The role of farm production systems in determining vegetation patterns and options for broad-scale conservation in temperate woodlands

Josh Dorrough

Chapter 17 in Lindenmayer, D.; Bennett, A. and Hobbs, R. (2010) Temperate Woodland Conservation and Management, pp 143-149

Summary

1. High-input livestock production systems are not compatible with maintaining native plant diversity and overstorey tree populations.

2. Sustainable grazing systems depend on maintaining diverse perennial ground-layer vegetation with associated drought tolerance and soil protection.

3. Overstorey tree populations and a moderate diversity of ground-layer plants can be maintained under extensive and/or infrequent livestock grazing systems, but only in the absence of soil nutrient enrichment.

4. Profitable alternatives to intensive high-input production systems do exist; however, there are significant barriers to widespread uptake.

5. In any particular situation there will be considerable uncertainty about whether reducing or excluding grazing and/or fertilisation will lead to a recovery in the diversity and abundance of native ground-layer plants.

6. Strategies for conserving and enhancing temperate woodland vegetation should include whole-of-farm approaches in addition to targeting remnants within farms.

7. Conservation planners need to consider different approaches across the landscape, owing to systematic variation in farm productivity and ecological processes.

Introduction

This chapter provides seven key lessons derived from collaborative research on vegetation patterns and dynamics in the temperate woodland landscapes of central and northern Victoria and the southern slopes and tablelands of New South Wales (see map below). These regions differ from the northern and coastal rainshadow grassy forests and woodlands of New South Wales in the lack of a summer-dominant rainfall pattern and the presence of frequent summer soil moisture deficits. The research has been directed towards: (1) understanding how management practices associated with agriculture (tree clearing, livestock grazing, nutrient enrichment and cultivation) affect the composition, distribution and abundance of plant species (ground-layer plants and overstorey trees) (e.g. Dorrough *et al.* 2004; Dorrough *et al.* 2006; Dorrough and Scroggie 2008); and, (2) identification of options for conserving native vegetation (e.g. Dorrough *et al.* 2007; Crosthwaite *et al.* 2008; Duncan and Dorrough 2009). Understanding how biota respond to agriculture has required examination of the full gradient of land use intensities, from never-fertilised remnant woodlands through to cleared, sown and fertilised exotic pastures. While the research has all been conducted within the temperate woodland zone, it has also examined other vegetation types such as grasslands and dry grassy forests that occur in a mosaic with temperate woodland. All of these vegetation types share similarities in how they respond to agricultural management practices and so the lessons provided here draw on the full range of research.

The lessons are derived primarily from ecological experiments and surveys conducted both at fine scales (<1 m) and broader scales within and among local (paddocks and farms, approximately hundresd of metres to tens of kilometres) and regional landscapes (hundreds of kilometres). Developing options for conserving native vegetation in temperate woodlands not only requires knowledge of the relationships between management practices and biota, however, but also knowledge of the farm production system itself and the role of native vegetation within that (Crosthwaite and Malcolm 2000). Therefore a number of the lessons are the result of collaborative investigations that have combined ecological, farm management and farm business data to explore alternative conservation scenarios at paddock, farm and landscape scales (Dorrough *et al.* 2007; Crosthwaite *et al.* 2008; Dorrough *et al.* 2008a; Duncan and Dorrough 2009). Some of these ideas have been trialed through a conservation market-based incentive program in Victoria (www.gbcma.vic.gov.au/downloads/Biodiversity/Green_Graze_final_report.pdf).

Lessons

1. High-input livestock production systems are not compatible with maintaining native plant diversity and overstorey tree populations

Intensification of grazing and fertiliser practices lead to dramatic declines in the diversity of native plants and changes in the types and abundances of plant species (Kirkpatrick *et al.* 2005; Dorrough *et al.* 2006; Dorrough and Scroggie 2008; McIntyre 2008). These changes have significant implications for key ecosystem functions such as nutrient cycling, carbon storage and soil protection (McIntyre 2008). While a small number of native grasses and broad-leaved forbs can tolerate moderate soil fertility and grazing intensities, most geophytes (orchids and lilies), shrubs, and many native grasses and forbs persist only when such management practices are absent or of very low frequency and intensity (Dorrough and Scroggie 2008). Intensive grazing and nutrient enrichment (via stock camping and fertiliser) also reduce the likelihood of overstorey tree recruitment (Dorrough and Moxham 2005; Fischer *et al.* 2009b) and lead to declines in health of mature trees (Close *et al.* 2008). Therefore, in the medium to long-term, intensive grazing and nutrient enrichment lead to the loss of both overstorey and understorey native vegetation. There is a need for more public discussion on whether there should be limits to the location and extent of intensive production systems at both farm and landscape scales (e.g. McIntyre 2002).

2. Sustainable grazing systems depend on maintaining diverse perennial ground-layer vegetation with associated drought tolerance and soil protection

Diverse perennial vegetation underpins sustainable grazing systems that have good drought tolerance and soil protection (McIntyre 2008), providing an important link between production and native vegetation conservation. The loss of perennial native vegetation and replacement by a small suite of exotic annual plants, as a result of intensive grazing and soil nutrient enrichment, is a key factor in the deterioration of ecological condition, compromising the production base and increasing risk to drought. Although annual pastures can be productive, they provide poor soil protection (McIntyre 2008) and collapse rapidly under drought conditions (Dorrough *et al.* 2008b). Data from hundreds of paddocks across the southern temperate woodland zone demonstrate that in the medium to long-term, and despite the best management intentions and skills, perennial pastures eventually become dominated by annual plants when soil fertility is high (>20 ppm Colwell phosphorus) (Dorrough *et al.* 2006; McIntyre 2008). This same conclusion was reached during the earliest pasture experiments (e.g. Davies *et al.* 1934).

3. Overstorey tree populations and a moderate diversity of ground-layer plants can be maintained under extensive and/or infrequent livestock grazing systems, but only in the absence of soil nutrient enrichment

A moderate diversity of native ground-layer plants is often associated with infrequent livestock grazing, but only when soil fertility is low (Dorrough *et al.* 2006). The likelihood of tree recruitment is also greater under infrequent (Dorrough and Moxham 2005) or rotational grazing regimes (Fischer *et al.* 2009b), but also could depend on pasture productivity (Vesk and Dorrough 2006). A large group of native plant species, however, are intolerant of even low levels of grazing and nutrient enrichment (Prober *et al.* 2002; Dorrough and Scroggie 2008). Woodlands of low fertility and that are lightly grazed, typically have lower diversity than those within stock reserves, cemeteries and other localities with a long-term absence of stock grazing pressure (e.g. McIntyre *et al.* 2002). Despite this, grazed native pastures with scattered woodland trees are the most extensive native-dominated habitat element in the temperate woodland zone (Dorrough *et al.* 2007). Their management may be critical for the persistence of native biota and delivery of key ecosystem services (Cunningham *et al.* 2008; Fischer *et al.* 2009a, 2009b).

4. Profitable alternatives to intensive high-input production systems do exist, however there are significant barriers to widespread uptake

Low-input rotational grazing systems appear to provide a profitable pathway for management of grazed temperate woodlands (Crosthwaite *et al.* 2008) and are predicted to directly benefit woody plant recruitment (Fischer *et al.* 2009b) and indirectly benefit the diversity of native perennial plants due to lower fertiliser use (Dorrough *et al.* 2008b). Profitable adoption of low-input systems across whole farms often entails significant capital investment in livestock grazing infrastructure (e.g. fencing and water) to enable more efficient use of pastures and thus compensate for production lost through ceasing fertiliser applications (Crosthwaite *et al.* 2008). In the absence of large holdings, opportunities to expand or to obtain alternative incomes, many producers will not feel able or willing to change their management philosophy. High land prices and agricultural extension and agribusiness will no doubt continue to encourage intensification as the major pathway to maintaining or improving farm profits. As a result, there is also a continuing need to identify strategies for managing woodlands that can be targeted towards high-input producers.

5. Vegetation recovery following relief from fertiliser and grazing is uncertain

There is still much uncertainty about how relief from livestock grazing and fertilisation affect the diversity, composition and abundance of native vegetation (Lunt *et al.* 2007; Dorrough and McIntyre unpublished data). Most of our current assumptions relating to possible benefits of reducing livestock pressure and nutrient concentrations are derived from studies examining the long-term historical impact of imposing these management activities (Lunt *et al.* 2007). Fewer studies have explored how plants respond as the intensity of agricultural land management declines. Ecological variation (e.g. plant composition, seed availability, landscape position, soil fertility, climate and weather) and a lack of empirical data lead to considerable uncertainty about the possible outcomes in any particular situation. More research is needed to examine these 'reverse' trajectories (Lunt *et al.* 2007). Policies and financial incentives to improve conservation outcomes in woodlands should take this uncertainty into account -

maintaining low-input grazing systems in localities with little or no fertiliser use should not be considered equivalent to reducing stock pressure and ceasing fertiliser in previously fertilised woodlands.

6. Strategies for conserving and enhancing temperate woodland vegetation should include whole of farm approaches in addition to targeting remnants within farms

Strategies that target only remnant woodland patches are likely to be insufficient in ensuring persistence of all native biota across landscapes as well as providing minimal contribution to other resource management objectives (e.g. soil protection, water quality, nutrient cycling, stock shelter) (Vesk and MacNally 2006; Fischer *et al.* 2009a). Site-based incentive funding could have unintended perverse outcomes and facilitate declines in the condition of the more extensive scattered tree and native pasture habitats, despite assisting protection and management of remnants within properties. Site-based payments, that potentially include opportunity costs, can be invested towards intensification elsewhere on the property, and infrastructure established through incentive payments (e.g. fencing and water points) could facilitate more intensive management in areas with remaining native vegetation (e.g. scattered trees and native pastures).

Conservation strategies that treat the farm as the unit of management within the context of a regional management plan, rather than focusing on individual patches within a farm, may be more effective in achieving broad-scale habitat reconstruction and conservation. Whole-farm approaches, that: (1) identify and account for future trends in all native vegetation; (2) jointly develop farm business plans and native vegetation management strategies; and (3) provide advice on alternative on- or off-farm investments that avoid further vegetation degradation, could prove advantageous (Crosthwaite and Malcolm 2000). Whole-farm conservation strategies that take into account the farm business and farm management practices may also identify options that are more cost-effective than direct incentive payments (e.g. farm restructuring, extension advice and training) (Crosthwaite and Malcolm 2000). A whole-farm approach would also provide a framework through which adoption of low-input systems can be facilitated. As discussed above, profitable alternatives to intensification do exist and whole-farm approaches can be useful in identifying them and facilitating their adoption.

7. Conservation planners need to consider different approaches across the landscape, owing to systematic variation in farm productivity and ecological processes

In low productivity native pastures, medium to long-term initiatives that target lower stocking rates, rest from grazing and cessation of fertiliser inputs are likely to be most cost-effective (e.g. Dorrough *et al.* 2008a). High land prices and a shift away from wool production have already led to significant changes in livestock type and intensities and hence there is potential to facilitate substantial passive revegetation in many native pasture areas with little direct public investment. Conservation strategies for highly threatened woodlands in productive parts of the landscape will, however, require considerably more financial investment. De-intensification at any reasonable scale imposes great cost in productive landscapes and active replanting and targeted conservation management of existing remnants are likely to be the most cost-effective strategies. Broad scale replanting of scattered trees should be considered for livestock grazing systems (Fischer *et al.* 2009a) while block planting may be the only feasible option in areas under crops, or transforming back towards cropping.

Conclusions

Ecological research and conservation management strategies for temperate woodland need to be better placed within an understanding of the current agricultural management systems, practices, trends and drivers of change. There is also a need for more research tackling the implications of current trends in land use, or predicting future plausible scenarios in an effort to inform current conservation planning (e.g. Duncan and Dorrough, 2009; Thomson *et al.* 2009). Conservation policies and management strategies need flexibility to enable them to adapt to often rapid changes in farm management trends and production systems. Collaborative research with other disciplines is important in this regard. Knowledge gained through developing connections with agribusiness, producer groups, agricultural research and development and extension also will be important in providing the context for research.

Ecologists working in temperate woodlands have done some important research examining historical patterns of vegetation change and describing the outcomes of past management on current vegetation patterns (Lunt *et al.* 2007). We have limited data to guide active management or broad-scale restoration, however,. There is a glaring lack of research examining the recovery of vegetation following relief from both intensive grazing (or changes in grazing strategy) and fertiliser application. More research funding and effort needs to be directed towards these problems as the current lack of knowledge seriously hampers our ability to make decisions about how and where to invest for conservation. There is funding directed towards medium-term stewardship payments (e.g. the Australian Government Box Gum Grassy Woodland Project, www.nrm.gov.au/stewardship) but often the management strategies being recommended have little empirical data to support them. The onus is on State and Federal Governments to ensure that such initiatives are adequately monitored and in such a way that they improve our current ecological knowledge and contribute to smarter and more cost-effective management.

Acknowledgments

The ideas presented here have developed over several years with significant input from many colleagues. In particular I would like to thank Jim Crosthwaite, Sue McIntyre, Peter Vesk, David Duncan, Jim Moll, Vivienne Turner, Ian Lunt and Joern Fischer.

Bio

Josh Dorrough undertook a Ph.D. on native plant persistence in grazed grasslands through the Australian National University, completing in 2002. From 2002 to 2008 he worked as a research ecologist with the Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Victoria. He is currently a Visiting Research Scientist with CSIRO Sustainable Ecosystems in Canberra and living on a small farm in the far south-east of New South Wales.

References

Close, D.C., Davidson, N.J. and Watson, T. (2008). Health of remnant woodlands in fragments under distinct grazing regimes. *Biological Conservation* **141**, 2395–2402.

Crosthwaite, J. and Malcolm, B. (2000). ‘Looking to the farm business: approaches to managing native grassland in south-eastern Australia. National Research and Development Program on Rehabilitation, Management and Conservation of Remnant Vegetation, Research Report 5/00’. Land and Water Resources Research and Development Corporation, Canberra

Crosthwaite, J., Malcolm, B., Moll, J. and Dorrough, J. (2008). Future investment in landscape change in southern Australia. *Landscape Research* **33**, 225–239.

Cunningham, R.B., Lindenmayer, D.B., Crane, M., MacGregor, C., Montague-Drake, R. and Fischer, J. (2008). The combined effects of remnant vegetation and tree planting on farmland birds. *Conservation Biology* **22**, 742–752.

Davies, J.G., Scott, A.E. and Fraser, K.M. (1934). Natural pastures: their response to superphosphate. *Commonwealth of Australia Council for Scientific and Industrial Research Bulletin* **83**, 1–76.

Dorrough, J. and Moxham, C. (2005). Eucalypt establishment in agricultural landscapes and implications for landscape-scale restoration. *Biological Conservation* **123**, 55–66.

Dorrough, J. and Scroggie, M.P. (2008). Plant responses to agricultural intensification. *Journal of Applied Ecology* **45**, 1274–1283.

Dorrough, J., Ash, J. and McIntyre, S. (2004). Plant responses to livestock grazing frequency in an Australian temperate grassland. *Ecography* **27**, 798–810.

Dorrough, J., Moll, J. and Crosthwaite, J. (2007). Can intensification of temperate Australian livestock production systems save land for native biodiversity? *Agriculture Ecosystems and Environment* **121**, 222–232.

Dorrough, J., Vesk, P.A. and Moll, J. (2008a). Incorporating ecological uncertainty and farm-scale economics when planning restoration. *Journal of Applied Ecology* **45**, 288–295.

Dorrough, J., McIntyre, S., Stol, J., Brown, G. and Barrett, G. (2008b). Understanding the interactions between biodiversity and the management of native pastures in the Murray Darling Basin. Meat and Livestock Australia: Sydney.

Dorrough, J., Moxham, C., Turner, V. and Sutter, G. (2006). Soil phosphorus and tree cover modify the effects of livestock grazing on plant species richness in Australian grassy woodland. *Biological Conservation* **130**, 394–405.

Duncan, D.H. and Dorrough, J. (2009). Historical and current land use shape landscape restoration options in the Australian wheat and sheep farming zone. *Landscape and Urban Planning* **91**, 124–132.

Fischer, J, Sherren, K., Stott, J., Zerger, A., Warren, G. and Stein, J. (2009a). Toward landscape-wide conservation outcomes in Australia's temperate grazing region. *Frontiers in Ecology and the Environment* **in press**

Fischer, J., Stott, J., Zerger, A., Warren, G., Sherren, K. and Forrester, R.I. (2009b). Reversing a tree regeneration crisis in an endangered ecoregion. *Proceedings of the National Academy of Sciences* **106,** 10386–10391.

Kirkpatrick, J.B., Gilfedder, L., Bridle, K. and Zacharek, A. (2005). The positive and negative conservation impacts of sheep grazing and other disturbances on the vascular plant species and vegetation of lowland subhumid Tasmania. *Ecological Management and Restoration* **6**, 51–60.

Lunt, I.D., Eldridge, D.J., Morgan, J.W. and Witt, G.B. (2007). A framework to predict the effects of livestock grazing and grazing exclusion on conservation values in natural ecosystems in Australia. *Australian Journal of Botany* **55**, 401–415.

McIntyre, S. (2002). The way forward – from principles to practice. In *Managing and Conserving Grassy Woodlands*. (Eds S. McIntyre, J.G. McIvor and K.M. Heard) pp. 201–218. CSIRO Publishing: Collingwood.

McIntyre, S. (2008). The role of plant leaf attributes in linking land use to ecosystem function in temperate grassy vegetation. *Agriculture Ecosystems and Environment* **128**, 251–258.

McIntyre, S., Heard, K.M. and Martin, T.G. (2002). How grassland plants are distributed over five human-created habitats typical of eucalypt woodlands in a variegated landscape. *Pacific Conservation Biology* **7**, 274–289.

Prober, S.M., Thiele, K.R. and Lunt, I. (2002). Identifying ecological barriers to restoration in temperate grassy woodlands: soil changes associated with different degradation states. *Australian Journal of Botany* **50**, 699–712.

Thomson, J.R., Moilanen, A.J., Vesk, P.A., Bennett, A.F. and Mac Nally, R. (2009). Where and when to revegetate: A quantitative method for scheduling landscape reconstruction. *Ecological Applications* **19**, 817–828.

Vesk, P.A. and Dorrough, J. (2006). Getting trees on farms the easy way? Lessons from a model of eucalypt regeneration in pastures. *Australian Journal of Botany* **54**, 509–519.

Vesk, P.A. and Mac Nally, R. (2006). The clock is ticking-Revegetation and habitat for birds and arboreal mammals in rural landscapes of Southern Australia. *Agriculture Ecosystems and Environment* **112**, 356–366.