Burrows et al., 2002).

The TRAPS monitoring work has led to current investigations into other tools to study vegetation change. For example, using the delta 13 carbon signature of soil carbon to identify other sites where woody vegetation thickening has occurred, as well as trying to predict a timeframe for the observed thickening. Other techniques such as photo pairs and determining fire history, using grasstree (Xanthorrhorea spp) signatures are also being pursued.

IMPLICATION OF THE RESULTS FOR GRAZING INDUSTRIES

The significant woodland thickening that has been measured in the monitoring program has large implications for the grazing industry. Tree-grass relationships have been established for some of the widespread communities within the eucalypt woodlands in Queensland (Scanlan and Burrows, 1990). A large reduction in pasture production from woodland thickening can be demonstrated by combining the tree-grass relationship with the mean annual increment in stand basal area of 2.1% per year (Burrows et al., 2002).

A poplar box (Eucalyptus populnea) community on duplex soils in Central Queensland was utilised to highlight the importance of woodland thickening, on a grazing enterprise's productivity. The decrease in pasture production with increasing tree basal area for the community is shown in Figure 2. When this relationship is incorporated with a 2.1% per year basal area increase, which has been observed in Queensland woodlands, reductions in pasture production of around 30% can be predicted in the next 40 years (Table 1).

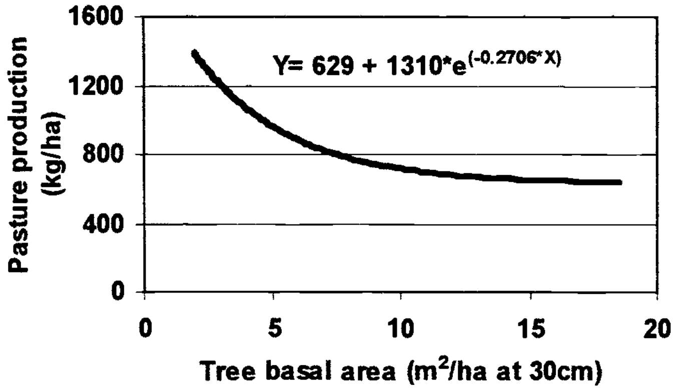

Figure 2 Tree-grass relationship for a poplar box (Eucalyptus populnea) woodland on duplex soil near Dingo, Central Queensland (Scanlan and Burrows, 1990).

This reduction in pasture production not only has an impact on the amount of pasture grown, cattle production and individual property viability, but also has social and viability implications for the surrounding rural communities. Environmental degradation is also likely to occur if cattle numbers are not reduced in line with the reduced pasture production. Over-utilisation of the pasture would result in soil erosion and landscape instability, which may lead to exotic weed invasion and loss of diversity of native plants and animals.

Table 1 Tree basal area increase over time and subsequent reduction in pasture production. Tree basal area is assumed to increase at 2.1% per year. The tree grass relationship uses the formula, Pasture production = 629+1310*e(-0.2706*tree basal area), for a poplar box woodland on duplex soil near Dingo, Central Queensland (Scanlan and Burrows, 1990).

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

Vegetation management legislation has recently been enacted in Queensland, due to community wide environmental concerns and the desire to limit further tree clearing. The availability of rigorous monitoring data has enabled input into vegetation management guidelines based on scientific evidence. The results of woodland monitoring have highlighted the process of woodland thickening, providing a case for woody plant thinning in "remnant" vegetation, which may allow producers to maintain production. This argument is now generally accepted in the compilation of Regional Vegetation Management Plans for Queensland's grazed woodlands. One question that still remains is, how to prevent or reverse woodland thickening through management in these low-input grazing systems?

FUTURE FUNDING AND MAINTENANCE OF MONITORING NETWORKS

Questions remain about the future funding and maintenance of monitoring networks. Currently, there is little commitment to long□term funding to ensure the integrity of monitoring sites. Data storage and collection often rely on a particular individual's passion and commitment through periods when monitoring is regarded as a low priority by Governments and institutions. What happens when the main drivers and often instigators of these monitoring schemes retire or move on? Will many years of monitoring be wasted? After 20 years we have only begun to encompass the lifespan of some of the shorter-lived components of the woodland communities we are currently monitoring in Queensland.

There is little doubt that the existence of the TRAPS network has enabled a more open and balanced debate to be engaged on the future of Queensland's grazed woodlands. Monitoring has shown that these woodlands are a substantial carbon sink. Similarly, the potential loss in pasture production resulting from ongoing increases in tree/shrub basal area in retained grazed woodlands has been highlighted and needs to be factored into management plans by land owners and administrators. In short the real question this paper asks is not why monitor, but how else can this valuable data contribute to current and future planning and management at local, regional, national and international scales.

REFERENCES

AGO (2001). National Greenhouse Gas Inventory 1999. Australian Greenhouse Office, Canberra, Australia.

Archer, S. (1995). Tree-grass dynamics in a Prosopis-thornscrub savanna parkland: Reconstructing the past and predicting the future. Ecoscience. 2: 83-99.

Back, P.V., Anderson, E.R., Burrows, W.H., Kennedy, M.K.K. and Carter, J.O. (1997). TRAPS – Transect Recording And Processing System: field guide and software manual. Queensland Department of Primary Industries, Rockhampton, Australia.

Back, P.V., Burrows, W.H. and Hoffmann, M.B. (1999). TRAPS: a method for monitoring the dynamics of trees and shrubs in rangelands. In 'Proceedings VIth International Rangeland Congress.' (Eds D.J. Eldridge and D. Freudenberger) Townsville, Australia. 2: 742-44.

Beale, I.F. (1973). Tree density effects on yields of herbage and tree components in south-west Queensland mulga (Acacia aneura F. Muell) scrub. Trop. Grassl. 7: 135-142.

Burrows, W.H., Hoffmann, M.B., Compton, J.F., Back, P.V. and Tait, L.J. (2000). Allometric relationships and community biomass estimates for some dominant eucalypts in Central Queensland woodlands. Aust. J. Bot. 48: 707-14.

Burrows, W.H., Henry, B.K., Back, P.V., Hoffmann, M.B., Tait, L.J., Anderson, E.R., Menke, N., Danaher, T., Carter, J.O. and McKeon, G.M. (2002). Growth and carbon stock change in eucalypt woodlands in northeast Australia: ecological and greenhouse sink implications. Global Change Biol. 8: 769-84.

Cliffe, N.O. and Hoffmann, M.B. (1999). Monitoring grazing lands in Queensland to identify trends in range condition. In 'Proceedings VIth International Rangeland Congress.' (Eds D.J. Eldridge and D. Freudenberger) Townsville, Australia. 2: 742-44.

Danaher, T., Carter, J.O., Brook, K.D. and Dudgeon, G. (1992). Broadscale vegetation mapping using NOAA AVHRR imagery. In 'Proceedings of the 6th Australasian Remote Sensing and Photogrammetry Conference.' Wellington, New Zealand, 3: 128-37.

Henry, B.K., Danaher, T., McKeon, G.M. and Burrows, W.H. (2002). A review of the potential role of greenhouse gas abatement in native vegetation management in Queensland's rangelands. Rangel. J. 24: 112-32.

Scanlan, J.C. and Burrows, W.H. (1990). Woody overstorey impact on herbaceous understorey in Eucalyptus spp. communities in central Queensland. Aust. J. Ecol. 15: 191-97.