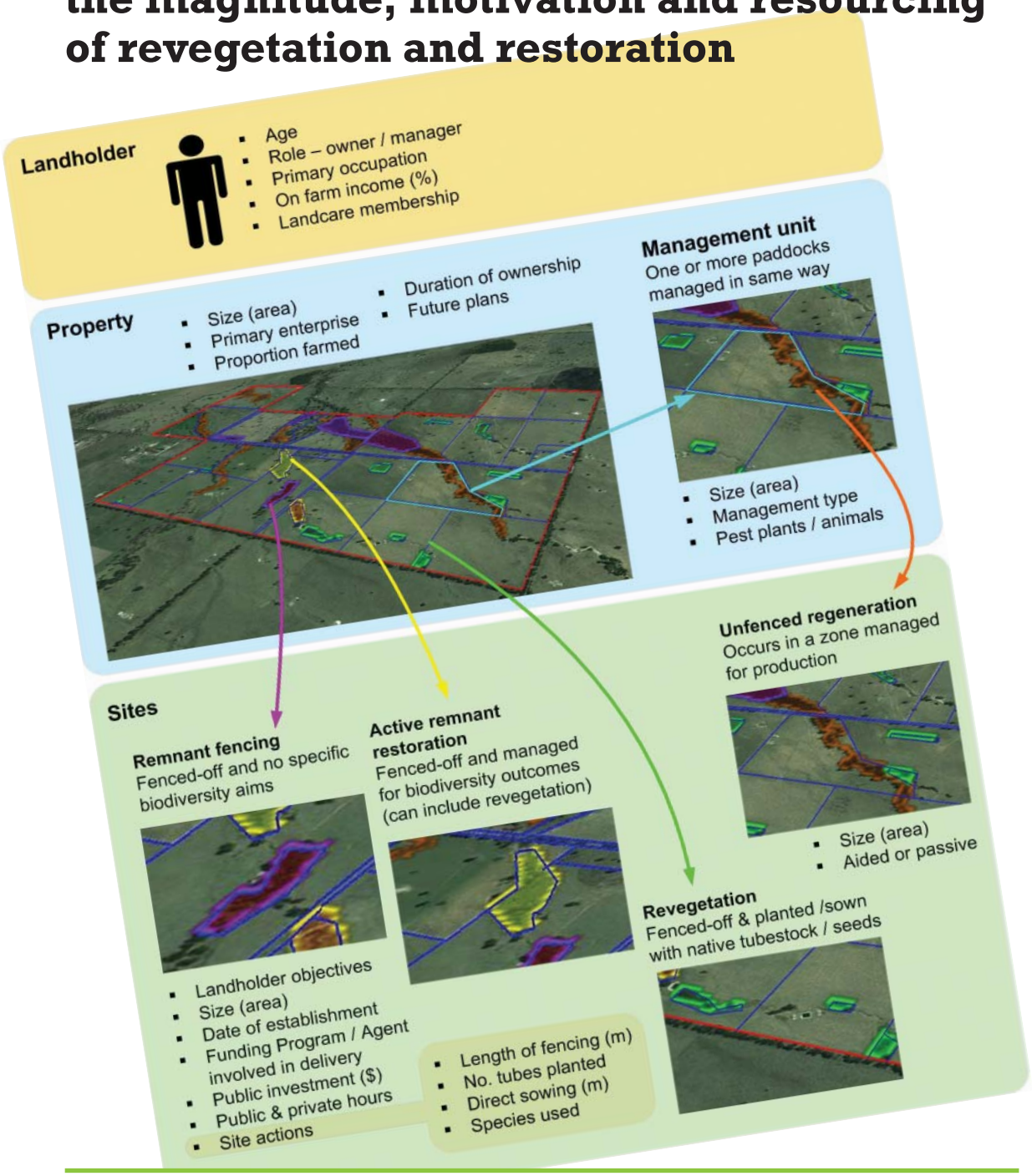
LANDSCAPE LOGIC

LINKING LAND AND WATER MANAGEMENT TO RESOURCE CONDITION TARGETS

Technical Report No. 23

Management of native vegetation on private land in northern Victoria: the magnitude, motivation and resourcing of revegetation and restoration



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Cover graphic: see figure 2 on page 8.

LANDSCAPE LOGIC is a research hub under the Commonwealth Environmental Research Facilities scheme, managed by the Department of Environment, Water Heritage and the Arts. It is a partnership between:

- **six regional organisations** – the North Central, North East & Goulburn–Broken Catchment Management Authorities in Victoria and the North, South and Cradle Coast Natural Resource Management organisations in Tasmania;
- **five research institutions** – University of Tasmania, Australian National University, RMIT University, Charles Sturt University and CSIRO; and
- **state land management agencies in Tasmania and Victoria** – the Tasmanian Department of Primary Industries & Water, Forestry Tasmania and the Victorian Department of Sustainability & Environment.

The purpose of Landscape Logic is to work in partnership with regional natural resource managers to develop decision-making approaches that improve the effectiveness of environmental management.

Landscape Logic aims to:

1. Develop better ways to organise existing knowledge and assumptions about links between land and water management and environmental outcomes.
2. Improve our understanding of the links between land management and environmental outcomes through historical studies of private and public investment into water quality and native vegetation condition.

Management of native vegetation on private land in northern Victoria: the magnitude, motivation and resourcing of revegetation and restoration

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Executive summary

Knowing how, where and why private land managers participate in native vegetation management through revegetation; and remnant fencing and restoration works is fundamental to understanding how landscape restoration goals are tracking, particularly where private land tenure is dominant.

We surveyed native vegetation management on 71 properties within three woodland bioregions on the north western slopes of the Great Dividing Range in Northern Victoria. We mapped all instances of native vegetation management and recorded the date, funding model and motivations of each site.

The properties selected for detailed mapping and interview were sampled from case study areas stratified according to the local prevalence of regeneration and revegetation identified from analysis of aerial ortho-photography. The 71 properties together accounted for 32,360 ha of land. The more than 400 revegetation, and native vegetation fencing and restoration sites accounted for 3264 ha or 10.1% of the total area.

1. An important reporting assumption about landscape change, the "times 2" assumption (i.e. ratio of 1:1 ha of public:privately funded vegetation management) was not supported by the data from these study areas. We found that the ratio declined over time from a 1:1 ratio in the 1980s to 10:1 now, largely due to a significant increase in public investment with programs such as NHT1 and NHT2.
2. Three main active forms of vegetation management were recognized with varying ratios of public:private investment as follows; revegetation 8:1, remnant fencing 10:1 and active remnant restoration 20:1.
3. These findings are in contrast to those of Ambrosio et al (2009) who concluded from their study of an overlapping geographic region that the x2 assumption was likely to be an under estimate. The primary difference appears to be that Ambrosio et al (2009) included all private in-kind contributions to vegetation management over the life of a particular site, not just the initial establishment costs which heavily weighted the private or unfunded component.
4. Importantly, while our new data suggest new reporting ratios, our regression modelling of annual private area revealed that private area is not closely related to, or predicted by, public area. The amount of private hectares had not declined over time despite the increasing scale of public investment. This suggests that ratios may not provide a good basis for reporting likely total area change.
5. A trend was observed in the motivation for undertaking vegetation management from multiple values including the utilitarian values of land rehabilitation, shelter and firewood to a greater nature conservation orientation including habitat protection and restoration.
6. Publicly funded sites tended to be larger and to more closely represent the Bioregional Conservation Status of vegetation on a property than privately funded sites which were more likely to be established within the less vulnerable communities (and therefore on the less productive land with the lowest opportunity costs).
7. A simple typology of landholders (Commercial Farmers, Part-time Farming Landholders and Lifestyle Landholders) developed by Race *et al.* (2010) was found to be a good predictor of levels of vegetation management activity and the source of public funds used to support vegetation management.
8. The approach described here of establishing a spatial database regularly updated and complemented with social research would improve the quality of monitoring and reporting the status of native vegetation on private land and the return on public funds invested in vegetation management.

Contents

Introduction

In Australia, state and federal governments are seeking to increase the extent of native vegetation cover in fragmented and heavily cleared landscapes (Saunders *et al.* 1993; Thackway & Lesslie 2008; Zerger *et al.* 2009). Increasing the cover of structurally complex and diverse native ecological communities will help protect biodiversity, and provide more environmental benefits and ecological resilience than homogeneous production landscapes (Fischer & Lindenmayer 2007; Tscharntke *et al.* 2005).

In Victoria, Australia's most densely populated state, public policy to increase native vegetation extent began in earnest around 1990, as increasing direct investment in replanting was combined with native vegetation clearing controls introduced into legislation (*Planning and Environment Act 1987* (VIC), Kyle *et al.* 2010). The equation is apparently simple. There are only two purposeful actions, broadly defined, that count towards increasing extent; the protection or enhancement of extant native vegetation; and revegetation of formerly cleared land with indigenous species. However, the cumulative impact of these investments is hard to quantify, for a number of reasons. Firstly, though government agencies have increasingly sought to be strategic in planning where and how public money *should* be spent (e.g., ANAO 2008; NCCMA 2003), the delivery model relies on attracting private landholders as partners. Willing private landholders may have priorities at odds with the strategic priorities of Government, and different motivations for participating in programs or undertaking specific actions (Pannell *et al.* 2006). Therefore, the degree to which the planned expenditure and outcomes are realised cannot be ascertained unless data on site locations and management is available. Secondly, program reporting is typically on outputs rather than outcomes, and centralised tracking of activity is complicated by distinct regional models of data capture. Consequently, records of where public money is *actually* spent and what it achieves remain patchy at best (ANAO 2004, 2008; Brooks & Lake 2007; Zerger *et al.* 2009). Furthermore, in addition to co-investing with government on revegetation and remnant protection, landholders may undertake similar activities independently of direct public investment (e.g., Ambrosio *et al.* 2009; Smith 2008), and these activities may not be recorded anywhere. Landholder communities themselves, and thus patterns of land use and management, may also be changing and diversifying (Barr *et al.* 2005b; Mendham & Curtis 2010). Considering these sources of uncertainty, it is not surprising that a recent landscape-level survey of change in native vegetation cover could not readily attribute identified change to specific public investment, private activity or unassisted natural recovery (e.g., Kyle *et al.* 2010).

Despite awareness of imperfect data on the location, extent and effectiveness of actions to protect, enhance and reconstruct native vegetation, Government agencies still have to report on progress toward the objective of reversing the decline in the extent and quality of the resource (e.g., *Catchment and Land Protection Act* 1994 (State of Victoria)). To achieve this agencies have little choice but to resort to incomplete spatial databases on vegetation management activities, and assumptions about levels of unmapped activity, to estimate expected net change or impact (Brunt & McLennan 2006; DSE 2008).

One of the key reporting assumptions employed in Victoria in recent years is that for every hectare of publicly funded activity, there is another hectare of privately activity; the ''times 2'' assumption'' (DSE 2008; GBCMA 2008). ''Publicly funded'' in this context refers to any activity that receives direct public investment, even if it is a minority contribution. ''Privately funded'' activity is work that does not receive *any* direct public contribution.

This is a simple utilitarian assumption to assist with reporting landscape change. However, the assumption addresses a fundamentally important question for the logic of how Natural Resource Management (NRM) agencies should interact with private landholders in order to achieve environmental outcomes. If the times 2 assumption is correct, the investment of public money on private land to increase native vegetation extent, including non-site specific investment in education and extension, can be seen to have flow-on benefits. If the assumption is not correct, or if the ratio of publicly funded works is higher, the reporting of vegetation works needs to reflect this. Also, the effectiveness and appropriate mixture of incentive models applied, and the achievability of landscape change targets, may need to be reviewed.

Previous studies of the amount and funding of native vegetation work on private land provided equivocal support for the times 2 assumption. Smith's (2008) study in the West Australian wheatbelt showed that the relationship of public, cost-shared and private funded revegetation sites had changed over time, such that more recent sites were heavily biased toward public funding. Ambrosio *et al.* (2009), explicitly investigating the times 2 assumption, concluded that the private contribution to

revegetation and remnant protection activities may be as high as six times higher than publicly funded input. However, they also noted that sites taken out of production within the last five years were more balanced at around 1 ha:1 ha. Importantly, their data were about funded and unfunded *activities* rather than *sites*. Although expressed on an area basis, these activities could co-exist on a given site, whereas the times 2 assumption is explicitly about the establishment of new sites that contribute to increasing the extent and/or quality of native vegetation. Consequently, the crucial question of whether public investment was required to catalyse private willingness to establish new sites remains unclear.

In this study we mapped extant native vegetation, naturally regenerating native vegetation and native revegetation on 71 landholdings across 3 case study areas in northern Victoria. We interviewed each landholder in order to characterise their socioeconomic profile and enterprise type; and to determine the date, type, and resourcing model for each parcel of revegetation, remnant protection and remnant enhancement. Our objectives were to establish who was undertaking these kinds of restorative works, particularly with respect to public and private funding; how much of these types of work different kinds of landholders were undertaking, and for what motivation. Importantly, to test the veracity of the times 2 assumption, and whether it varied by type of works, we determined the funding model and extent of landholder contributions in money and labour to each site.

Method

Case study areas

This study was located in three case study areas in northern Victoria, Australia (Figure 1). Using the categories of McIntyre and Hobbs (1999), we identified broad zones of 'transitional fragmented' landscapes, which occurred between the extremes of intact and relictual landscapes. These occurred in the Goldfields, Victorian Riverina, and Northern Inland Slopes Bioregions, as defined by associations of landform, soils and vegetation (NLWRA 2001).

The socio-economic character of these areas has been broadly characterised as 'rural amenity' and 'rural transitional' (Barr *et al.* 2005a). Formerly dominant farming practices such as livestock grazing are decreasing in area and intensity, whilst rural residential, peri-urban, wine and olive growing, and hobby farm uses are increasing, and pushing land values beyond their value for extensive grazing (Barr *et al.* 2005a; Costello 2007). Transitions from cropping and grazing to hobby farming and residential use via subdivisions are more common in the Muckleford and Chiltern–Springhurst case studies, whereas Longwood Plains–Violet Town retains a stronger primary production focus.

Broadly speaking, the areas have received considerable public investment aimed at vegetation protection and enhancement on privately owned land. Over recent decades they have come to present significant possibilities for spontaneous regeneration due to fewer producers, and a shift towards more intensive use of a smaller proportion of land area (Crosthwaite *et al.* 2008; Dorrough *et al.* 2008).

Selection of participants

We interviewed 71 landholders across the 3 case study areas with landholdings greater than 5 ha. With the help of local contacts, landholders were identified based on the modelled local density of revegetation and regeneration. Firstly, using spatial data on native tree revegetation and regeneration from aerial photograph interpretation in a linked study (Kyle *et al.* 2010), we calculated separate density grids of revegetation and regeneration using

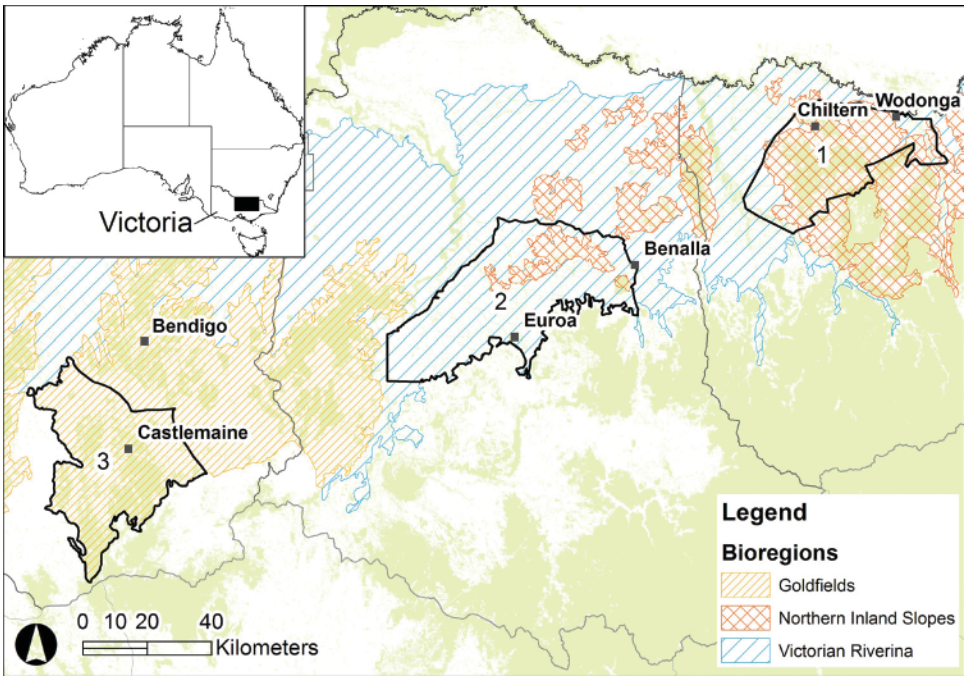


Figure 1. Chiltern–Springhurst (1), Violet Town–Longwood (2) and Muckleford (3) case study areas in northern Victoria, Australia, in their Bioregional context. Some major towns and extant cover of mature native woody tree cover (DSE 2006, shaded) are also shown.

Table 1. Distribution of interviewees across case study areas, subdivided into parts of the landscape characterised by above (H) or below (L) median values for density of spontaneous woody regeneration (Regen.) and Revegetation (Reveg.)

N interviewees	Violet Town–Longwood	Muckleford	Chiltern–Springhurst	Total
Reveg.^{H} Regen.^{H}	13	4	0	17
Reveg.^{H} Regen.^{L}	2	7	8	17
Reveg.^{L} Regen.^{H}	4	5	3	12
Reveg.^{L} Regen.^{L}	6	9	10	25
Total	25	25	21	71

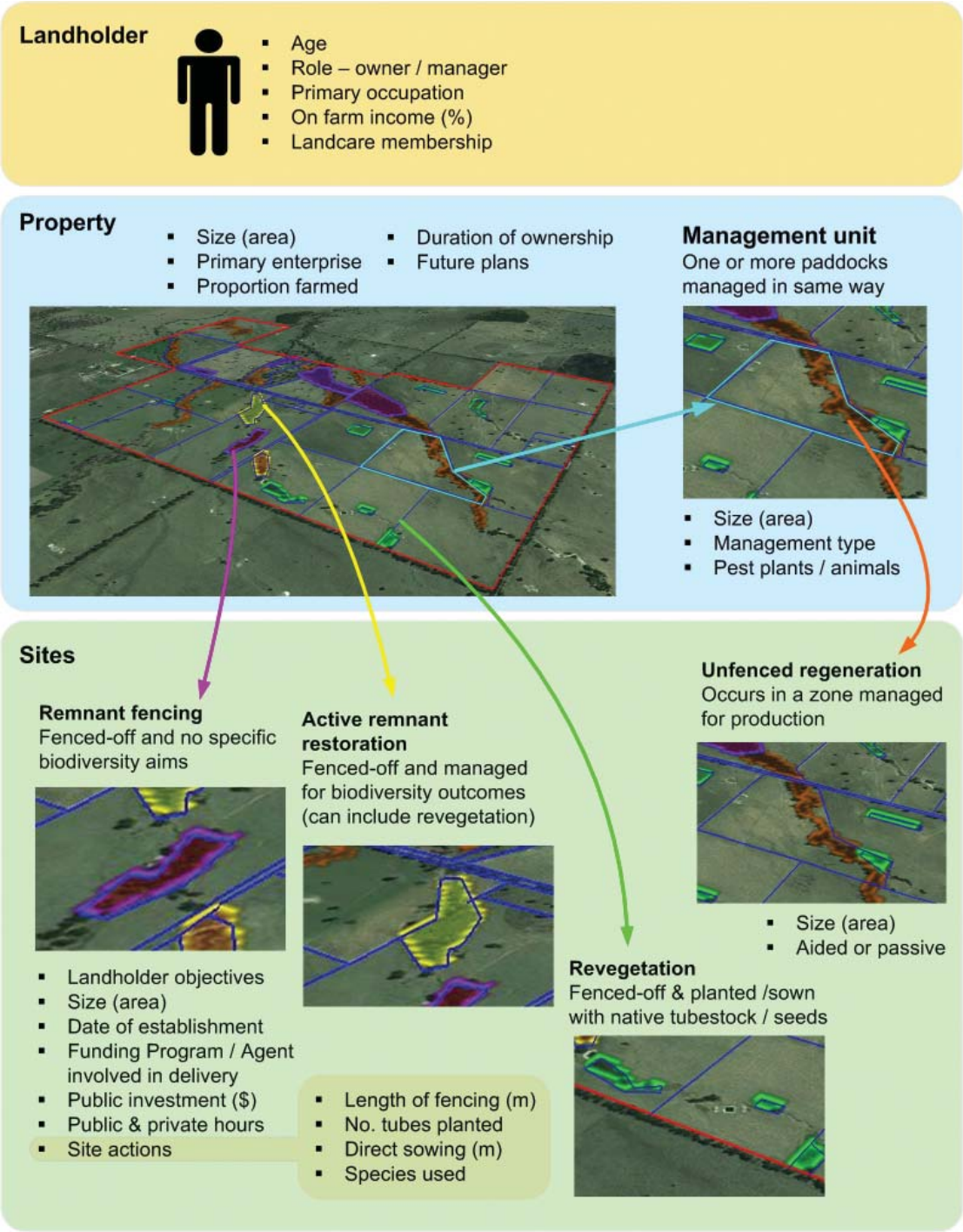


Figure 2. Schematic of the structure of data collected about landholders, their properties and production management units, and active and passive native vegetation work sites. The imagery was produced using Google Earth Pro 5.1.x.

the focal statistics tool in ArcGIS (Version 9.3, ESRI). Using the focal statistic tool we calculated a mean density value for each 10 x 10 m raster cell for circular neighbourhood of 3000 m. The resultant output rasters of revegetation and regeneration density were grouped into zones of high and low density using the median density value of cells for each case study area. These grids were combined to produce four classes (high high, high low, low high and low low revegetation and regeneration respectively (Table 1). In each of our case study areas, regional contacts were asked to help us locate approximately seven landholders in each class, with the exception of low revegetation and regeneration part, where we sought around three participants. We sought landholders distributed throughout each of the zones to minimise spatial auto-correlation. Thus, we set out to distinguish between different kinds of landholders engaged in native vegetation management rather than learn about baseline rates of engagement amongst the broader population. However, our eventual cohort of interviewees did not conform to our intended landscape sampling bias (Table 1) with the largest number being in lower density part of the case study areas. Note, however, that this does not exclude the possibility that the interviewees were exceptions to their local landscape in terms of levels of activity. All personal data were collected and are maintained under the provisions of the *Information Privacy Act 2000* (State of Victoria).

Mapping and interview

We mapped participating landholders' properties and all zones of apparent woody native vegetation cover on their land from aerial photographs (Figure 2). On-site, those vegetation features, plus the production management units, and details on the native vegetation units were recorded using a custom adaptation of the VegTrack database (Zerger et. al 2009). The structure of the data is illustrated in Figure 2. A management unit refers to a continuous area of the property that is managed in the same manner, for example, a paddock or several paddocks managed for grazing livestock. Within those management units there could be native vegetation, which may be regenerating naturally (''unfenced regeneration'', Figure 2), but we distinguished vegetation zones that had been fenced out of the production units as ''revegetation'', ''remnant fencing'' and ''active remnant restoration'' (Figure2 and Table 1). These categories reflect the intensity of active work applied, and to some degree include the motivation of landholders.

Determining private and public resourcing

Importantly, to test the veracity of the times 2 assumption, and whether it varied by type of works, we determined the funding model for each site. Participants were asked to nominate the funding source as ''Private'' if the project was wholly privately resourced, or by nominating the relevant agency or agent if public funds were received (''Public''). Even though all sites that received public funding would have had private co-investment, we grouped them as ''Public'' for some analyses because, in attracting public money, there were presumably public-good criteria to be satisfied as well as the personal motivation of landholders. There is a slight difference in the application of this assumption comparing a regional body such as the Goulburn Broken CMA (GBCMA) and the Victorian Department of Sustainability and Environment (Table 3). Although the times 2 assumption originated at the regional level as a response to reporting requirements, for practical reasons we analysed the data according to the more simple public private split, following DSE (2008). The difference in total area is minor, and can be seen in the Results (Table 5).

Data analysis

In this report we have employed a broad range of analytical approaches to represent our key findings.

Table 2. Definition of native vegetation works carried out on private lands. These represent mutually exclusive categories in the mapped data.

Type of work	Description
Remnant fencing	Zones of remnant tree cover that have been fenced off and are not actively managed. Often the primary motivation for the landholder is to keep stock out of unproductive or dangerous land. Grazing may occur when feed is low elsewhere.
Active Remnant Restoration	Zones of remnant native vegetation cover that have been fenced-off and are actively managed to promote natural regeneration. Pest plant and animal control, strategic grazing and/or sub-zones of revegetation or supplementary planting are typically applied.
Revegetation	Zones of reconstructed native vegetation artificially established via tubestock or direct sowing, typically sites are prepared with ripping, and weed spraying.

Table 3. Differences in the application of the 'times 2' assumption for estimating regional and state wide change in native vegetation extent and quality.

Source	Public	Private
Dept of Sustainability and Environment DSE (2008, p16)	Any site established with government support, including minority contribution	Sites established wholly by private
Goulburn Broken CMA (Brunt & McLennan 2006)	As above, provided the program is administered by CMA ("funded")	As above, plus government support not administered by CMA ("unfunded")

We present simple graphs of raw data to communicate the full range and shape of our data in some cases. By contrast, to explain variation in the proportion of landholdings comprised of remnant and revegetation works we used Boosted Regression Tree modelling to explore and represent the principal explanatory factors (Elith *et al.* 2008).

In our presentation of raw data we have in some cases subdivided those data according to the landholder classification developed by our collaborators (Race *et al.* 2010). Their classification distinguishes between Commercial Farmers, Part-time Farming Landholders, and Lifestyle Landholders on the basis of self-identification, size of property holding, and source of income. It was developed following qualitative interviews with a representative subsample of 30 landholders from within the full sample of 71 (Race *et al.* 2010). Such classifications, which are generated to delimit decision-making tendencies, for example; industry type and scale; value-orientation; and attitude to NRM issues, may help NRM practitioners to better understand their audience and therefore better target incentives and other programs (Vanclay *et al.* 1998). In this report we have used the classification to subdivide data in some graphs, however we did not use it as a factor in modelling.

We applied Boosted Regression Tree (hereafter BRT) models to identify the primary drivers of the proportion of a holding comprised of remnant fencing, active remnant restoration and revegetation (''total works''). BRTs combine the flexibility and problem solving advantages of machine learning techniques with the transparency and interpretability of regression modelling (Elith *et al.* 2008). The BRTs were implemented in R (R Development Core Team 2010) using the gbm package (Ridgeway 2007) and additional code provided by Elith *et al.* (2008). The factors we tested were: the log of total property area; proportion of property under tree cover; proportion of income derived on-farm; proportion of the property in-production, membership of production or landcare (yes/no); Terrain Wetness Index (Q1, median, mean, Q3), Age of property owner, duration of management/ownership of property.

We also used BRTs to explore the total area of privately funded sites in each year, since the earliest records in 1960. The response variable was the natural log of area (ha), and the predictor set include the number of privately funded sites contributing to the total in each year (N); the number of publicly funded sites in that year and the total area for those sites; time (the year); and whether it was pre or post NHT program.

In both cases we experimented with allowing and constraining interactions (tree complexity) and selected a single model on the basis of % cross-validation deviance explained balanced with fewest predictors.

Results

Our interviews with 71 landholders yielded data on native vegetation works for a total of 401 sites, established between 1967 and 2009, when the interviews were conducted. The sites ranged in size from a privately funded revegetation site at 0.1 ha to a publicly funded remnant fencing project at 164 ha. The median size was 2.9 ha. All participants had at least one native vegetation management site on their property with a median of five (Figure 3a). Fenced remnants and active remnant restoration sites tended to be relatively few with median values of one per property and maxima of six in both cases (Figure 4b&c). By contrast the median number of revegetation sites was 3 and one landholder had 15 individual revegetation sites (Figure 4d).

The interview sample included 31 Commercial Farmers, 21 Part-time Farming Landholders and 19 Lifestyle Landholders, according to the classification of Race *et al.* (2010). The most common land uses were sheep grazing, mixed farming, and cattle grazing (Table 4). Most Lifestyle Landholders used their property for a residence or non-farming place of work only, though a few ran some sheep or cattle or had minor plantations.

The typology of Race *et al.* (2010) was also a useful filter for exploring the landholders included in our interview sample (Figure 4). The median age of interview participants was around 50 years of age (Figure 4a), and the median duration of property ownership or management around 20 years (Figure 4b). On-farm income as a percentage of household income ranged from 0% for some Lifestyle Landholders to 100% in the case of many Commercial Farmers (Figure 4c). Property holdings varied from around 5 ha for residential blocks to farms over 3000 ha in area (Figure 4d). Properties were bigger on average in the Violet Town–Longwood case study area, which is a flatter landscape with much lower extant cover of native vegetation than the other two areas (Figure 4e).

The proportion of property area that consisted of the three active native vegetation management types varied from 0 to 100% (Figure 4f), and the proportion was strongly correlated with property size. Although Commercial Farmers had proportionately less land under native vegetation works, the median

Table 4. The number of participants by on-farm enterprise category and Landholder Typology after Race et al. (2010).

Landholder Typology	Property enterprise type				Total
	Cattle	Sheep	Mixed (livestock plus other)	Residential Only	
Commercial farmer	6	11	14	0	31
Part-time farming landholder	9	7	3	2	21
Lifestyle landholder	3	2	1	13	19
Total	18	20	18	15	71

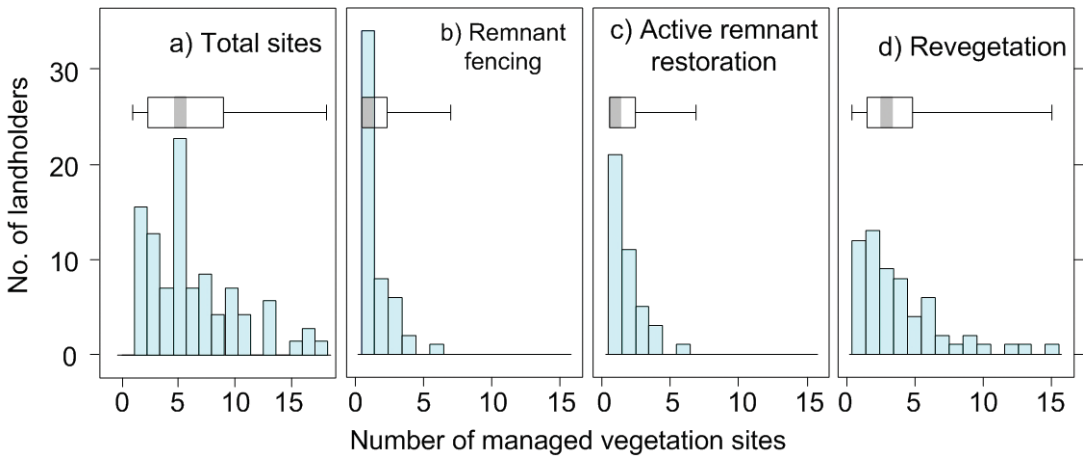


Figure 3. The total number of native vegetation management sites on the landholding of each participant (a), as well as the number by type of work (b–d). In the superimposed boxplot, the grey line indicates the median value, and the box edges represent upper (and lower) quartiles.

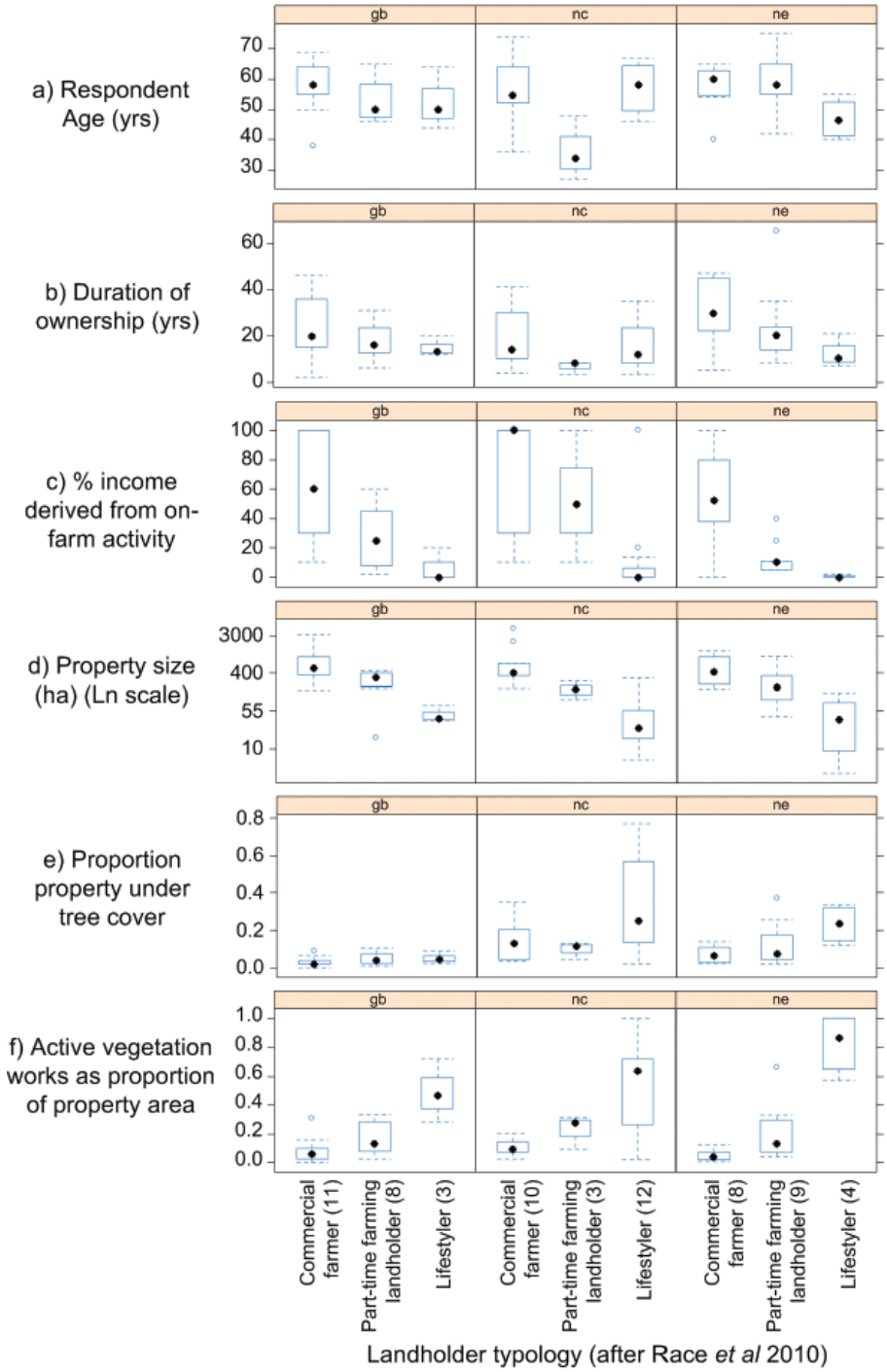


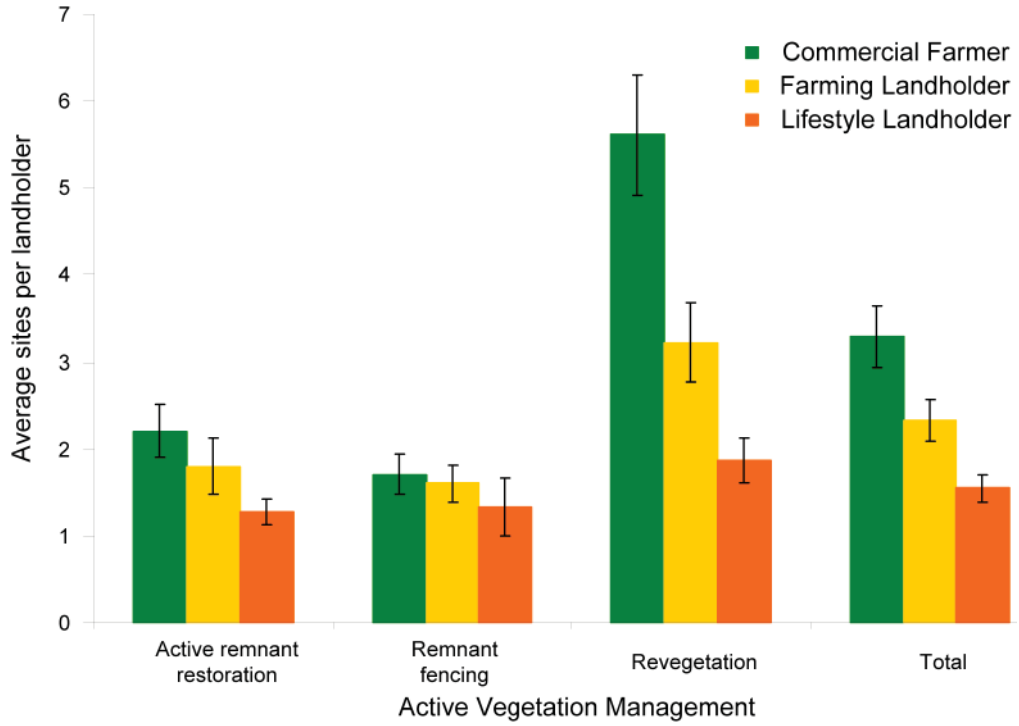
Figure 4. Summary of landholder data according to the landholder typology of Race et al 2010. Data are split by region and the numbers in each group are indicated in brackets. The boxes indicate the values in between the 1st (25%) and 3rd (75th) quartiles, and the black dot indicates the median value.

value for the Commercial Farmer group was still around 10%. The average count of vegetation works per landholder across typology was consistently higher for Commercial Farmers, followed by Farming Landholders then by Lifestyle Landholders (Figure 5). In the case of active remnant enhancement and remnant fencing the differences were not large. However there was a substantial difference in the average number of works per landholder between all three landholder typologies.

The BRT model of the proportion of property comprised of managed native vegetation works explained about 45% of the deviance in model cross-validation, indicating reasonable explanatory power. The most important predictor, not surprisingly, was property size. The proportion of property that under active management of native vegetation was often high for properties under about 50 ha, then decreased rapidly to property sizes of 500 ha (Figure 5a). Beyond 500 ha property size had no further marginal effect. Existing wooded vegetation on property was associated with greater proportions of managed vegetation up to about 20% cover, beyond which it was no longer influential (Figure 5b). Where properties were over 50% in production by area, there was a decline in proportion of property area under works towards those 100% in production (Figure5c). The marginal effect of area in production declined more precipitously beyond 80% of the landholding under production. Landholders with proportionally lower on-farm income had proportionally more total managed vegetation. The proportion of property under works declined in steps to 40–50%, beyond which there was no further marginal effect (Figure 5d).

After the proportion of income derived on-farm, the influence of remaining predictors was relatively minor (Figure 5e–g). All other things being equal, participants older than 50 years had a higher proportion of their property under managed native

Figure 5. Average number of native vegetation management sites for each landholder group by landholder typology and site type.



vegetation than those who were younger than 50 years old. Those with the steepest country had a marginally higher proportion of their property under works, with the 25th percentile value of Terrain Wetness Index values (related to steepness and drainage) explaining around 4% of the model performance. Lastly, those who had owned or managed their property for about 10–20 years had done marginally more works, whereas those who had an association with their land for longer than 20 years had done less.

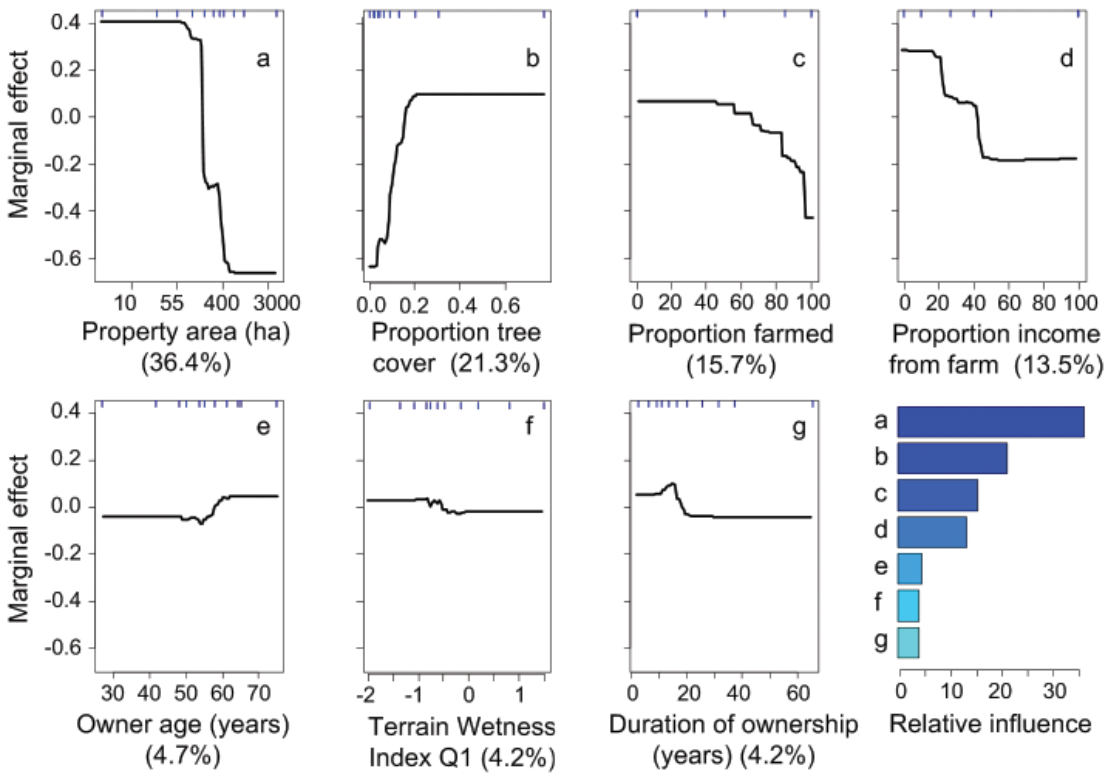


Figure 6. The major influences on the proportion of 71 land holdings under remnant fencing, restoration, and revegetation (combined). The marginal effect of each predictor is displayed, holding the other predictors at their mean value. The contribution of each predictor (%) to the Boosted Regression Tree model is provided in parentheses and graphically (bottom right). For continuous predictors the spread of training data is indicated by tick marks on the top of each panel.

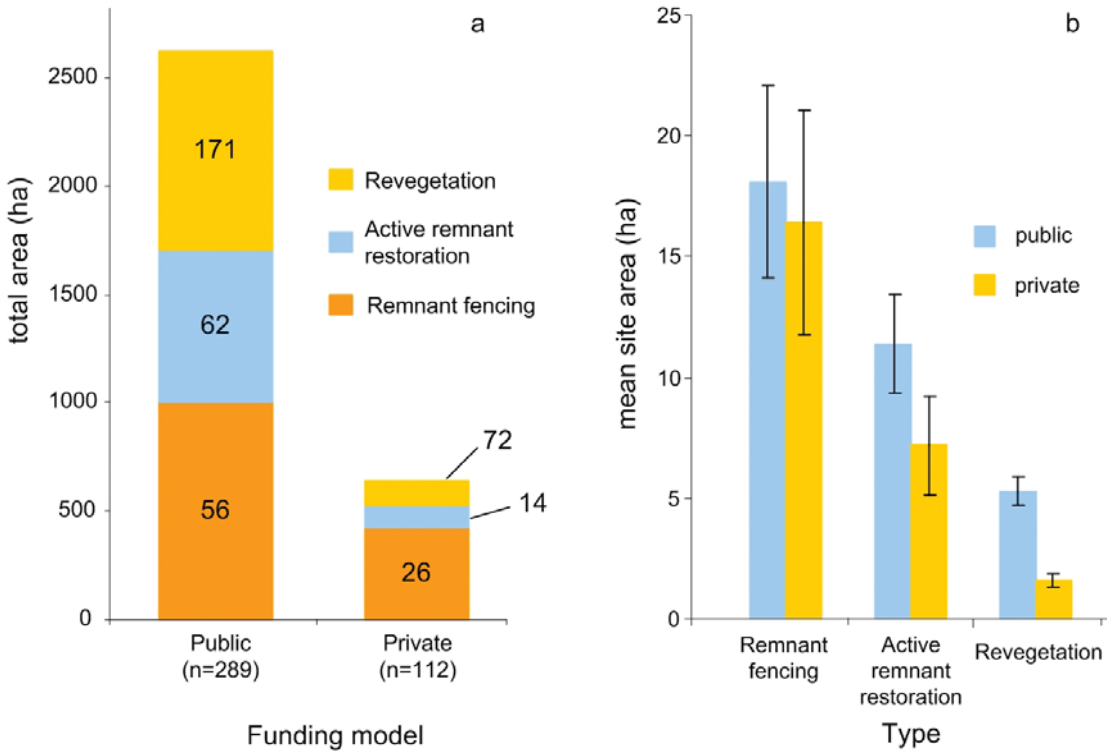


Figure 7. Public and privately funded contributions to new revegetation, remnant fencing and active remnant restoration sites since 1967. The contribution of public and private sites to the total area, and the number of each sites (annotated) is given as panel (a) and the average size (±se) of publicly and privately funded sites is panel (b).

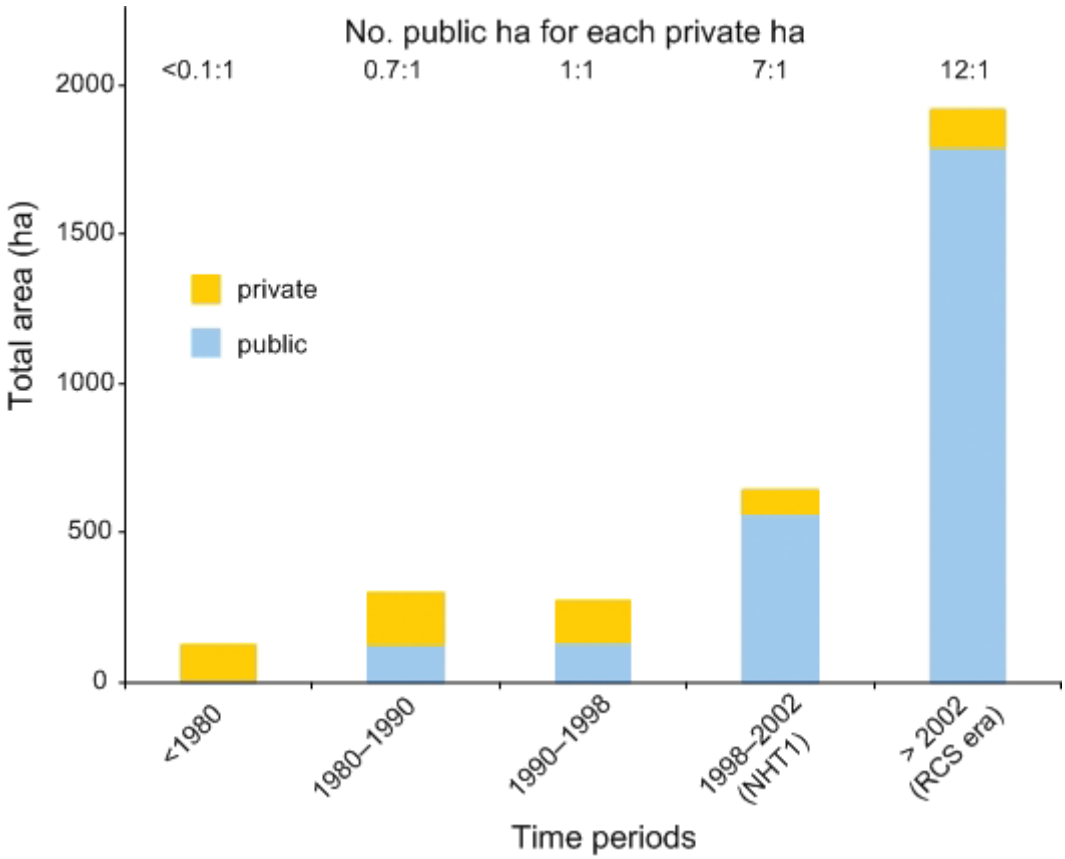


Figure 8. Public and private components of total works area over time, and the ratio of public to private contributions to the total for each time period. The break points are arbitrary for earlier years but tied to major investment phases for the most recent periods.

Testing the "times 2" assumption

For the full sample of vegetation management sites there were 289 publicly funded sites providing 2600 ha compared with 112 sites of privately funded works accounting for over 600 ha (Figure 7a). For the full set of sites we found four publicly funded ha for each one ha of private area contribution, or, the privately funded area is ¼ of that achieved with public funding. Of the publicly funded sites, most were revegetation. However, on an area basis there was slightly more area comprised of fenced-off remnants. Remnant fencing also accounted for the majority of privately funded area, but revegetation projects were far more numerous. The average size of remnant fencing projects was similar in public and private (Figure 7b), but public active restoration works and revegetation were larger than their private counterparts. The greatest difference was in revegetation sites where publicly funded sites were on average nearly five times larger than privately funded sites.

Separating the data into time periods, it becomes clear that the ratio of public to private works was far greater than 4:1 for the periods 1998–2002 and post-2002 (Figure 8). The change in ratio was largely driven by a large increase in publicly funded sites when the money from Natural Heritage Trust was being spent.

In fact, our BRT model results suggested there was little support from these data for the use of a ratio to describe the likely combined total in any given year. A ratio view emphasises a decreasing private proportion of the yearly total (e.g., Figure 8). However, holding all other things at their average, the amount of privately funded work has been relatively stable and trended slightly upward during the 1980s (Figure 9b, Figure 10a). The most important predictor of the amount of private area added in a given year was simply the number of privately funded sites (Figure 9a), whereas the number and amount of publicly funded area had no negative impact on private activity (Figure 9c).

Comparing privately and publicly funded sites

The average site area varied through time differently for public and private sites (Figure 11a–c). The average size of publicly funded remnant fencing sites increased from the 1980s through to the more recent sites whereas privately funded remnant fencing sites declined after some very large early works to about half the size of public sites (Figure 11a). By contrast the average site size for active remnant restoration was quite similar through time for public

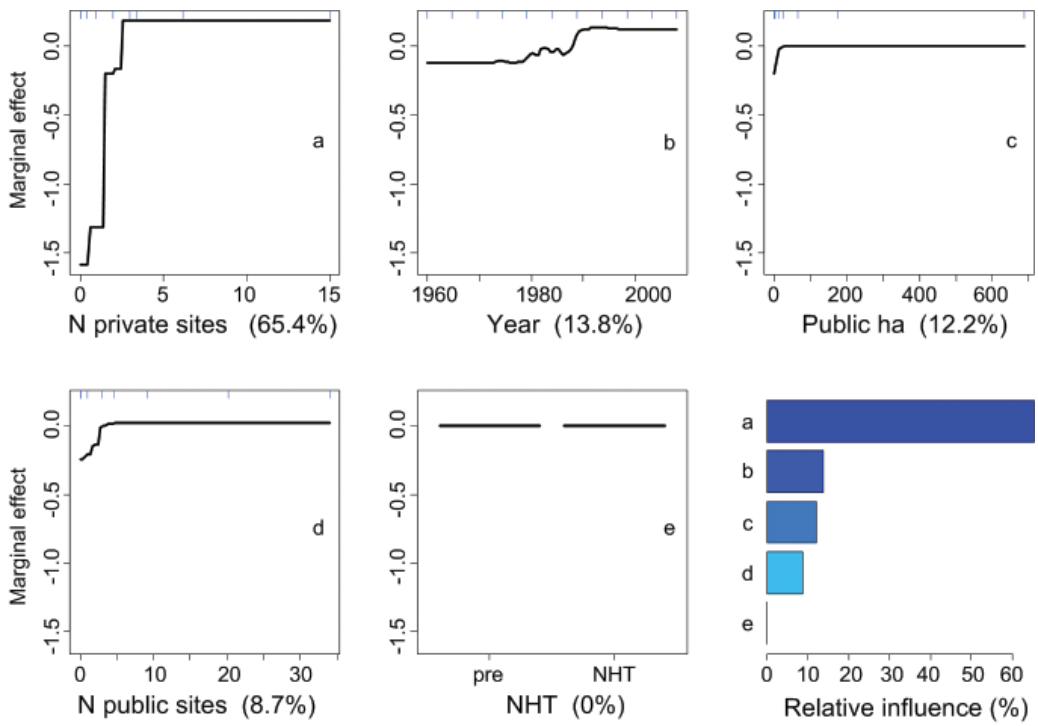


Figure 9. The major influences on amount (ha) of privately funded sites established each year between 1960–2008 including remnant fencing, restoration, and revegetation (combined). The model explained 42% of the deviance in cross-validation. The marginal effect of each predictor is displayed, holding the other predictors at their mean value. The contribution of each predictor (%) to the Boosted Regression Tree model is provided in parentheses and graphically (bottom right). For continuous predictors the spread of training data is indicated by tick marks on the top of each panel.

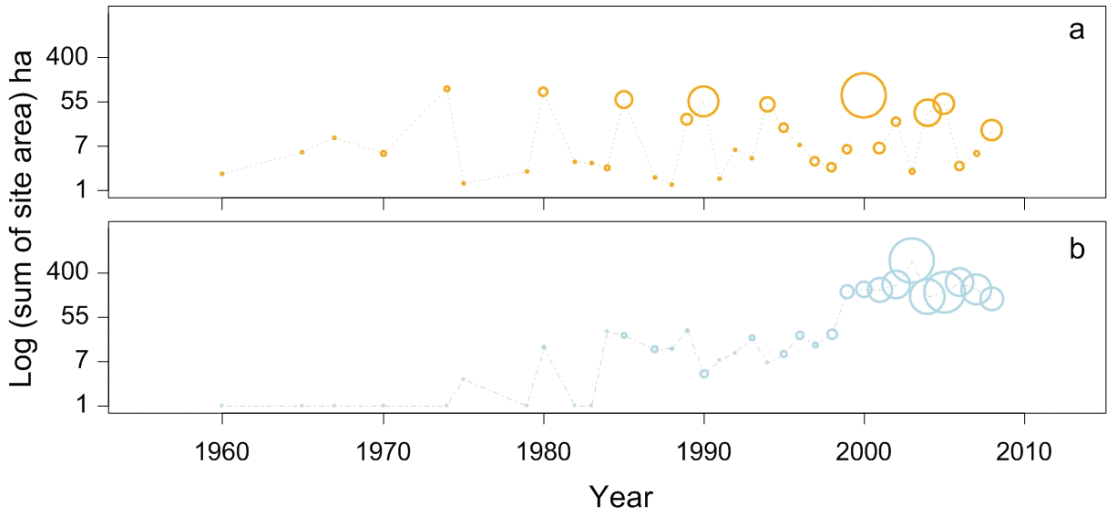


Figure 10. Patterns of total private (a) and public (b) area per year. The y axis, area, was log scaled (ln) but is presented with back-transformed labels. The size of the symbols varies according to how many sites contribute to that year's total area. The largest example for private was 15 sites, and for public the maximum number of sites in a given year was 31.

and private sites, though the most recent set of publicly funded sites were more than twice as large on average (Figure 11b).

The pattern for revegetation sites was different again. Publicly funded revegetation sites have tended to be larger over the whole time period, increasingly so in the two most recent time periods (Figure 11c). For revegetation sites completed since 2002 the average area was four times as large as privately funded sites.

Size isn't everything! The matter of landscape prioritisation

Whilst establishing larger sites is one important goal for increasing native vegetation extent, Agencies also try to strategically invest in conservation or restoration of the most endangered vegetation types within their jurisdiction. Our data showed that in general, publicly funded sites have been more strategically allocated in higher Bioregional Conservation Status areas than were private funded sites (Figure 12). There was little difference between funding sources in the lower BCS categories, and the prevalence of BCS categories associated with works was proportional to their property level prevalence. However, in the vulnerable class the proportion of publicly funded site was higher than the proportion of the property classified as vulnerable, whereas the proportion of privately funded sites was lower. While there were lower proportions of publicly and privately funded works occurring in land classed as endangered compared to the property level distribution, the proportion of publicly funded sites was significantly higher than privately funded sites.

Exploration of landholders' collaboration with Agencies

The "publicly funded" group of sites can be further explored according to the specific agency nominated in association with the establishment of individual sites. Fifteen agencies or programs were named in total (Table 5), although some had apparently only contributed to a single project across the 283 publicly funded sites. The CMAs were named as the source of funding for almost 30% of the 289 publicly funded sites, followed by Trust for Nature and Dept. Primary Industries (DPI). DPI was also *named* as the agency involved in the Land Protection Incentive Scheme and Heartlands sites and therefore was very prominent in the data. In fact the CMAs, for example, were also involved in delivering the LPIS program (Geoff Park pers. comm.), and may be under-represented to some degree.

Looking at the collaborations between landholders and agencies in site establishment using the landholder typology of Race et al (2010), some apparent differences emerged. Trust for Nature, Heartlands, and Envirofund had established sites with similar percentages of the Commerical Farmers, Part-time Farmers and Lifestyle Landholder groups (Figure 13a). By contrast, more of the commercial farming group had established sites through their own resources ("private", >80% compared with <60%), and with support from Landcare (>40% compared with <20%) and DPI (>50% compared with <40 and <20%) than Part-time Farming Landholders and Lifestyle Landholders. Conspicuously fewer Lifestyle landholders had established one or more sites with support from DPI or the LPIS than either of the farming groups.

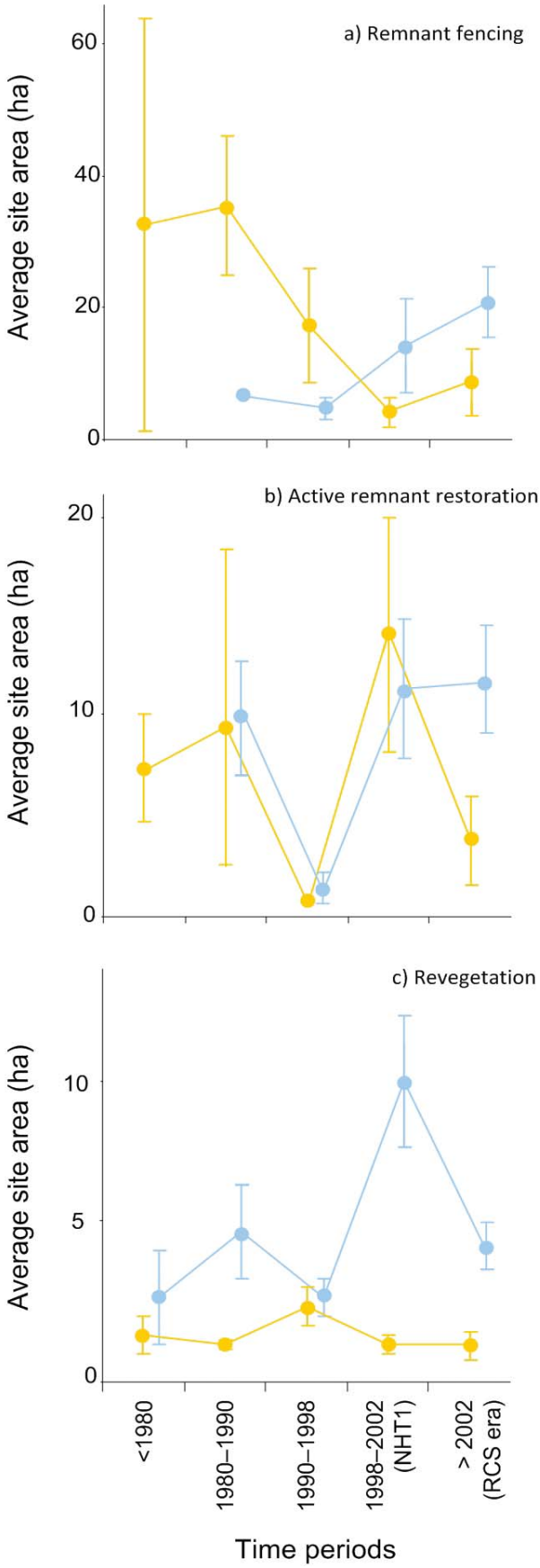


Figure 11. Mean size (ha, ±se) of publicly (blue) and privately (yellow) funded native vegetation sites over time. The points are slightly displaced for ease of interpretation. Sites are (a) remnant fencing, (b) active remnant restoration and (c) revegetation.

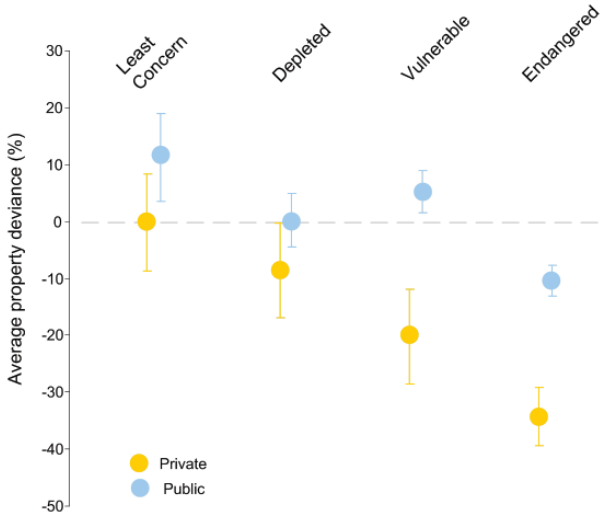


Figure 12. Distribution of private and public native vegetation sites (all types combined) classified according to Bioregional Conservation Status of the recipient Ecological Vegetation Class. This graph shows the average deviance in the percentage of works located in each BCS category relative to the prevalence of that BCS type as a percentage of the property area. If site area was distributed proportionally, the mean would be 0.

Table 5. The agencies or programs nominated by landholders as having contributed funds, labour, or both to specific native vegetation projects on their property. We have not independently verified if these assignations are substantiated by public records. We list both Agencies and Programs as ventured by landholders, which may hint at the effectiveness or otherwise of branding efforts by the agencies involved. Agencies that were credited with supporting less than 10 ha and fewer than 10 sites are combined under the category ''Other''. Superscript notations indicate whether, in today's terms, the funding source would be considered ''funded'' [f], unfunded [u], or too variable to estimate [?]. Some agencies such as DPI & DSE were funding work well before the CMAs were established in 1994, therefore the funded or unfunded status would have varied through time.

Agency or Program	Description (year range in dataset)	Remnant fencing		Active remnant restoration		Revegetation		Total Area
		N	ha	N	ha	N	ha	ha
Catchment Management Authorities (CMA)[f]	Regional Natural Resource Management Authorities. Regional investment delivery responsibility for a range of State and Federal programs. (1989(sic)–2009)	21	167	23	405	37	307	879
Trust for Nature (TFN) [f]	Statutory Authority for conservation on private land, chiefly through establishment of legal covenants and management plans. (1997–2006)	7	189	5	33	6	24	246
Vic. Dept of Primary Industries (DPI, includes "Ag Dept" sites) [f]	State agency that directly funds work for land protection, also acts as a delivery agent of terrestrial (or non-riparian) revegetation and remnant protection programs for CMAs in some jurisdictions. (1975–2009)	8	196	13	121	44	234	551
Land Protection Incentive Scheme (LPIS) [f]	A long running program funded by the Victorian Government, often attracting co-investment from other agencies or smaller programs. Most respondents attributed it to DPI. (1989–2009)	7	68	3	28	26	89	184
EnviroFund [u]	Community fund established by the Australian Government's Natural Heritage Trust (NHT) program. (1997–2008)	4	137	5	19	4	26	182
Dept of Sustainability and Environment (DSE) [f~80%]	State agency charged with wise use of natural resources including water and biodiversity. (1987–2008)	2	85	4	46	5	14	145
Landcare[?]	National umbrella organisation, locally comprising community-based groups that undertake and fund site works. (1985–2009)	7	81	2	8	23	42	131
Heartlands[f]	Consortium project led by CSIRO and Murray-Darling Basin Commission, with CMA, State Agencies and Landcare. Focused on four catchments, one of which was in our Longwood–Violet Town case study area. (2000–2005)			1	6	15	109	115
Local Council[u]	No further detail available (2006)	1	48					48
"River Trust" [*?*]	No further detail available (1984–1990)	1			26	1	2	28
Developer[u]	Presumed to be established as a legal offset for a clearing proposal (e.g., BushBroker scheme). (2006–2007)					2	26	26
Tree Victoria[u]	Program of Victorian Government, no longer active. (1992–1997)	1	8			1	9	17
Other[u]	Greening Australia; Farm Trees Group; GreenFleet (2005;1975;2003–2007 respectively)					4	7	7
Unknown	Landholder was unable to recall source of support (1980–1999)	1	26	2	5	3	29	60
Total		76	799	82	1431	243	1034	3264

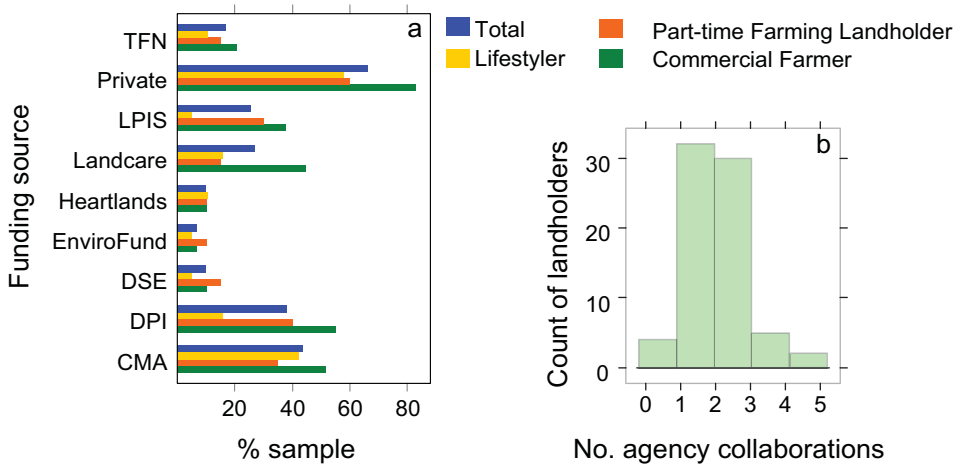


Figure 13. Collaborations by landholders with agencies or programs to establish native revegetation or remnant fencing or restoration sites. The left panel (a) indicates what percentage of landholder types, or the total interview sample, had established at least one site with the assistance of the various funding sources, or their own investment ("Private"). Only agencies who had dealt with more than 10 landholders are included. The right panel (b) is a frequency histogram showing how many ***different*** *agencies landholders had collaborated with.*

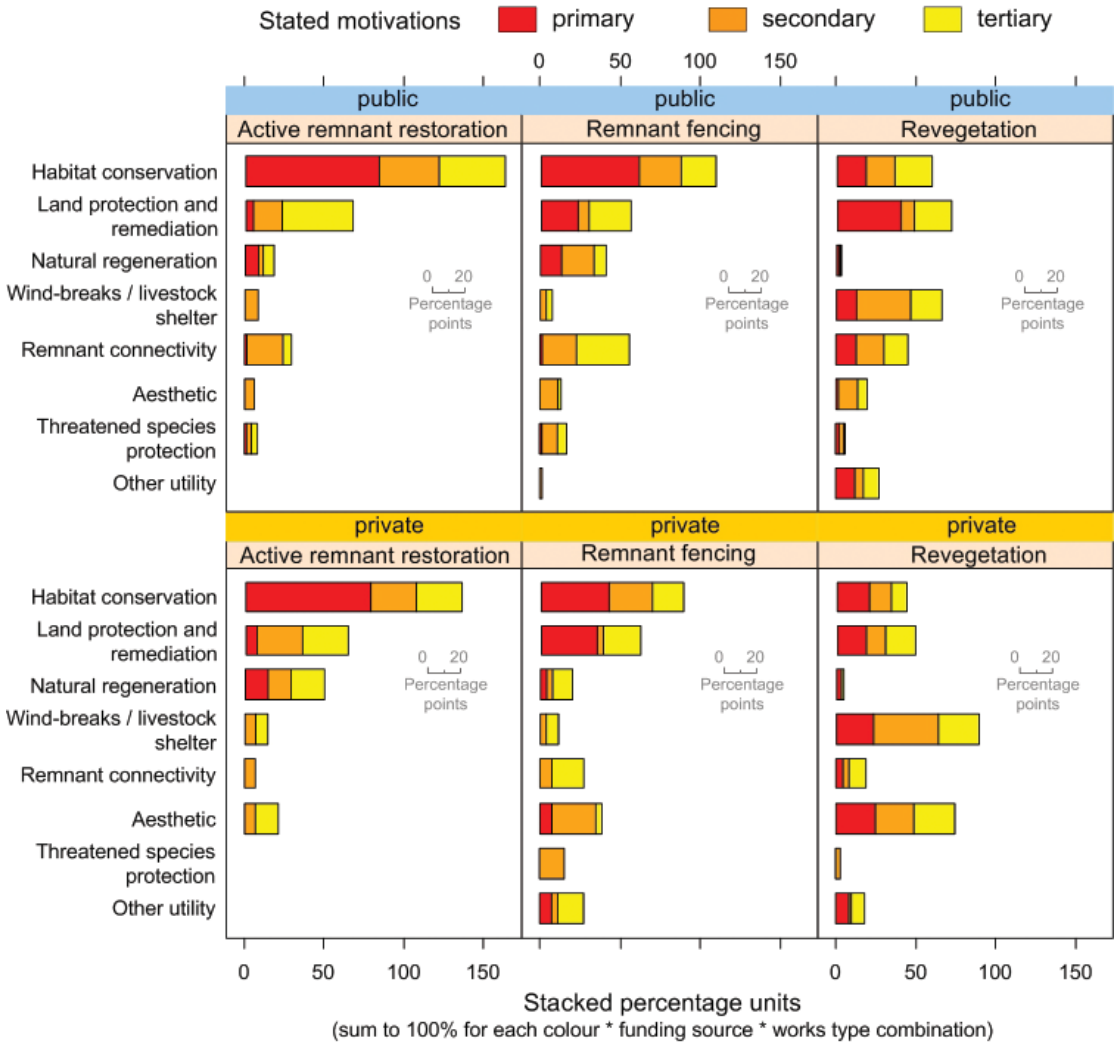


Figure 14. The motivations of participants for undertaking active remnant restoration; remnant fencing; and revegetation, as a function of private or public funding. "Private" signified wholly privately funded, whereas "Public" included some public money and / or labour. In each of the six cells, each colour bar sums to 100% (i.e., 100% of primary motivations plus 100% of secondary motivations plus 100% of tertiary motivations). Several conservation oriented goals have been left un-grouped as they allude to subtly distinct notions of species, habitat, connectivity and natural regeneration.

Across the whole sample, most landholders had collaborated with only one or two agencies to establish sites (Figure 13b). Considering the entire dataset

Landholder objectives for establishing native remnant and revegetation sites

Our landholder sample provided three ranked objectives for the majority of the activities, though in a handful of cases only one or two objectives were offered. The distribution of those primary, secondary and tertiary motivations differed amongst works types, and within types amongst public and private sites (Figure 14). The simplest case was active remnant enhancement, which was undertaken overwhelmingly for reasons of habitat conservation, and in general was the least variable in terms of number of objectives, and their spread amongst public and private sites. For publicly funded fenced-off remnants, there were three dominant primary objectives being habitat conservation, land protection or remediation, and natural regeneration. Remnant connectivity was a conspicuously popular lesser objective. For privately funded fenced-off remnants habitat conservation and land protection were also the two most commonly cited objectives; however the next two ranked objectives were aesthetic and other utility, such as firewood.

The revegetation sites were the most diverse in terms of spread of objectives. For funded sites the two most commonly cited primary objectives were land protection and remediation, followed by wind-breaks and livestock shelter, and connectivity with remnants. For unfunded sites the two most commonly cited primary objectives were wind-breaks and livestock shelter, and aesthetic reasons. Land protection and remediation ranked third and habitat conservation fourth. Though habitat conservation ranks lower for unfunded sites considering the distribution of primary, secondary and tertiary motivations, it had the same share of primary objective as did publicly funded sites.

Tracking the primary objective over time for revegetation, the most numerous site type, the emphasis in public sites shifted from land protection dominated (<50%) to conservation objectives (~40%), with other objectives lower in prominence (Figure 15). For privately funded works, the primary objectives were broadly distributed for sites established prior to 1998. Conservation objectives, though always prominent for private sites, increased to become the dominant objective, apparently at the expense of aesthetic and utilitarian objectives such as stock shelter and firewood.

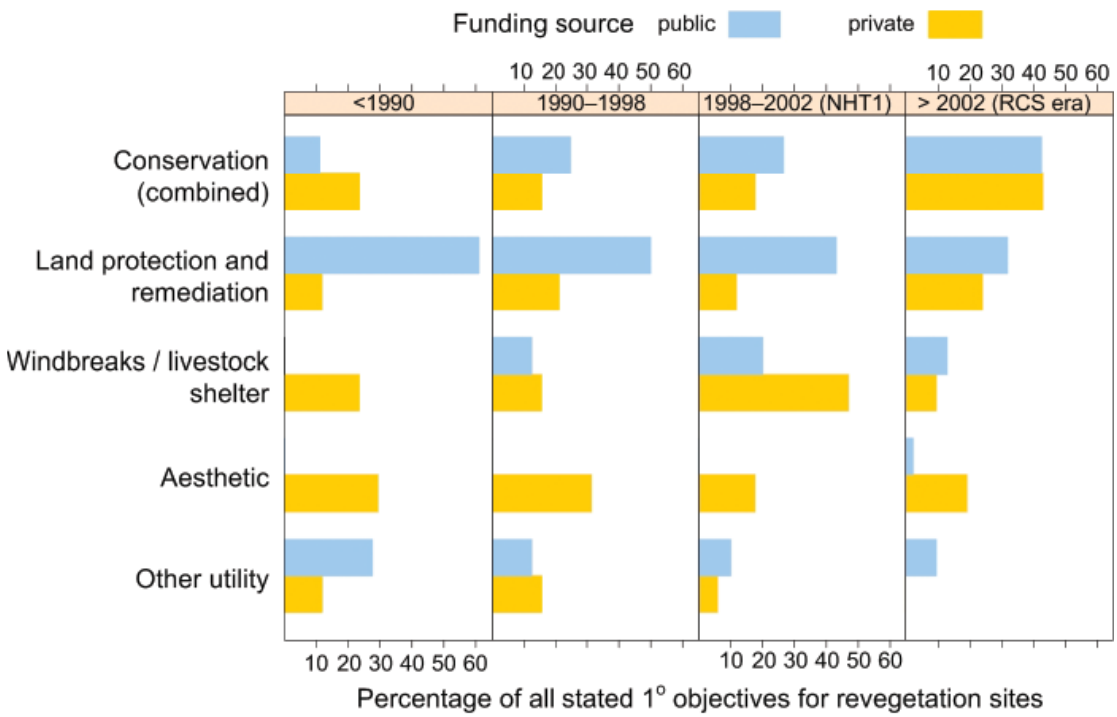


Figure 15. Landholder's primary objectives for establishing revegetation sites, starting with works completed prior to 1990 (left panel) through to the current era of Regional Catchment Strategies (right panel).

Discussion

Knowing how, where and why private land managers participate in native vegetation management through revegetation and remnant fencing and restoration works is fundamental to understanding how landscape restoration goals are tracking. It also suggests whether or not targets are likely to be achieved, particularly in landscapes where private land tenure is dominant. Our comprehensive spatial survey of 71 holdings in northern Victoria revealed some important findings which will help predict and report landscape change in terms of native vegetation extent, and to a lesser extent, quality.

Firstly, the reporting assumption that each hectare of publicly funded increase in extent or protection is matched by a hectare of similar unfunded work is strongly refuted by these data. During the earlier phases of emerging land protection and stewardship ethic amongst rural landholders (1960s–1990s) private works were more prevalent or balanced with publicly funded work. Since the late 1990s however, privately funded works have been proportionally dwarfed by the increase in public funding for private land conservation through national programs like Natural Heritage Trust (I and II), the National Action Plan for Salinity and Water Quality. Smith's (2008) analysis of revegetation activity in a Western Australian wheatbelt case study also showed a steady decline in wholly privately funded work from the early- to mid-1990s. For the last decade, our data would suggest that rather than an assumption of 1 private hectare for each funded hectare, that estimates of extent change at the landscape scale are closer to 1 ha of private work for every 10 ha publicly funded. Expressed in terms of the three different active management types; for revegetation we found around 1 ha for every 8 ha publicly funded; for remnant fencing around 1 ha for every 10 ha; and for active remnant restoration around 1 ha for every 20 ha. However, rather than proposing that new ratios be adopted for reporting purposes., a more fundamental finding of this work was that the area of privately- and publicly-funded sites were unrelated. Given that the amount of privately funded area per year was stable, though variable, over time, a more defensible approach would be simply add the long term average area of privately funded sites (~20 ha/yr across these 71 land holdings for the period after around 1990). The lack of a relationship between private and cofunded works is more problematic for extrapolation beyond these areas, as knowing the amount of public investment elsewhere cannot predict the likely private complement.

Our findings regarding the times 2 assumption contrasted strongly with a previous study conducted in a similar location, ostensibly with the same primary objective (Ambrosio *et al.* 2009). Ambrosio et al concluded on the basis of 224 mail surveys that the times 2 assumption was confirmed, and indeed possibly a conservative estimate of the relative contribution of unfunded compared with funded works. Their study area encompassed and extended north, south and west beyond our Violet Town–Longwood area, including more intensive horticultural and cropping landscapes, although the postcode that contributed most survey returns substantially overlaps with our case study area. Ambrosio *et al.* (2009) structured their survey questions around public and privately funded native vegetation management *activities* that occur on sites, rather than specifically on the funding model that facilitated *establishment of the sites*. In so doing, we believe that they critically misinterpreted the context and manner in which the times 2 reporting assumption is employed. Thus, their findings of private bias in undertaking native vegetation management activities likely reflects that post establishment, most maintenance and further enhancements are undertaken by landholders at their own expense and, often, initiative.

In addition to the broad, cumulative area impact of publicly funded versus unfunded works, we also found evidence that publicly funded work followed strategic priorities for larger and better placed on-ground work. Publicly funded sites were usually larger, and this pattern was more pronounced for the most cost-intensive the activity. Thus, whilst over the full sample there was no difference in the average size of fenced-off remnant areas between public and private sites, publicly funded revegetation sites were more than four-times larger on average than unfunded sites. In addition to being larger, our analysis showed that the placement of publicly funded sites reflected strategic priorities for higher conservation significance areas considerably more than unfunded works. Whilst such data are not direct evidence that NRM investment in native vegetation is benefiting biodiversity, they at least demonstrate that the investing bodies are allocating support to more strategic projects than landholders tend to do of their own accord.

Motivations for works

We found distinct patterns of motivations and objectives according to the type of work and funding model. In active remnant restoration sites, where fencing out of stock was combined with concerted weed control or supplementary planting, the dominant objective was habitat conservation, regardless

of whether or not the works were publicly funded or not. In that case the objective and the site type were arguably one and the same, thus the result is unremarkable. For remnant fencing sites, although habitat conservation was again dominant, there was greater diversity of motivations for unfunded sites, including aesthetic and a range of utilitarian objectives such as firewood resource.

Initially, we were surprised that the objectives for remnant fencing and restoration between publicly and privately funded sites both favoured conservation themes. However, aside from habitat conservation, and land protection benefits such as enhanced erosion control and drainage line stabilisation, the utilitarian benefits are arguably diminished rather than enhanced for landholders. This is particularly true of objectives such as stock shelter and ''other utility'', which included firewood resources. If the remnant vegetation is already there, the main way that fencing out or restoring the site can contribute to those objectives is by facilitating replacement and regeneration of the next generation of trees and shrubs. Similarly, whilst it is known that many landholders in this region value remnant vegetation for aesthetic reasons (Dettmann *et al.* 2000), depending on the degree to which they believe that value may be threatened by, say, stock access, they may not be motivated to enact any change in management to safeguard that benefit. For these reasons, conservation becomes one of the few conceivable reasons why a landholder might engage with such projects. The other widely cited anecdotal benefit, which arguably our interviews failed to identify, is that often landholders are willing to abide by the conservation requirements in order to have critical farm infrastructure such as new or replacement fences subsidised. A general criticism of these data could be that, although we asked landholders about their own objectives for establishing the various sites, we did not include any corroborating questions that might have indicated to what extent their personal objectives aligned with or diverged from those of the various funding agencies.

The objectives for revegetation sites were more diverse than for remnant works, and also more different comparing publicly and privately funded works. Whilst land protection and remediation; stock shelter and windbreaks; and habitat conservation were dominant across funding types, remnant connectivity was also prominent for publicly funded works whereas aesthetics was very prominent for private works. The aesthetic gain from replanting vegetation on previously cleared land is clearly greater than that obtained from remnant protection and restoration. The motivations and objectives for native vegetation works revealed in our study generally accord with those identified previously in a range of studies and contexts. A study of landholder attitudes to forest and woodland remnants by Dettman *et al.* (2000) found that by the participants most strongly valued utilitarian benefits such as stock shelter, ground water control, river protection and erosion control (all valued by >70% of sample). In more heavily cleared wheat and sheep farming zones in Victoria (Duncan & Dorrough 2009) and Western Australia (Smith 2008), farmers were found to have greater emphasis on production values, including stock shelter value of small remnant patches (Duncan & Dorrough 2009), and timber or oil harvest potential for revegetation projects (Smith 2008).

When will enough be enough?

Whilst we gathered critical data to evaluate the rates at which publicly funded and unfunded works are occurring across our sample of landholders, one of the enduring gaps in knowledge is a sense of when nominally willing and engaged landholders may stop, feeling that they have done all that they care to. Smith's (2008) Wallatin case study of revegetation activity by a highly engaged group of landholders in the central wheatbelt of WA found that threshold to be approximately 10 % of the landholding. However, there was no clear sense of saturation amongst our data or landholders. Race *et al.* (2010) series of interviews with a subset of our participants, and local NRM managers, found instead a sense of frustration that sufficient resources were not available to capitalise on the degree of interest. The changing nature of land holdings in our case study areas with a growing cohort of Lifestyle Landholders (e.g., Mendham & Curtis 2010), and the resulting diversity of the community, is clearly one of the drivers of that sustained interest in undertaking native vegetation works. For example, whereas Smith's (2008) landholders were all wheat and sheep farmers, the majority of the landholders in our sample had other sources of income, and some required no return from their holding other than somewhere quiet to live. Some of this latter group of Lifestyle Landholders had restoration in mind for up to 100 % of their holding.

Race *et al.* (2010) response to the diversity of landholders they interviewed was to propose a three-category classification of Commercial Farmers, Part-time Farming Landholders, and Lifestyle Landholders. Whilst these categories were based on somewhat arbitrary thresholds in on-farm activity, income, size of holding and self-identification, we found it a useful filter for exploring variation in not only amounts of work undertaken,

but also in patterns of engagement by landholders with NRM agencies. Whereas most landholders had established sites with support from more than one Agency, Commercial Farmers had disproportionately engaged with Landcare, DPI and the Land Protection Incentive Scheme, particularly in comparison to Lifestyle Landholders. This bias may exist because these agencies disproportionately deliver revegetation programs and Commercial Farmers are more likely to interact with these agencies, or because Commercial Farmers favour revegetation and the agencies involved with them tailor their programs to suit. The Catchment Management Authorities by contrast had apparently similar reach into all three of the landholder types. One would expect these distinctions to be breaking down with time. In recent years sub-contracting relationships have developed between some of these agencies, for example DPI in a number of jurisdictions now delivers on-ground works programs for CMAs, so their relationship with Commercial Farmers may become increasingly asymmetrical.

The dynamic change in landholder types and objectives, whilst clearly creating engagement opportunity for these NRM agencies (Race *et al.* 2010), may have attendant risks. For example, ongoing care and management of native remnants or revegetation could be counted upon with farming landholders, particularly where they had a sense of stewardship and leaving the farm in better shape for their children. By contrast, Race *et al.* (2010) found that none of the Lifestyle Landholder properties had been passed down between generations, but they are a relatively novel group so it is not yet clear whether differences in patterns of succession exist. Indeed, it may be likely that environmental stewardship for intergenerational purposes is equally likely in all but the most productive parts of these case study areas. The increase in part-time and non-farmers may mean that the group most strongly associated with succession, the declining farmer group, may instead have subdivision as their notional long term plan. Therefore, except in those cases where the work is protected by legal covenant that is not extinguished by resale, there may be less security in general around native vegetation management actions carried out on private land..

Extent is not the whole story for native vegetation change

The findings described in this report are directly relevant to important reporting assumptions about the spatial extent of management beneficial to native vegetation. Specifically, they will help in estimating total hectares of revegetation completed within a given timeframe, which is anticipated to contribute at maturity to the extent of native vegetation cover. Many remnant-based actions, whilst they can contribute to the spatial extent of native vegetation cover by facilitating natural regeneration and re-colonisation of formerly cleared land, are mostly about increasing the spatial extent of remnant vegetation that has been protected from stock access by fencing, plus or minus weed control and supplementary planting. The key management change of stock exclusion can improve the structure and composition of native vegetation for habitat and biodiversity outcomes (Briggs *et al.* 2008; Duncan *et al.* 2007; Spooner *et al.* 2002; Yates *et al.* 2000). A key question in this regard is; to what extent are equivalent stock management practices taking place independent of establishment of "sites" recognised through the establishment of fences? Race et al (2010) found that most of their 30 interviewees had decreased or ceased grazing activity in recent times due to decline in profitability of grazing given that prolonged drought necessitated purchase of additional feed. Therefore, our data on remnant fencing probably greatly underestimates the spatial extent of stock exclusion by management choice, or benign neglect. However, the act of erecting a fence may hint at greater commitment or acceptance of conservation goals, and perhaps denotes greater security of the gain in improved management.

Limits to the generality of our findings

The extent to which our findings are representative of the entire community within our study areas is unclear. Whilst we purposefully sought to bias our sampling of landholder in favour of landscapes with higher density of revegetation and regeneration, our final sample did not conform to our plans (Table 1, Methods). Instead, the majority of sample came from landscapes characterised by less than median values for revegetation and regeneration, but that does not necessarily mean that the landholders themselves conformed to the statistics of their local landscape. All of our interviewees had fenced out at least one area of remnant native vegetation, and each had undertaken at least one instance of active remnant restoration on their property. This suggests that we may not have sampled from the least engaged tail of the distribution of landholder activity, but the extent to which our sample may have represented highly engaged landholders is unclear. Bias in this regard should not affect the relevance of the findings regarding proportional area contributed by public and privately funded works, as privately funded works were mostly small scale revegetation activities. Thus, even if we sampled disproportionately few landholders who were not

engaged with NRM agencies and activities, there is no reason to suspect that the number and scale of their works would be sufficient to alter our key findings. However, caution should certainly be applied in extrapolating the average amounts of work done on holdings of different kinds from our sample, as this is where the bias may be misleading.

Just as limits apply to extrapolating within our case study areas, even greater caution must be applied in extrapolating to other areas where the biophysical, climatic, land use, and land use change settings may be different. However, we believe that our findings should prompt interest and consideration of the magnitude and motivations for native remnant protection, enhancement and revegetation in any jurisdiction, regardless of those conditions.

Lessons for investment and reporting landscape change

In order to maintain, extend and update the input of important findings such as these into landscape change reporting and decision making, in this and other areas, greater emphasis must be placed on recording, curation and interpretation of remnant protection and revegetation activities on public and private land (Zerger *et al.* 2009). Fortunately, most of the elements required to achieve this have already been developed, thus only modification, standardisation and integration is required. For nearly 10 years Victoria has had a system for spatially capturing where and how public money was invested in private land sites, known as the Catchment Activity Management System (CAMS). This system was designed to address a critical failure in data management where investment sites could not be reliably located, let alone monitored for effectiveness (Brooks & Lake 2007). CAMS was designed for use and access by government agencies to capture data on *public* investment sites but information on *privately* funded activities is also required to tell the full story of landscape change. Individuals in Victoria can already access relevant imagery and thematic spatial data to create their own activity maps and plans using the *Biodiversity Interactive Map* (DSE 2007), but this platform currently has no upward-aggregation function for private data. Other interactive, map-based platforms, for example the *eFarmer* prototype (Roberts *et al.* 2009) and the *FarmPlan 21* pilot (DPI 2010), have been designed for landholders to map management units and farm information. These farmer / rural landholder focused platforms draw down government spatial data on soils and biodiversity information to assist with farm planning processes. Though primarily designed for landholders the *eFarmer* prototype (Roberts *et al.* 2009) can also feed data up to regional NRM staff to assist planning and reporting. There is clearly scope and technical ability to capture the spatial data, however with many competing models, data compatibility is likely to be problematic. However, if at least partial compatibility can be engineered between platforms such as the examples described above, covering both public and privately funded works, then analyses such as those presented in this report can become far easier, more affordable and more routine. A fundamental requirement will be at least partial standardisation of data collection and coding, perhaps converging on a standard such as that recently trialled and advocated by Zerger *et al.* (2009) and informed by accumulated wisdom represented in the relevant international standard for spatial data quality of ground and image data (AS/NZS ISO 19115:2005).

Conclusion

Our study tested the 'times 2' assumption (for each hectare in which public funds are invested in vegetation management there is matching privately funded activity) and found that the ratio over recent years was in fact around 10:1, not 1:1. We definitively concluded that each hectare of public investment does not leverage an additional hectare of private work, though in decades gone by it may have. However we also found that the area per year of private and public activity was unrelated at the scale of the case study areas, thus the reporting value of new ratios from these data is questionable. Our data provides critical new base line data useful for reporting three distinct types of works: remnant fencing; active remnant restoration; and revegetation, which could be used and further updated. We have also showed how the patterns of public and private investment have changed in these case study areas since the earliest recorded sites in 1960, and how objectives for undertaking such works have also changed. Insights such as these could become routinely available to natural resource managers and investment planners where similar approaches to spatial recording of publicly funded and privately funded works were adopted. If not, we will continue to rely on unsafe assumptions about what, where and why people are engaging in vegetation management as a basis for planning and investment.

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