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Cost-effective landscape revegetation and restoration of a grazing property on the Northern Tablelands of New South Wales: 65 years of change and adaptation at 'Eastlake'

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Abstract. This paper describes the restoration of woody vegetation on my family's grazing property, 'Eastlake' (1202 ha) on the Northern Tablelands of New South Wales. We commenced revegetating 'Eastlake' in 1981 to reverse the loss of native tree cover due to New England dieback and improve shelter for livestock and pastures to increase farm profitability. We treated the revegetation program as a long-term business investment and, apart from a 5-year period of overseas employment, have allocated annual funding in the farm business plan ever since. Our decision was based on the benefits of shelter to livestock and pasture production. Once we began revegetation, aesthetics, amenity and the positive impact on the capital value of the farm became important motivations. More recently, increasing the farm's biodiversity and resilience, and conserving native flora and fauna, have also motivated us. Our strategy is to link upland areas of remnant timber with ridgeline corridors of planted vegetation to maximise shelter, minimise pasture production losses and provide dispersal corridors for fauna and wildlife habitat. Initially, we planted introduced species of tree and shrub, but now we revegetate mainly with native species, as well as fencing off remnant timber to encourage natural regeneration and direct seeding understorey species (mainly acacias) in degraded remnants and elsewhere. Our target is to increase the area of fenced-off and planted timber cover from 8% to 10% over the next few years, which will take the proportion of total effective timber cover from ~8% in 1980 to 18% of the property. The key lessons are to: (1) plan, prepare, plant the right tree or shrub in the right place for the right purpose, and post-planting care (the '4 Ps'); (2) integrate revegetation into the whole-farm business plan; (3) finance the work slowly over time with the aid of a spatial farm plan; and (4) adapt to changing circumstances, values and understanding. Research is required to help farmers understand the role of on-farm biodiversity in contributing to the health of the farm business, owner–managers and their families and the farm environment, as well as to regional economies, communities, landscapes and society more generally.

Additional keywords: biodiversity conservation, direct seeding, groundcover, integrated farm management, livestock and landscape shelter, native and exotic temperate pasture, native and exotic trees and shrubs, New England dieback.

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Introduction

Restoration of almost half of the Earth's terrestrial vegetated surface to reverse productivity declines due to land use is essential to maintain the ecosystem services and biodiversity upon which humanity depends (Daily 1995; MA 2005; Aronson and Alexander 2013). However, restoring productive land is costly and often constrained by limited information (MA 2005). Revegetation and sustaining native biodiversity in agricultural land requires clear goal setting and integrated management (Norton and Reid 2013). Without integrated planning, revegetation works and biodiversity conservation are unlikely to be included in the farm business plan. The realities of running a farm business mean that these activities often assume a lower priority than other aspects of farm management, especially when economic conditions are difficult. Because of the significant costs of restoring tree cover and conserving biodiversity and the reluctance of most legislatures to fund public-good conservation on private land, successful revegetation and on-farm biodiversity conservation require a financially viable farming operation to fund the on-ground works (Norton and Reid 2013).

Much of the Northern Tablelands of New South Wales (NSW) has been developed by applying phosphorus and sulfur-based fertilisers to address the issue of naturally nutrient-deficient soils, as well as by sowing and spreading the seed of legumes and introduced pasture grasses to address the region's winter feed drought (McDonald 1968). Through this form of 'pasture improvement', and with the extra production from some of the native pasture species in response to fertiliser addition (Cook *et al*. 1976), Northern Tablelands grazing systems have been changed to the point where a return to pre-European landscapes while retaining a productive grazing business is unlikely, if not impossible. Pasture development has increased the production of food and fibre by between 4 and 10 times (Langlands and Bowles 1974). At the same time, farmers are under increasing pressure from society to improve land stewardship and biodiversity outcomes on farmland (Norton and Reid 2013). This is a good thing, but there is a poor understanding by the wider community as well as among scientists and farmers as to the degree to which revegetation and restoration of native biodiversity in farmland can be achieved, how it can be achieved in a cost-effective manner, and who should pay for such work (Balmford and Whitten 2003; Productivity Commission 2004; Martin and Shepheard 2011; Martin 2016). The issue is how to find a balance between production, long-term sustainability and biodiversity conservation.

In the early 1980s, my late father, John, and I decided to try to reverse the effects of New England dieback, which had increasingly afflicted the region since the commencement of widespread pasture improvement in the early 1950s (Mackay *et al*. 1984; Taylor *et al*. 2003). New England dieback is the chronic defoliation of eucalypts (*Eucalyptus* spp.) by a wide range of herbivorous insects, but particularly scarab beetles that have an underground larval phase and whose numbers increased markedly as a result of pasture improvement and the decline in natural control agents due to farmland development (Lowman and Heatwole 1992; Campbell and Brown 1995; Reid and Landsberg 2000). Other suggested causes of dieback include the more extreme micro-climate due to increased landscape exposure, hydrological change, soil compaction and increased nutrient cycling caused by increased livestock numbers (Lowman and Heatwole 1993). Dieback killed and debilitated millions of farmland eucalypts in the region's more intensively developed grazing lands in the 1970s and 1980s.

Our principal motivation was to reverse the loss of shade and shelter for livestock, pastures and people across the farm. Although we had no data, we were convinced that the farm micro-environment had become more extreme as a result of dieback (colder in winter, drier in summer), and we were concerned that the property would end up with virtually no effective tree cover. My interest in revegetating parts of 'Eastlake' was fuelled by the 'Focus on Farm Trees Conference' in Armidale, NSW, in 1984 (Hofler 1984). The conference heard about the effects and advantages of shelter for livestock and pastures (Bird 1984; Bird *et al*. 1984), the revegetation of degraded farmscapes elsewhere in Australia, and the role of natural invertebrate and vertebrate biocontrol agents in managing pasture pests (Davidson 1980, 1984). By the late 1980s, once we had begun to revegetate 'Eastlake', aesthetics and the amenity of restoring tree cover across the farm became important motivations, as well as the potential for a positive impact on the property's capital value. More recently, the challenge of restoring native biodiversity to the farm has become an important objective, as well.

To finance the revegetation of 'Eastlake', we decided to allocate a budget line each year for restoration and native vegetation protection works, just as we would for other longer term investments like fertiliser or fencing. This approach minimised and spread the risks associated with short-term spending to generate longer term returns. Some graziers argued that they could not afford to invest in restoring woody vegetation, given the potentially long delay in return on investment. However, we were convinced by the research on the impact of shade and shelter on pastures and livestock returns (Bird 1984; Bird *et al*. 1984) that restoring tree cover would be profitable for our farm business. I reasoned in 1985 that if we were spending \$5000 p.a. in cash on drenches, it was reasonable to outlay \$2000 p.a. cash for re-establishing tree cover.

In 1984, Dr R. L. Davidson at the 'Focus on Farm Trees Conference' stated: 'A survey of landholder attitudes to the [South Australian Native Vegetation Retention] Scheme (Craig *et al*. 1983) suggests that more definite arguments are needed to prove that wholesale clearing is uneconomic compared with a planned vegetation retention scheme.' The question that arises is how much more do we know now, and more importantly how well has it been publicised and extended?

The aim of this paper is to document the restoration of woody vegetation to our family farm, 'Eastlake', initially mainly introduced species of tree and shrub, but now principally native species. Our objectives are to: (1) explain the reasons for our long-term investment in revegetation; (2) publicise our restoration efforts as a case study in farmland restoration; (3) persuade others of the benefits of farmland restoration through revegetation and conservation of remnant vegetation in the region and beyond, and (4) argue that further monitoring and research is required to better understand the collateral benefits of farmland biodiversity restoration and conservation for farm businesses, regional sustainability and the health and wellbeing of rural communities.

Property description

'Eastlake' (30.82°S, 151.64°E; 1202 ha) is situated on the Northern Tablelands of NSW, 20 km east of the Great Divide and approximately half way between Uralla and Walcha. Altitude varies between 1069 m and 1166 m a.s.l. The geology is mainly varying types of metasedimentary parent material ('trap' rock) overlain by relatively infertile duplex soils. These trap soils are mainly red and yellow chromosols on mid and lower slopes, skeletal gravelly soils on ridgelines, and sodosols with lighter shallower A horizons lower in the landscape in the east of the property. An area of 275 ha of 'East Lake Adamellite' (Pogson and Hitchins 1973) occurs in the central part of the property in the Neils and House Paddock Block sections, associated with somewhat heavier-textured, more fertile soils (Fig. 1).

The climate is temperate with mild summers and cool winters. The nearest Bureau of Meteorology weather stations recording both precipitation and temperature over time-spans of several decades are Uralla and Walcha (Table 1), with mean maximum daily temperatures of 25–26°C in January, mean minima of −2–0°C in July, and up to 75 frost days p.a. (BoM 2017). Mean annual rainfall is ~800 mm, with an average of 78 rain days (≥1 mm) per year with a slight summer dominance (~60% of rain falling between October and March). Annual and monthly precipitation is variable, with recorded annual totals varying between 479 and 1348 mm and monthly totals varying between 9 and 285 mm in January and between 2 and 213 mm in July (Uralla, 1901–2017; BoM 2017).

The property was originally watered by Mihi and Jacks Creek (Fig. 1), and is now watered by numerous farm dams as well as a reticulated water system fed by a 500-ML dam on Jacks Creek.

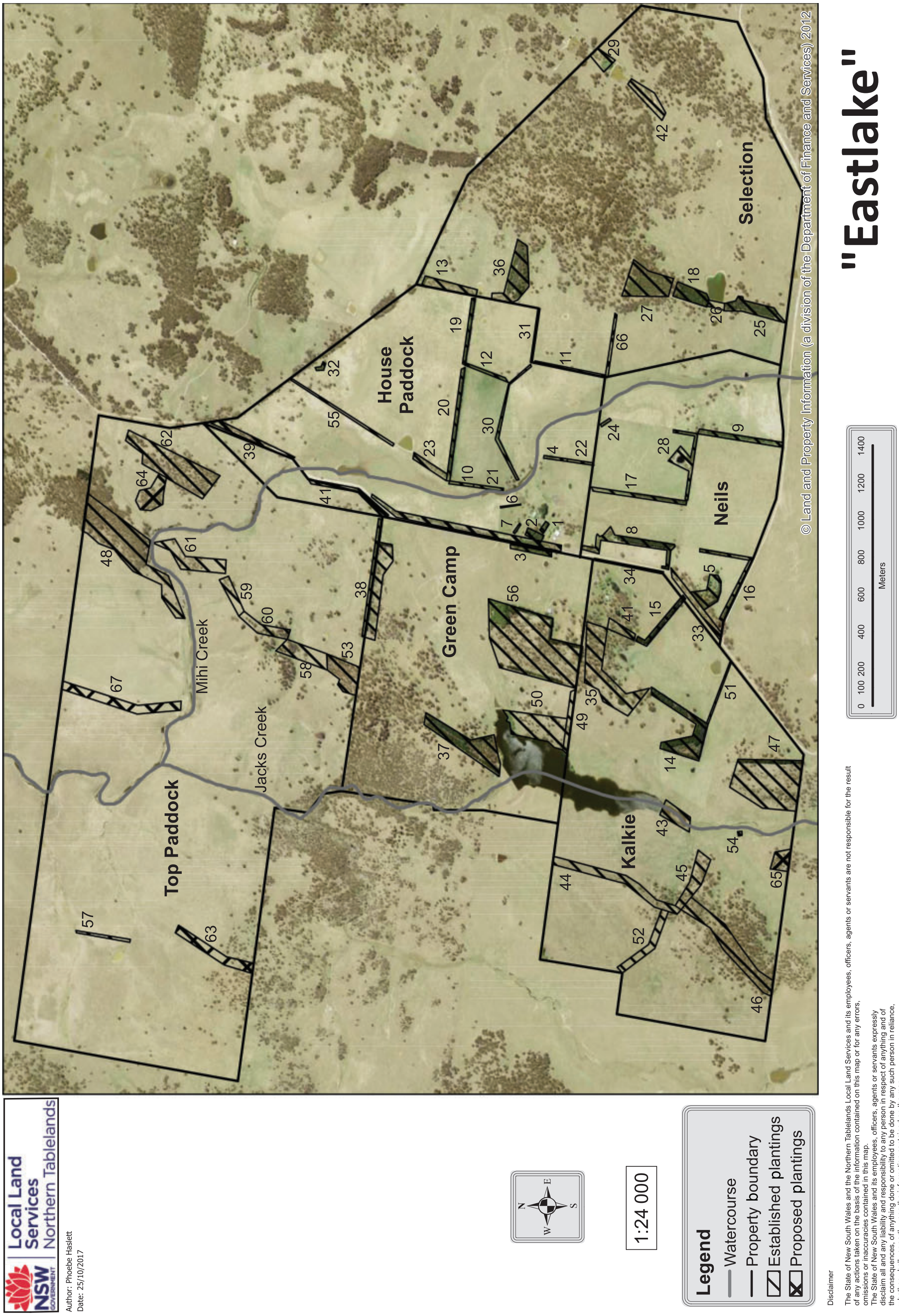

Fig. 1. The current state of the 'Eastlake' farm revegetation plan (source: Phoebe Haslett, Northern Tablelands Local Land Services).

Table 1. Long-term climatic data for the 'Eastlake' district, Northern Tablelands of NSW

Weather stations are Uralla (station no. 056034, 1012 m a.s.l., 30.64°S, 151.49°E) and Walcha Post Office (station no. 056035, 1050 m a.s.l., 30.99°S, 151.59°E). Each station collected temperature and rainfall data over different periods of time. Source: BoM (2017)

Weather station	Month												Annual
	J	F	M	A	M	J	J	A	S	O	N	D	
Uralla													
Mean max temp (°C)[A]	26.4	25.7	24.0	20.0	15.8	12.8	11.8	13.3	17.0	20.0	23.6	25.9	19.7
Mean min temp (°C)[A]	12.5	12.7	11.1	6.8	3.0	0.9	–0.4	0.4	2.8	6.2	8.7	11.1	6.3
Mean rainfall (mm)[B]	104.5	83.5	60.3	40.0	44.9	53.8	56.1	54.8	53.3	71.9	85.5	87.8	795.2
Mean no. of rain days (≥1 mm)[B]	7.7	7.0	5.9	4.6	5.1	6.4	6.6	6.3	5.9	7.1	7.9	7.8	78.3
Walcha Post Office													
Mean max temp (°C)[C]	25.3	25.2	23.1	20.3	15.5	12.7	11.9	12.7	16.2	19.9	22.5	24.7	19.2
Mean min temp (°C)[C]	11.6	12.1	9.7	5.5	1.3	0.0	–2.0	–0.2	1.8	5.6	7.8	10.4	5.3
Mean rainfall (mm)[D]	103.9	86.3	63.1	44.8	46.2	58.6	54.4	53.4	56.1	70.7	80.8	90.0	807.8
Mean no. of rain days (≥1 mm)[D]	7.6	6.5	5.8	4.9	5.5	6.8	6.4	6.7	6.3	7.2	7.3	7.4	78.4

[A]Data for 27 years (1938–1967).
[B]Data for 107–112 years (1901–2017).
[C]Data for 16 years (1957–1975).
[D]Data for 113–115 years (1879–1996).

The country was 'rung' (i.e. the timber was ring-barked to increase pasture production) in the early 1900s, leaving some elevated areas of stringybark (*Eucalyptus* spp.) and open eucalypt woodland lower in the landscape in certain parts. Pastures were affected by European rabbits (*Oryctolagus cuniculus*) until the mid 1950s. When the property was purchased by my grandfather in 1931, the pastures were native and 'unimproved' (i.e. unamended with fertiliser or introduced seed). Beginning in the 1950s, the whole property was fertilised aerially with superphosphate and clover seed, sometimes with ryegrass, cocksfoot and fescue seed, as well. About 30% of the property (and 70% of the Neils and House Paddock Block) were ploughed or direct-drilled between the 1960s and 1990s to establish cool-season temperate pastures, although some sown pastures retain or have been partly recolonised by native species (e.g. weeping grass *Microlaena stipoides* (Labill.) R.Br., red grass *Bothriochloa macra* (Steud.) S.T.Blake, Parramatta grass *Sporobolus creber* De Nardi, and paddock lovegrass *Eragrostis leptostachya* (R.Br.) Steud). Generally pastures have only needed to be sown once due to annual applications of superphosphate and conservative stocking, coupled with pasture spelling (Cook *et al*. 1978*a*) in some blocks, and they remain productive due to the retention of sown species as well as production from the native species where they occur. Currently, the whole property is ground-fertilised annually, generally with single superphosphate at a rate of 1 kg P DSE^{-1}, to account for farm-gate losses of P and S (Table 2). In 2017, we will spread 600 t of lime on the adamellite soils (2.5 t ha^{-1}) based on soil tests and agronomic advice, to manage an aluminium toxicity issue. This should increase topsoil pH_{Ca} by ~0.5 unit and raise the topsoil pH to ~5.3 (in $CaCl_2$). Acidity has not significantly changed over 60 years of pasture improvement, so acidification itself is not the problem.

Initially there were seven large paddocks and five smaller holding areas. We set about subdividing the property by land class, based on slope, aspect and soil type, in order to use the different land classes to best advantage. The ridgelines on 'Eastlake' mainly run north–south and are best suited to native trees and shrubs. Upper slopes grow a range of native pastures, whose productivity and phenology vary with aspect and soil depth. Lower slopes support more productive pastures with a higher proportion of sown exotic species, and some of the flats can support occasional fodder cropping (but are not currently used for this). The different pasture types are grazed and spelled according to their seasonal growth patterns and seeding cycles. There are now 55 paddocks fenced as far as possible to land class and pasture type. As the native vegetation program proceeds and ridgelines are fenced to protect or replant native timber and form upland native vegetation corridors to shelter livestock and pastures and for fauna and flora (Table 2), we continue to subdivide the country downslope into similar land classes of ~10–70 ha for improved grazing outcomes.

Enterprises and grazing management

From 1931 to the early 1950s, my grandfather and father ran a fine-wool breeding enterprise with up to 50 cattle, or a maximum of ~3500 DSE (~2.9 DSE ha^{-1}). With pasture improvement, livestock numbers rose to 12 000 DSE (10.0 DSE ha^{-1}), with a 4-fold increase in meat and wool production. The enterprise mix consisted of one-third cattle up to the late 1990s. Subsequently the farm was leased for grazing, with varying mixes of sheep (60–65%) and cattle between 2001 and 2010, and all cattle thereafter. Since 2000, total stock numbers have been reduced to ~9100 DSE (7.6 DSE ha^{-1}) and as low as 6500 DSE (5.4 DSE ha^{-1}) in dry seasons. For the past 3 years, we have leased 'Eastlake' to a neighbour to grass fatten or background weaner and yearling cattle. The changes in enterprise mix have not altered the revegetation approach, other than the need for stronger fencing with cattle and increased eucalypt regeneration in some areas, in the absence of sheep. Leasing the property has allowed me more time to focus on revegetation when not employed overseas (2001–2005), and the evolving revegetation program has not hindered and may have assisted in attracting lessees due to the enhanced shelter.

Grazing management is adaptive and based on set-stocking 85% of the time and adapting to conditions the rest of the time by

Table 2. Design and revegetation principles for biodiversity conservation and restoration at 'Eastlake'

Principle	Rationale
Right tree, right place, right purpose	It is important to plant right tree or shrub in right place for right purpose, as even small variations in slope, aspect, soil type or elevation can mean difference between success and failure, and planting wrong species of tree can reduce ecosystem service provision. Radiata pines thrive in mid-slope and upland positions across 'Eastlake', but eucalypts provide a wider range of ecosystem services
Non-local natives have a role	Many native tree and shrub species from elsewhere in region have flourished at 'Eastlake', increasing diversity of restored vegetation and its resilience to environmental change
Introduced trees and shrubs have a role	Low-lying exposed parts of landscape are prone to severe frosts and waterlogging in wet periods and to becoming dry and hard in droughts, which few native trees or shrubs can tolerate. Such conditions have probably been exacerbated by woodland clearing in more intensively developed landscapes. Introduced woody species may be needed for shelter and amenity in such situations and to increase diversity and resilience of restored vegetation
Prioritise ridgelines for shelter, habitat and connectivity	Most remnant stands of timber on 'Eastlake' occur higher in landscape and atop ridges, as a result of historic thinning and clearing and widespread loss of trees to dieback lower in landscape. Ridgelines are also best position to re-establish timber for far-reaching shelter benefits. Hence 'Eastlake' revegetation strategy focuses on establishing ridgeline corridors of trees and shrubs to provide maximal shelter for least cost (upland pastures on skeletal soils are not as productive as lowland pastures), as well as providing connecting vegetation between remnants for native fauna habitat and dispersal
Conserve and enhance native biodiversity (within production limits) for free ecosystem services, some of which improve bottom line	Native flora and fauna provide a range of free services that sustain farm production and, appropriately managed, increase farm profitability. An example is grazing production from winter-active and year-long green native grasses (*Microlaena*, *Poa*, *Anthosachne* and *Rytidosperma* spp.) on trap soils in Selection Block, which provide feed in cooler months, provided they are spelled briefly during flowering and seeding in autumn and spring. Another example is shade and shelter benefits from native timber for pasture and livestock production. Areas of native and planted timber also support a range of bird species and native wildflowers of conservation concern, which is an important contribution to grazing industry's social licence to farm in region
Stock conservatively at all times	Conservative stocking is important in cooler part of year (Cook *et al*. 1978*a*) to retain a high proportion of sown pasture species, maintain high levels of production and avoid sown pasture degeneration. Where pasture composition suffers because higher numbers of stock are retained for longer than desirable in a dry spell, graze pasture more conservatively subsequently in appropriate seasons to restore abundance of desirable pasture species. Aim to maintain at least 80% (and preferably 95–100%) groundcover 95% of the time, and pasture biomass (for cattle) in range 1.5–3.0 t dry weight ha^{-1}
Spell pastures at flowering and seeding times to increase abundance of desirable grass species	Importance of strategic grazing to favour desirable pasture composition is well established (Whalley and Lodge 1986; Firn *et al*. 2013). A desirable abundance of year-long green and cool-season perennial native grasses is maintained by spelling native pastures on trap soils over a 6-week period (or so) during flowering and seeding of these species in autumn and spring. We also spell sown pastures in mid-summer when native pastures are grazed more heavily to keep them vegetative. The growth of sown species during this period remains more palatable to livestock later on
Top dress pastures with superphosphate annually to replace P and S lost in export of livestock and wool	Research shows that annual application of superphosphate to replace P and S lost through livestock export is important to avoid soil nutrient depletion and sown pasture degeneration (Cook *et al*. 1978*a*, 1978*b*). Annual fertiliser application coupled with appropriate grazing management has seen introduced pasture species persist with only a small percentage of sown pastures needing to be resown in 65 years
Integrate spatial farm planning in business plan	All farm operations must be integrated in farm business planning so that physical infrastructure development and revegetation works (fencing, water, shelter, access, stock movements, etc.) are included in annual and longer term financial plans

varying grazing pressure or spelling. Stocking rate is adjusted seasonally to cater for the greater pasture productivity in summer than winter, and for reduced pasture productivity in dry seasons. Grazing management is largely dictated by groundcover and pasture biomass, with the aim of maintaining at least 80% (and preferably 95–100%) groundcover 95% of the time. Given the current lease arrangement with the cattle backgrounding enterprise, I prefer to see pasture biomass maintained in the range 1.5–3.0 t dry weight ha^{-1} (MLA 2017). If pasture drops below these thresholds, for instance due to lack of rain, then the stocking rate is reduced in subsequent seasons until the pasture has recovered. With the variation in pasture types across the property, native pastures on some of the lighter shallower soils in the Selection Block are spelled twice a year to encourage cool-season and year-long green palatable perennial grasses (i.e. wallaby grasses *Rytidosperma* spp., tussock poa *Poa sieberiana* Spreng., wheat grass *Anthosachne scabra* (R.Br.) Nevski, and *Microlaena stipoides*). These pastures are spelled for ~6 weeks in spring

Table 3. Eastlake balance sheet for selected financial years (ending 30 June) between 1981 and 2017

Year	Farm income ($000)	Farm expenses ($000)	Net farm result ($000)[A]	Wool (c/kg)	Net off-farm result ($000)[B]	Annual rainfall at 'Eastlake'[C] (mm)
1981	84	55	29	316	0	488
1989	530	146	384	1658	13	736
1990	446	171	275	1182	27	872
1991	295	127	168	1078	23	795
1992	134	154	(20)	625	25	574
1993	157	150	7	545	32	670
1994	187	110	100	780	23	615
1995	242	130	112	1250	30	583
1996[D]	155	122	33	850	30	941
2001–2005	60	7	53	–	35	–
2006–2017	89–100[E]	25–30	64–70	–	60	–

[A]Net result is before tax and owner/operator salary.
[B]Investments plus superannuation, all which were initially derived from farm income.
[C]Rainfall for the financial year, 1 July–30 June.
[D]Estimates of financial data.
[E]Increasing by $1000 p.a.

(October–November) and autumn (April–May), timed to allow these species to reproduce, seed and establish new seedling populations (Table 2).

Pastures are top dressed with superphosphate annually to replace the nutrients lost in livestock exports (Table 2).

Farm finances

Since the 1950s, property improvements, including buildings, fences, dams, pastures and some off-farm investments have all been financed from farm profits and surpluses, with some occasional short-term borrowings. We have always maintained good equity levels. The native vegetation program at 'Eastlake' has been funded each year by maintaining profitability in almost all years despite variable farm income (Table 3). With the current leasing arrangement, we obtain an annual return of 1.75% on capital, while upgrading much of the farm capital infrastructure through new fencing and native vegetation. The lessees aim for yearling or weaner cattle weight gains of at least 4 kg week^{-1} averaged over the year (varying from 0 kg week^{-1} at times in winter to 10 kg week^{-1} under good seasonal conditions in spring), providing an estimated 12–15% return on working capital (leasing and livestock costs). Greater liveweight gains could be achieved, but with our type of country, the aim is to maximise profit rather than production while maintaining if not improving the pasture resource base.

The past 36 years of revegetation works have been self-financed to ~85%, with the balance consisting of subsidies from Landcare, the Northern Tablelands Local Land Services (LLS, and the predecessor catchment management authority) and, in the early years, a native vegetation research project led by Dr David Curtis. Over the past 10 years, grants from Landcare and the LLS of ~$55 000 have helped us undertake native plantings, direct seeding and encourage natural regeneration. It has cost about the same again ($55 000) for labour (mine and some casual fencing) and $55 000 of our cash for native plants and seed, fencing materials and watering equipment. Between 1981 and 2000, we funded 95% of the revegetation ourselves. Without grants, we probably would have achieved only half of the on-ground works in the past 10 years. Over the 36 years of the revegetation program, we have spent $450 000 (in today's dollars), of which ~$80 000 (15–20%) were grants, at an average of $12 000 p.a. (for the cost of trees and planting, including labour) and $3000 p.a. on fencing specifically for trees. This compares with an annual average spend over the past 36 years of: (1) $3000 p.a. on maintenance of internal subdivisional fencing unrelated to tree cover restoration; (2) $2000 p.a. for a half share of maintaining the 18.5 km of boundary fencing (maintaining and rebuilding an average of 0.5 km p.a.), and (3) $2000 p.a. on water infrastructure (e.g. building, desilting and repairing dams, piping and troughs, excluding my labour). In the 1950s and 1960s, we spent $0.5 million (in today's dollars) on dams, including the large 500 ML storage from which we reticulate water across most of the property.

Planning revegetation and biodiversity conservation in the context of the farm business

Farming is a complex, high-cost, high-risk business with low returns to capital (<2% for small to medium-sized grazing properties in Australia; Malcolm *et al*. 2005; ABARES 2016*a*), although the farm itself should generate a long-term capital gain (Valuer General 2016). Farmers face climatic and market fluctuations, and often substantial finance is required to address short-term business risks as well as more predictable outlays on infrastructure and equipment. The tyranny of the urgent means it can be difficult to prioritise funds for long-term (10–30-year) returns. As farmers have to largely fund revegetation themselves, it is often problematic to prioritise surplus cash for investment in environmental endeavours with long financial return times. However, much can be achieved if a long-term plan is developed and acted upon. A good plan integrates environmental initiatives into the whole-farm business and requires sound strategic business, financial and environmental planning for both the short and longer term and good day-to-day operational and management decision making that is aligned with short and longer term strategic goals (Table 2). The plan needs to be progressively fine-tuned and updated, based on experience and changing circumstances. Commitment is required to implement a worthwhile plan, both in terms of labour and financial outlay.

In the early days, I had a spatial plan of the farm in my head. I subsequently used a hand-drawn map of the farm to assist with planning the location of revegetation. Ten years ago I moved to an aerial photograph enlargement and transparent overlays (Fig. 1). Most of the remaining native timber occurs on higher ground and most of the restoration plantings are similarly planned along ridgelines to link remnants, to form a network of upland vegetation corridors. Existing natural vegetation is progressively fenced off or enriched with plantings or direct seeding where the timber is sparse. New corridors are planned to extend out from remnants to shelter pastures and livestock and provide wildlife habitat and dispersal pathways. Noxious weeds and pest animals can be a cost burden and are managed, as required, in the corridor network.

Design and restoration principles

Achieving successful woody plant revegetation is only possible with good planning and ground preparation, correct planting techniques, appropriate tree and shrub species, and the control of weeds for 6–8 months after planting ('after-care'). All of this can be difficult to fit into the work schedule around other farming priorities.

Several principles have been reinforced through our experience with revegetation and farmland biodiversity conservation (Table 2). The first is 'right tree, right place, right purpose'. Learning which species will grow in which topographic positions and soils across the farm, whether they are best planted as seedling tubestock or can be direct-seeded, and ensuring each species is in the right place to fulfil important ecosystem functions (e.g. nectar-producing shrubs beneath dieback-affected eucalypts) is important. We have been assisted with species selection over the years by publicly funded extension officers and local farm foresters and suppliers of trees and shrubs. We prefer to plant a range of species to minimise the risk of poor species selection and to undertake small amounts of revegetation at a time, to minimise losses if seasonal conditions or pre or post-planting care are problematic.

Utilising remnant vegetation as a building block and starting point, and extending and linking such areas by revegetation has been successful in extending both the area and amount of pasture and livestock shelter, and wildlife habitat. Similarly, by focusing on revegetating ridgelines where most of the remnant timber occurs and linking such areas increases the efficacy of the ridgeline shelter and habitat connectivity.

Species selection and revegetation methods

In the early 1980s, we mainly planted exotic tree species such as radiata pine (*Pinus radiata* D.Don) to close up the landscape and restore shelter (Table 4). Given the sensitivity of many native trees and shrubs to frost and waterlogging, we intended to create a less extreme environment suitable for the reintroduction of native species. We also hoped that the radiata pines would provide a potential income stream from the sale of the timber (now unlikely). At the time, knowledge was limited and the range of native alternatives available was restricted. Between 1980 and 2006, we planted radiata pine and cypress (*Cupressus lusitanica*, *C. arizonica* and *C.* × *leylandii*) for windbreaks; exotic shrubs, such as hawthorns (*Crataegus* spp.), japonicas (*Chaenomeles* spp.), pyracantha (*Pyracantha* sp.) and photinias (*Photinia* sp.); deciduous exotics such as oaks (*Quercus* spp.), elms (*Ulmus* spp.), poplars (*Populus* spp.) and robinias (*Robinia* spp.), and some native trees and shrubs (mainly locally occurring species). We direct-seeded acacias with some success, and also fenced upland stands of timber to encourage natural regeneration of the remnant vegetation. In 2001, we fenced out 500 m of eroding drainage line in the Selection Block, repaired the worst of the erosion and planted it with native shrubs and trees commonly found close to water.

We trialled different methods for restoring native vegetation. In sites lacking existing native trees and shrubs, we now generally plant seedlings, mainly BCC HIKO™ tubestock of eucalypts, wattles (*Acacia* spp.), hakeas (*Hakea* spp.), callistemons (*Callistemon* spp.), leptospermums (*Leptospermum* spp.) and blackthorn (*Bursaria spinosa* Cav.). In the past, we used speedlings (small seedlings grown in multi-celled trays with a root volume of ~21 mL) or larger native tubes such as stock from the former Forestry Commission of NSW, but we prefer the reliability of HIKO tubestock and usually plant thousands of such seedlings each year. The popular HIKO V-93 seedling tray contains 40 seedlings (cell depth and volume, 8.7 cm and 93 ml, respectively). Our current plantings are generally at least 40 m wide (to provide habitat for small birds; Forestry SA 2017) with around eight rows of trees and shrubs, costing \$5–6 per seedling if new fencing is required on all sides, or \$4–5 per seedling if an existing fence can be used on one side. Permanent seven-wire fencing is used, as lighter weight or electric fencing requires too much maintenance, particularly with cattle, and lasts around half the time.

To enrich scattered or degraded timber with little understorey, we often direct-seed native species (mainly acacias) in fenced ridgelines of New England stringybark (*Eucalyptus caliginosa* Blakely & McKie) and other eucalypts. By fencing such areas, we have also successfully encouraged the natural regeneration of eucalypts and understorey species, including palatable herbs such as chocolate lilies (*Dichopogon* spp.) that are generally only seen in ungrazed vegetation. Although livestock are excluded from fenced remnant vegetation, such areas may occasionally be stocked briefly, either for emergency shelter or for some other management purpose.

In recent years, we have introduced native species not found at 'Eastlake' but that occur elsewhere on the Northern Tablelands into plantings, and some have done very well (Table 2). These include *Eucalyptus acaciiformis* H.Deane & Maiden, *Hakea eriantha* R.Br., *Acacia rubida* A.Cunn., *A. fimbriata* A.Cunn. ex G.Don, *A. dealbata* Link, *Callistemon sieberi* DC., *C. pungens* Lumley & R.D.Spencer, *C. pityoides* F.Muell., *Leptospermum minutifolium* C.T.White and *Casuarina cunninghamiana* Miq. We also continue to plant some exotic trees and shrubs (various *Quercus*, *Ulmus* and *Populus* spp.), because in low-lying parts of the landscape subject to severe frosts, introduced species are the most likely to survive and prosper (i.e. right tree, right place, right purpose; Table 2).

Table 4. Timeline of important events, activities and changes in the 65-year history of pasture improvement at 'Eastlake'

Year	Land ownership	Livestock numbers	Pasture development		Timber cover and revegetation
1931	700 ha purchased by grandfather, Eric Williams	Stocked at 20–25% of current production (i.e. increasing from 2000 to 3500 DSE, as property area grew)	Unimproved native pastures		~20% of landscape had effective tree cover for shade and shelter
1935	Additional 200 ha purchased				
1948	Additional 302 ha purchased				Dense stringybark regrowth over half of 302-ha addition was ring-barked and 'sucker-bashed' (lignotuberous seedlings dug out with a mattock) in 2 years after purchase
Early 1950s			Pasture improvement began in early 1950s	Up to 30% of farm sown to improved pasture	
1955		Stock numbers gradually increased to around 9000–10 000 DSE (70% sheep, 30% cattle) apart from drought years			
1958			Aerial top dressing of whole farm commenced in 1958 with superphosphate and clover and grass seed and has continued ever since, changing to ground-spread from 1990		
1970s					Severe eucalypt dieback and loss of timber cover
1981					Revegetation initially mainly with exotic species (80%). Commenced plantings and direct seeding with native species in 1980s, both trial and larger areas. Greater use of natives through time
1990					
2000				From 1980s, native pastures managed by (1) subdivision based on land class (slope, aspect and soil type), and (2) adaptive grazing (stocking or spelling) varying with season to improve pasture composition and productivity	
2001	Property maintained at present size of 1202 ha	Farm leased for sheep (60%) and cattle production (limited to 9100 DSE in good years, less in drought)			No revegetation due to overseas employment
2005					
2007					Revegetation plantings recommenced, much (80%) with subsidised funding from Landcare and Local Land Services with predominantly native species (95%)
2010					
2010		Farm leased only for cattle			
2014		Farm re-leased to neighbour for grass fattening and backgrounding of weaner and yearling cattle			
2017					Around 8% of farm in tree enclosures (normally unstocked), with total woody vegetation around 15%

Revegetation achievements at 'Eastlake'

Since commencing our native timber restoration and revegetation program at 'Eastlake' 36 years ago, we have incorporated ~8% of the property in fenced and planted windbreaks and shelterbelts or remnant timber to regenerate native vegetation (Fig. 1). This has been achieved through planning, hard work and funding restoration works from the annual budget in most years. Overall, a total of ~15% of the farm has some form of tree cover, coming off a low base of 8% in 1980 before the commencement of revegetation. If 15% of the farm had been naturally occurring tree cover and conserved by previous generations simply by fencing out timber, the cost would have been less than half of our costs of revegetation and remnant protection.

We have an area of lighter metasedimentary country in the Selection Block, which has naturally regenerated with eucalypts to the point that in places there is too much, despite annual fertiliser applications of superphosphate and more or less continuous grazing by cattle for the past 15 years. The cattle have been set-stocked apart from strategic spelling of the native pastures in most springs and autumns for 4–6 weeks to allow cool-season grasses to seed and regenerate. Abundant eucalypt regeneration under continuous cattle grazing has been noticed elsewhere in the region (Reid and Landsberg 2000). I suspect cattle do not graze as closely to the ground or as selectively as sheep, and unlike sheep avoid browsing eucalypts.

Ornithologist, Dr Andrew Huggett, monitored bird populations at 'Eastlake' from 2011 to 2016. His research shows that woodland birds of conservation concern (Reid 1999) occur at 'Eastlake' and that revegetation as well as remnant timber are habitat for these species (A. Huggett, pers. comm.):

> . . . patches of remnant woodland are the core areas of woodland bird foraging and breeding activity, including threatened species such as Little Eagle [*Hieraaetus morphnoides*], Varied Sittella [*Daphoenositta chrysoptera*], Scarlet Robin [*Petroica multicolor*], and known decliners on the highly fragmented Northern Tablelands [of NSW] including Jacky Winter [*Microeca fascinans*], Satin Flycatcher [*Myiagra cyanoleuca*], Crested Shrike-tit [*Falcunculus frontatus*] and Dusky Woodswallow [*Artamus cyanopterus*] . . .
>
> Older revegetation (9–28+ year-old) [supports] a core group of woodland birds including some of these threatened and declining species. [The revegetation is] effectively augmenting the role of remnants on the property by providing key food resources and nest sites in this part of the fragmented [tablelands environment]. In time, we expect the amount and spatial layout of the revegetation, linking with the remnants, to improve the overall ecological connectivity, function and value of [the] farm . . .
>
> . . . younger revegetation (3–8 years-old) [is] currently providing food, local habitat linkages and in some cases, nest sites, for a group of more common, resilient bird species (Noisy Miner [*Manorina melanocephala*], Red Wattlebird [*Anthochaera carunculata*], Grey Butcherbird [*Cracticus torquatus*], Australian Magpie [*Gymnorhina tibicen*], Magpie-lark [*Grallina cyanocleuca*], Eastern Rosella [*Platycercus eximius*], Superb Fairy-wren [*Malurus cyaneus*], *etc.*). In time, however, we expect to see more of the core group of woodland-dependent bird species return to these plantings, especially where they are wide enough (40+ m) and connected to the ridgetop and upper slope remnants.

I believe the benefits of restoring timber cover to 'Eastlake' are: (1) the shelter for livestock from the extremes of both hot and cold, and similar shelter for pastures; (2) increased capital and intrinsic value of the farm, in excess of normal capital gain; (3) the fact that the farm is a more aesthetically pleasing and comfortable environment in which to live and work, and (4) the increased abundance and diversity of native flora and native birds, insects and other fauna, leading to increased resilience and profitability of the farm ecosystem through the provision of free ecosystem goods and services, such as shade and shelter, and natural pest control against dieback-causing agents such as scarab beetles. In relation to the last point, we have not had the huge numbers of Christmas beetles (*Anoplognathus* spp.) in the past 15 years at 'Eastlake' that characterised the worst of the dieback in the 1970s. Nor have naturally occurring stands of eucalypts declined in health or died on 'Eastlake' as they did in the 1970s, unlike remnant eucalypt cover in certain parts of the Northern Tablelands, which has deteriorated markedly in the past 10 years.

Future planned activities

What of the future? The target is to achieve 10% of the farm as managed windbreaks in the next 5 years. Whenever a project is completed and I look at the farm plan or am out in the paddock, some extension to a previous planting or an idea for a new project comes to mind. More time, energy and money will be spent in planning and restoring 'Eastlake', not necessarily in the same way as in the past, but considering long-term needs and incorporating new ideas and information tempered with experience.

Discussion

Evaluation of achievements

Much of the original farm revegetation program envisaged over 30 years ago has been achieved. However, the plan has been adapted over time to suit changing circumstances, ideas and knowledge, and has grown in extent and vision. The benefits of the farm revegetation program at 'Eastlake' were described above. They are discussed below in relation to the emerging body of evidence of similar farmland benefits of revegetation elsewhere.

(1) Shade and shelter benefits from planted and restored tree cover. After 36 years of revegetating 'Eastlake', experiencing different parts of the farm under a wide variety of environmental conditions and monitoring the productivity and profitability of the various grazing enterprises, I believe that the research showing production gains in both pastures and livestock through the provision of shelter applies to my farm. The research that convinced us to act (Bird 1984; Bird *et al*. 1984) has been repeatedly confirmed in Australia (Bird *et al*. 1992, 2002; Abel *et al*. 1997; Nuberg 1998; Walpole 1999; Gillespie 2000; Cleugh *et al*. 2002; Cleugh 2003; Young *et al*. 2014) and elsewhere (Pollard 2006; Garrett 2009). My observations and experience suggest there have been both livestock and pasture production benefits at 'Eastlake': in cold weather, livestock move behind planted shelter, I assume to get out of the wind and cold, and in hot weather in relatively unshaded paddocks, stock congregate beneath single trees in the shade as a mob, but spread out in the shade behind a shelterbelt. Most other producers planting trees on their farms agree with me: 90–98% of NSW farmers in the wheat–sheep and high rainfall zones of NSW expect shade and shelter benefits from farm-tree plantings (Wilson *et al*. 1995).

My target of 18% tree cover across the farm in due course, with 10% of it revegetated in some form, may be a greater target than some are willing to concede. In the US, the National Agroforestry Centre recommends that 3–5% of farms can be planted to 'working trees' for the direct economic returns to the farm business (Brandle and Schoeneberger 2014). In Australia, Stewart and Reid (2006) argued that 10% multipurpose farm tree cover for shelter, land and remnant vegetation protection, and production of commercial tree products, could reduce risk and provide greater opportunities for farm families and local communities. Andrew Stewart's experience in revegetating his family farm in the Otway region of Victoria is that increasing tree cover from 3.5% tree cover in 1992 to 15% in 2008 has not lowered stocking rate, rather it has improved their prime lamb enterprise in various ways (Stewart and Reid 2008). Locally, the Taylor family have found that revegetating their property, 'The Hill', to 15–20% tree cover, most of it planted, has not lowered carrying capacity, rather it has provided a range of additional benefits and enterprises. Finally, Walpole (1999) showed for 31 farms in a mixed-farming district on the North West Slopes of NSW that the gross value of pasture output was maximal when the proportion of tree cover was 34% of farm area.

(2) Increased capital value of the property. I believe the capital value of 'Eastlake' is now greater than it would have been if we had not embarked on our revegetation program. This is more difficult to justify, as I have not had valuations conducted over time. As a keen observer of the regional market over many years, however, advertised property with appropriate shelter, either planted or natural, with other good infrastructure is always worth more than the opposite. Properties that might have invested heavily in high-intensity short-duration grazing systems can meet with buyer resistance, because such systems are not widely appreciated and the density of fencing and water infrastructure can sometimes appear problematic to potential purchasers. Nevertheless, I think our revegetation program is sufficiently flexible to cater for either rotational systems or our more traditional approach of mainly set-stocking. The literature is sparse in this regard, and more work would be useful, despite the relative ease with which revegetation programs and remnant vegetation can be valued using revealed-preference and stated-preference techniques. What work has been done suggests that in north-eastern Victoria and adjacent southern NSW, in a broad-acre farming region, the presence of remnant vegetation had a positive influence on farm purchase values by raising the value of the average property by 29%, although not if the proportion of the property was >50% native vegetation, as would be expected in a region largely comprised of grazing and mixed-farming properties (Walpole and Lockwood 1999). Similarly, in the South-East of South Australia, where rural land use is dominated by grazing, native vegetation not subject to mandatory heritage restrictions increased the value of rural holdings, although the relationship was not significant if the native vegetation was subject to a restrictive heritage agreement (Marano 2001).

In the case of 'Eastlake', I asked Steven Broun, Director and Senior Valuer with MVS New England & North West Pty Ltd, and with almost 30 years of rural property valuation experience, to comment on the impact of the revegetation on the capital value of the property. After inspecting the property and examining historical and current aerial photograph enlargements, Mr Broun (pers. comm., 12 December 2017) wrote:

> The piecemeal valuation approach is a well-recognised valuation approach in the valuation profession and is relevant in this estimation exercise. There are some areas of 'Eastlake' that have significantly benefited from revegetation (pine and native timbers) such as within approximately 1.1–1.2 km of the homestead area in every direction, estimated at approximately 550 ha, whilst other areas have received little or no benefit.
>
> The following piecemeal percentage estimates are a guide to the added value of the re-vegetation work carried out on 'Eastlake' to the land in the above described 550-ha area. Please note they are . . . not based on analysed sales evidence.
>
> – Land areas with close by/clearly visible recently established and well-established fenced-in native timber/shrub tree-dominant lots and small size (less than 4 ha) native re-vegetation areas within say 1.2 km of the homestead area: 5–7% added value to land value.
>
> – Land areas with close by/clearly visible recently established and well-established fenced in native timber/shrub, mixed pine/other tree lots less than 50 years, and small size (less than 4 ha) native re-vegetation areas within say 1.2 km of the homestead area: 3–5% added value to land value.
>
> – Land areas with close by/clearly visible long-established pine-only timber tree lots (less than 50 years old) within say 1.2 km of the homestead area 2% added value to land value.
>
> Any other re-vegetation areas on 'Eastlake', i.e. outside the 550 ha, are estimated to have 0% added value to the land.

(3) A more comfortable and aesthetically pleasing place to live and work. 'Eastlake' is intrinsically more valuable to me due to the revegetation program. This is due to the material comfort and aesthetic pleasure I gain from the modified environment, as well as the pride I feel in having protected and restored a substantial area of timber cover to the farm. My pride is increased by my belief that farm productivity, biodiversity value and resilience of the farm ecosystem to environmental change and future shocks have all increased due to the on-ground works. Little research has been undertaken to date on the relationships between farmland restoration and the psychological wellbeing of farmers in Australia. However, emerging evidence from Professor David Lindenmayer's long-term research of a link between the two on the South West Slopes of NSW has been suggested (Pedersen 2016). Indeed, the design of therapeutic and restorative landscapes for the treatment of psychological disorders dates back to the eighteenth and nineteenth centuries in Europe and North America (Paine 1999). Recent research has shown that engaging in natural resource management (NRM) activities in southern NSW had a positive effect on the wellbeing of most of the 113 farmers involved (Schirmer 2017). It was rare for the respondents to report negative effects of NRM involvement on their wellbeing, except for a few who reported that their finances had suffered. Of landholders who had entered into agreements, around half experienced an overall improvement in wellbeing, whereas the other half did not report any change. The positive impacts of engaging in NRM agreements were (1) increased self-efficacy, (2) improved health, and (3) feeling positive about identifying as farmers.

Given that access to mental health services, the culture of self-reliance and avoiding seeking help, and the high rate of rural suicide are major social concerns in regional Australia (RANZCP 2017), the effect of undertaking environmental restoration works on farmer wellbeing should be an important focus of future transdisciplinary research in sustainable agriculture.

(4) Increased abundance and diversity of native flora and fauna, and increased resilience and ecosystem service provision. The revegetation at 'Eastlake' provides habitat for a range of native bird species, including species that are declining in woodland habitats across the Northern Tablelands of NSW (Reid and Zirkler 2006) and across the wheat–sheep belt of south-eastern Australia more generally (Reid 1999). The observations of Dr A. Huggett (pers. comm.) are consistent with a mounting body of evidence of the positive impact of farmland revegetation on the abundance and diversity of fauna, including species of conservation concern (Kinross 2004; Barrett *et al.* 2008; Kinross and Nicol 2008; Lindenmayer *et al*. 2018).

What is less clear is the extent to which the increased biodiversity as a result of revegetation has increased the provision of ecosystem services (with the exception of shade and shelter, discussed above) and therefore the productivity, profitability and resilience of the farm ecosystem. We first learnt about linkages between native fauna and ecosystem health through the work of Dr R. L. Davidson (Davidson 1980, 1984; Davidson and Davidson 1992), which linked the chronic defoliation of New England eucalypts by Christmas beetles and other scarab beetles and defoliating insects to changes in grazed ecosystems dominated by pasture improvement, and the loss of the natural biological control agents (e.g. parasitic and parasitoid invertebrates) of the herbivorous insects from the landscape. Recent research has begun to document the benefits (and costs) of native fauna and their ecosystem service provision to farmland productivity (Norton and Reid 2013; Peisley *et al*. 2015, 2016; Saunders *et al*. 2016; Smith and Watson 2018), and this work should be extended to New England grazing properties.

We have increased plant biodiversity on the farm through the deliberate introduction of germplasm of locally occurring woody species from other parts of the region, as well as the introduction of native trees and shrubs from elsewhere in the region and introduced (exotic) species. We are also connecting ungrazed stands of naturally occurring timber across the property with ungrazed corridors of planted vegetation, which should permit greater dispersal and mixing of grazing-sensitive plants. All of these practices align with recommended strategies for natural resource management in the face of uncertainty about climate change and future potential ecosystem shocks (Millar *et al*. 2007). In addition, we have encouraged natural regeneration of the native vegetation, both in grazed and ungrazed reserves, permitting the regeneration of trees, shrubs and wildflowers that were previously in decline under sheep grazing. This has enhanced the biodiversity conservation value of the property.

There are wider benefits of the 'Eastlake' revegetation program than just to the property owners. 'Eastlake' is an extension resource in disseminating good practice in regional natural resource management. The farm has frequently been used since the 1980s for field days and inspections by extension officers, educators and students to demonstrate farmland revegetation practice and outcomes, as well as visits by interested individual primary producers, researchers and academics. A recent example was the field excursion by the *Restore*, *Regenerate*, *Revegetate* conference in February 2017. I provide this *pro bono* community service because I enjoy describing and explaining the background and philosophy of our pasture improvement and/or revegetation program and find it intellectually rewarding and helpful, as I am often challenged by visitors and forced to consider alternative perspectives, as well as gaining new ideas and information.

Our approach may be criticised for departing from the formula of putting back the original vegetation and trying to return the restored parts of the landscape to their pre-European state (or what we understand that to have been: Curtis 1989; Benson and Ashby 2000). Rather, we have opted to restore timber cover that generally consists of novel mixtures of introduced trees and shrubs, non-local native species from elsewhere in the region, as well as off-site provenances and seed sources of locally occurring species (Table 2). We have largely configured the restoration as ridgeline corridors linking and enriching stands of native timber, to maximise commercial production gains, rather than trying to restore the land according to local indigenous reference ecosystems (SRG SERA 2017). Our strategy has been influenced by practical considerations of running a commercial grazing operation as well as time, cost, lack of information and local germplasm, and the need to minimise the risk of failure due to environmental change and shocks, tempered by what we have found works. However, where success is likely and to minimise expense, we have also encouraged natural regeneration of the locally occurring native flora wherever possible to improve biodiversity conservation of the indigenous plants while increasing the extent of structurally complex vegetation (i.e. the primary goal).

Despite concerns about embracing novel ecosystems (Murcia *et al*. 2014), the approach of engineering novel ecosystems in the upland temperate environment of the Northern Tablelands is widespread across the region (Taylor *et al*. 2003; Southern New England Landcare 2008), doubtless for similar reasons to those underpinning the philosophy of the 'Eastlake' revegetation program. Norton and Reid (2013) acknowledged that biodiversity conservation goals in agricultural landscapes must be flexible and will often reflect the realities of current and likely future conditions, rather than trying to turn the clock back. In some parts of the Northern Tablelands of NSW, such as the Guyra plateau (60 km north of 'Eastlake'), heavy fertile soils, strong competition with sown pastures and more extreme exposure due to elevation (1400 m a.s.l.), dieback and clearing, pose a major challenge for restoring tree cover, particularly of native species. In these cases, exotic species may have an even greater role in re-establishing shelter in such situations, at least initially.

Some things have not turned out the way we expected. In hindsight, we might have planted less radiata pines, as they proved worthless for timber (due to the lack of silvicultural management and small quantity of the resource). The old trees will become a liability as they reach the end of their useful life at ~70 years. When we planted them, however, they offered quick shelter and a possible future timber income.

Native biodiversity and pasture productivity at 'Eastlake'

In addition to the sown pasture program and the introduction of seed of exotic grasses and legumes in 'Eastlake' pastures since the early 1950s, pasture management has focussed on maintaining well-fertilised native and naturalised pastures dominated by productive species of native grass, particularly year-long green and winter-active perennials (i.e. *Microlaena*, *Poa*, *Rytidosperma* and *Anthosachne* spp.), but also productive summer-active perennials (e.g. *Bothriochloa* and *Eragrostis* spp.). In other words, native plant biodiversity in the form of valuable forage species has underpinned a large part of the farm's productivity throughout the past 65 years of transformation. This has been the common experience of graziers, scientists and advisers across the NSW Tablelands throughout the period in question (Robinson and Lazenby 1976; Robinson and Archer 1988; Lodge and Whalley 1989; Simpson 1993; Reid *et al*. 2006).

Sector needs going forward

What do farmers and land managers need by way of assistance in planning and implementing farmland restoration programs for multiple economic, social and environmental benefits from native vegetation and revegetation going forward? Private individuals and farmers still manage or own most of the food and fibre producing land, with 58% of Australia's land mass dedicated to agricultural production (ABARES 2016*a*, 2016*b*). Given the pervasive societal expectation that private individuals should manage land sustainably in both the private and public interest (Industry Commission 1998), there is a continuing need for farmers to be assisted with this challenge in several ways. Indeed, most Australian farmers are yet to be persuaded that fencing native vegetation to control grazing, planting native vegetation or encouraging regrowth revegetation is worthwhile (Harris-Adams *et al*. 2012). Given the public-good aspects of revegetating farmland for environmental and perhaps social benefits, the first and most important need is for continuing public funding and cost-sharing in cooperative on-farm projects to assist land managers to commence and expand on sound revegetation and biodiversity conservation initiatives. More of this important work would be done if biodiversity conservation credits were paid to primary producers (Productivity Commission 2004). Every farm and farmer is different, not to mention within-farm environmental heterogeneity. Given the importance of farmland restoration and the various constraints to on-farm revegetation and other environmental initiatives, multiple ways of farmers and their advisers partnering with scientists and the community should be developed if realistic and sustainable farmland restoration outcomes are to be achieved in a timely manner.

Second, given the many knowledge gaps noted above, further investment in trans-disciplinary on-farm and regional-scale research is required to clarify and understand the short- and long-term scientific evidence to assist farmers to make robust decisions about:

(1) The ecosystem services and financial benefits that native vegetation and on-farm biodiversity provide farmers and the wider community (Harris-Adams *et al*. 2012; Saunders *et al*. 2016).

(2) As an example, whether revegetation programs are likely to significantly affect a farm's carbon balance through increases in aboveground and below-ground carbon stores. Recent research has focussed on property-scale carbon budgets (e.g. Eady *et al*. 2011), but farmers need simple ready-reckoner tools or 'apps' to help them decide whether farmland revegetation at a practical scale is likely to assist them achieve carbon neutrality in an emissions-conscious world.

(3) The regional and long-term value to biodiversity conservation of the emerging positive changes in declining woodland birds and other fauna of conservation concern in revegetated farmland. Existing programs monitoring the fauna associated with farmland restoration must be continued to evaluate regional and long-term benefits, and long-term monitoring projects are needed in those agricultural regions where such work has not yet commenced. Monitoring has been considered a 'Cinderella' science and is underfunded, if funded at all (Lindenmayer *et al*. 2018). This is wrong; monitoring is integral to adaptive management (Norton and Reid 2013) and must be funded accordingly. At 'Eastlake', Andrew Huggett's monitoring findings about birds of conservation concern and my own observations of grazing-sensitive plants regenerating in fenced timber enclosures have encouraged me to fence and link upland remnant timber with corridor plantings and ridgeline stepping stones, as well as widening planted corridors to 40–50 m width.

(4) The marketing potential of sustainably produced food and fibre. In Australia and the US, there is an increasing market for quality grass-fed meat with no antibiotics or grain supplementation (e.g. Coles Graze brand beef and a similar guaranteed product marketed by JBS). These market opportunities, although adding another layer of complexity to the farm business, can be financially worthwhile. The agricultural sector should be moving towards a future where farms with good biodiversity, shelter and a more agreeable environment and where extra animal welfare criteria are met and accredited, receive a premium for livestock products, and consumers should be an important part of ensuring it happens (Bridle and Bonney 2010).

Related to farmland restoration, there are further sustainability research questions that farmers and graziers would like definitive answers to. These questions include: (1) the role of conventional chemicals and fertilisers versus alternative fertilisers and minerals and 'soil biology' additives to farm productivity, profitability, sustainability and biodiversity. Revegetation (and farm management more generally) at 'Eastlake' makes use, where appropriate, of conventional farm chemicals. Are these chemicals damaging biodiversity and the long-term productivity and sustainability of the farm business? (2) The potential advantages of different grazing management systems, particularly high-intensity, short-duration grazing, are widely debated. At 'Eastlake', I have never seen the need to abandon my strategy of conservative adaptive grazing management based on set-stocking, with strategic spelling and reduced or heavy grazing as required, in order to maintain adequate groundcover, appropriate pasture biomass, and encourage winter-active palatable perennial grasses in certain native pasture types. This strategic approach to grazing management has served us well. Nevertheless, scientific debate about the strengths and weaknesses of alternative grazing management systems continues, including questions about the impact of different grazing systems on native biodiversity (Savory 1991; Earl and Jones 1996; Lodge *et al*. 2003; Teague *et al*. 2013; Briske *et al*. 2014).

Individual adaptation

An important point that should not be lost on researchers, extension agents, policy experts and decision makers is that it is not just about the management system, but how well individual farmers manage their particular system. A 'one-size-fits-all' approach to farm management extension and policy is a recipe for failure. Unfortunately, in NSW, we have floundered from crisis to crisis over the past 20 years for exactly this reason in the debate over native vegetation on farms. Each farm, farmer and the current set of circumstances facing them is unique, and so management and policy solutions must accommodate the need for individualistic solutions, allowing farmers to tailor their management to suit each situation. A focus on outcomes rather than prescriptions is required. The only constants in my experience that are a given, and these are non-negotiable outcomes, not prescriptions, is an overall management focus on (1) shelter for livestock and pastures, and (2) groundcover and pasture biomass in the case of grazing management. How one manages and adapts livestock numbers in time and space to suit changing conditions is up to the individual, and various grazing systems evidently work well for different managers. Equally, all such systems can fail in incompetent hands.

The current debate around managing native vegetation in NSW has raised many questions and exacerbated tensions. An outcomes-based focus on the need for long-term food security and environmentally sustainable production in rural Australia, and compromise between the more radical proposals at both extremes in the debate would be useful. The narrow mentality that characterises both extremes could be broken down by the introduction of well trained and well resourced staff to work with landholders to achieve sustainable commercial, environmental and social outcomes (Norton and Reid 2013). This new breed of rural ecologists need to be trained in biodiversity as well as rural science and in the art of talking with people, not talking at them. With their help, maybe farmers and the rest of society can forge a relationship based on mutual trust, respect and understanding, in the knowledge that both will benefit from safeguarding the future of native biodiversity in agricultural landscapes, and where all beneficiaries pay accordingly.

The need for farmers to customise their decision making for their preferred management system and current and likely set of circumstances highlights the importance of adaptive management and research and extension services for farmers to draw upon to further improve their individual farming systems. Whether these are high-input systems with high returns but more risk, or lower input systems with lower returns and production, but perhaps an equal or better financial bottom line over time, does not matter. Research is required to optimise decision making for the range of systems, and extension officers need to be able to provide the relevant advice skilfully and sensitively, to work within individual farmers' capacity, and challenge ingrained beliefs where these are not supported by the evidence or are unhelpful, no matter the system.

Conclusions

Managing a farm business is complex, and all the more complex if a revegetation and biodiversity restoration program is integrated in the business plan. I often reflect on a farm management analogy of Dr Keith Hutchinson, a former CSIRO pasture researcher: 'it's like rolling a marble around the outer part of a saucer, as close as possible to the edge without losing it and then trying to recapture it if control is lost, before it hits the floor'. A conservative slow-and-steady approach will generally be more successful and less risky, both in terms of grazing management and revegetation. Such an approach is all the more realistic given the financial constraints that farmers operate under, particularly as farmers are expected to foot part or all of the restoration bill for farmland revegetation, despite mounting evidence of the public-good benefits for biodiversity and society.

The principal motivation for embarking on our revegetation program was to restore and expand shelter for livestock and pastures across the property, and so the cost of annual works was included in the farm business plan as a long-term investment in farm sustainability. Within 10 years of commencing the revegetation program, aesthetics and amenity and the likely positive impact on the capital value of the property had become co-objectives. In the last decade or so, increasing the farm's resilience, biodiversity and ecosystem service provision, as well as providing habitat for native flora and fauna, have become important goals. I have documented our experience in restoring woody vegetation cover to our farm because it is important that society appreciates that some farmers, albeit perhaps a minority still (Harris-Adams *et al*. 2012), are receptive to new knowledge and changing community values about the role of native vegetation on farms, and are willing to co-invest with governments to achieve a mix of public and private goods and services from remnant and planted native vegetation and natural regeneration. Although individual producers will have their own preferred plans and means of revegetating farms with too little cover, I suspect all of the benefits that we have found are likely to apply generally, wherever revegetation is undertaken to restore shade and shelter to farms.

The key lessons for native vegetation management from my journey since 1971 and from our farm revegetation program since 1981 have been to: (1) plan, prepare, plant the right tree or shrub in the right place for the right purpose, and not to forget adequate post-planting care (the '4 Ps'); (2) integrate revegetation into the whole-farm business plan, based on proven science (not fads); (3) finance the work slowly over time with the aid of a farm plan and map, and (4) be prepared to adapt to change.

Perhaps the greatest challenge for the future is the need for all of us to consider and untangle the inherent complexity of how agricultural systems function at both local and regional scales, and ponder how biodiversity, farm and ecosystem management can be integrated across all scales to produce farming systems that benefit not only producers and consumers, but regional communities, society more generally and last, but not least, the long-term sustainability of our farmland. Sound long-term scientific research is required to better define the economic, social and environmental benefits of biodiversity in farming systems (and other land uses) throughout Australia. It will be important to differentiate between commercial benefits due to shade and shelter and economic benefits due to other ecosystem services, including contributions to environmental and social wellbeing and resilience. Otherwise, the respective value of individual services will remain clouded. The emerging evidence of productivity and psychological benefits from restoring farmland biodiversity is extremely encouraging in this respect.

Conflicts of Interest

The author declares no conflicts of interest.

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