Title: What motivates ecological restoration?

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Abstract

Ecological restoration projects are motivated by diverse environmental and social reasons. Motivations likely vary between stakeholders or regions, and influence the approach taken to plan, implement and monitor restoration projects. We surveyed 307 people involved in the restoration of native vegetation across Australia to identify their underlying motivations. We also elicited information on planning, implementation and monitoring of restoration projects. We found that biodiversity enhancement is the main motivation for undertaking restoration, with biodiversity offsetting, water quality improvements and social reasons as important secondary motivations. Motivations varied significantly by stakeholder type and region. Restoration projects primarily motivated by ecosystem service provision (e.g. water quality improvements and social reasons) sought less pristine ecological outcomes than projects motivated by biodiversity enhancement or offsetting. Rigorous monitoring designs (e.g. quantitative, repeatable surveys and use of performance indicators) were rarely used in restoration projects, except for projects motivated by scientific research. Better alignment of different restoration motivations with the planning and monitoring of restoration projects should deliver greater benefits through setting appropriate objectives and evaluating outcomes against these objectives. These improvements will increase the capacity of the restoration practice to meet international biodiversity commitments and communicate restoration outcomes to stakeholders.

Key words: motivations, revegetation, biodiversity enhancement, ecosystem services, restoration planning, restoration monitoring.

Implications for practice

- Restoration planners should allow for the strong inherent motivation of individuals to restore for biodiversity enhancement when designing national restoration programs or large-scale restoration initiatives, to avoid a potential mismatch between the desired outcomes of governing bodies and the individuals undertaking the restoration projects.
- Integrating different motivations in the planning and monitoring of restoration projects should allow the project to deliver multiple benefits and help resolve stakeholder conflict.
- Restoration projects primarily motivated by ecosystem service provision should be mindful of their impacts on biodiversity to minimize the trade-off between ecosystem service and ecological objectives.
- Wider application of rigorous monitoring, that objectively evaluates the performance of restoration projects against desired outcomes, would inform more effective restoration strategies in the future.

Introduction

Around the world deforestation and forest degradation has negatively impacted biodiversity and human well-being (Lamb 2014). Ecological restoration is the principle means for recovering the loss and degradation of ecosystems (SER 2004) and has considerable potential to conserve biodiversity (Hobbs & Norton 1996). It also has potential to deliver socio-economic benefits through provision of ecosystem services (the benefits people obtain from ecosystems) such as provision of clean water and mitigating climate change (Rey Benayas et al. 2009; Aronson et al. 2010; Cunningham et al. 2015).

Restoration is undertaken for different reasons reflecting the diversity of outcomes that can arise from restoration projects (Bernhardt et al. 2007; Burton & Macdonald 2011; Aradottir et al. 2013). Clewell & Aronson (2006) categorised the range of possible motivations as **biotic, technocratic, pragmatic, heuristic, and idealistic**. Enhancing the conservation of biodiversity, including threatened species, is historically the main **biotic** motivation for restoration (Hobbs & Norton 1996; Ehrenfeld 2000). Legal and policy requirements are an increasingly strong **technocratic** motivation for restoration, in particular to mitigate or offset habitat loss from development and mining (Suding 2011). The provision of ecosystem services (Chazdon 2008; Aronson et al. 2010; Groot et al. 2013; Brancalion et al. 2014) and the reversal of land degradation (Bernhardt et al. 2007; Aradottir et al. 2013) are increasingly important socio-economic, or **pragmatic,** motivations for restoration. The **heuristic** motivations for restoration are to elicit scientific data through experimental investigations (Perring et al. 2012), and **idealistic** motivations seek atonement for environmental degradation or reconnection with nature (Clewell & Aronson 2006; Wyborn et al. 2012; Brancalion et al. 2014).

Despite this array of motivations, the frequency that these are invoked has not been previously synthesised across a diversity of contexts, regions or stakeholders. Information on motivations has been derived from catalogues of restoration projects across countries, e.g. 100 projects in Iceland (Aradottir et al. 2013) and 119 projects in Colombia (Murcia et al. 2016), project goals published in scientific literature globally (Burton & Macdonald 2011), or evaluation of major restoration programs (Yin & Yin 2010; Rodrigues et al. 2011; Durigan et al. 2013; Pinto et al. 2014; Richards et al. 2015). Studies specifically eliciting motivations have so far been limited to project managers of river restoration projects in the United States (Bernhardt et al. 2007) or volunteers of environmental groups in Sydney and the Bass Coast in Australia (Measham & Barnett 2008).

Understanding and reconciling different motivations is especially relevant given the pressing need to scale-up restoration to meet international biodiversity commitments (Suding et al. 2015), such as the Aichi Biodiversity Target 15 to restore at least 15% of degraded ecosystems globally (CBD 2010) . A person's motivation to undertake restoration can be influenced by political context and their cultural worldviews and social identities (McCarthy & Prudham 2004; Fielding & Hornsey 2016) and it is these motivations that define desired outcomes of restoration. As such, differences in motivations between groups can lead to divergent outcomes, especially where social conflict exists (Colvin et al. 2015; Fielding & Hornsey 2016). There are also concerns that international commitments may themselves motivate actions that compromise biodiversity. For example, specialized programs targeting threatened species conservation or ecosystem service delivery may not achieve ecological restoration (Suding et al. 2015).

Scaling-up restoration necessarily involves a larger number and diversity of stakeholders. In Australia, for example, several landscape restoration initiatives have recently emerged, including Gondwana Link and the Great Eastern Ranges Initiative (Fitzsimons et al. 2013). Such large-scale initiatives are commonly delivered by locally-based groups that attract funding independently with support from the governing body (Bradby 2013). Consequently, broader initiatives are implemented as multiple smaller projects across different land tenures and jurisdictions. It is therefore possible that individual projects can differ considerably in their motivations, despite having a common vision.

Given the varied ecological and social contexts in which restoration can occur, and the different motivations and associated outcomes, several general frameworks have been developed to plan

(Beechie et al. 2008; Wilson et al. 2011), monitor and evaluate restoration projects (Ehrenfeld 2000; Hobbs & Harris 2001; Miller & Hobbs 2007). Important considerations include diagnosing ecosystem damage to determine the type of intervention required, setting clear and realistic objectives, prioritising restoration actions by taking into account the relative costs and likely benefits of the interventions, and developing appropriate indicators to measure performance. Guiding principles are also important to achieve sustainability and resilience of restoration outcomes (Suding et al. 2015; McDonald et al. 2016). Structured decision making is a useful framework for adaptive management in restoration involving multiple stakeholders that can affect the outcome of restoration decisions. It defines clear objectives and ensures there are performance measures for each objective (Falling et al. 2013). Monitoring and evaluation of restoration outcomes can also improve decision making for future restoration projects (Suding 2011). Performance can be monitored at several points over the lifetime of a restoration project; however effective monitoring requires well-documented objectives and inputs before monitoring outputs and evaluating outcomes (Kapos et al. 2008; Freudenberger 2012). Monitoring approaches also vary in both intensity and cost. Regular inspections may be adequate for the early detection of problems, however quantitative, repeatable surveys are required to more reliably assess outcomes against predefined indicators (Block et al. 2001; Ruiz-Jaén & Aide 2005; Kanowski et al. 2010).

Despite numerous options on how best to plan, monitor and evaluate restoration projects, it is unclear how many projects define measurable objectives and corresponding performance indicators, or monitor those indicators (Bernhardt et al. 2007; Burton & Macdonald 2011; Murcia et al. 2016). Unclear or conflicting objectives could also emerge from differences among stakeholders in their original motivations for restoration. Understanding how motivations differ across stakeholders, regions and contexts, and how they influence planning and monitoring approaches can improve understanding of past restoration outcomes, and inform more effective coordination of large-scale restoration efforts in the future. Reconciling different motivations can help to avoid potential trade-offs in intended outcomes and resolve conflict between stakeholders. Recognising stakeholder motivations may also help to sustain their commitments to restoration in the long-term.

Using Australia as a case study, we report on a national survey of restoration stakeholders to determine: (1) What are the motivations for undertaking ecological restoration; (2) How do motivations vary among different stakeholder types, administrative regions and landscape contexts; (3) Does the source of funding for restoration affect the motivation; and (4) How do planning and monitoring approaches vary between motivations?

Methods

Creation of the online survey

We surveyed individuals and organizations across Australia involved in the restoration of terrestrial native vegetation (hereafter referred to as stakeholders). Restoration was defined as any method of reinstating native vegetation on previously cleared lands, including by plantings, seeding, assisted natural regeneration or a combination of these methods. The aims of the broader survey were to identify the restoration motivations of people from different stakeholder types and regions, ascertain their perceptions on the factors influencing restoration success and elicit data on restoration methods, costs and outcomes for Australia's major terrestrial vegetation types. Our survey dataset was extensive and here we report only the results relevant to the research questions.

Given the size of our sample, we undertook an online survey to collect data on specific variables. The survey design was informed by qualitative methods to ensure its contextual relevance (Dillman et al. 2009; Newing 2011). Firstly, thirteen semi-structured interviews were held with individuals involved in scientific research of restoration to scope the issues. A two-hour regional focus group was then held with nine individuals with different roles in restoration in south-east Queensland (SEQ), from planning and implementation to research, to explore diverse perspectives on restoration issues. A pilot study of the online survey was then undertaken by six individuals from different target groups (e.g. restoration practitioners and researchers), as well as people qualified in social science research to test the survey and refine the survey questions. A Participant Information Sheet was developed to address elicitation of sensitive information and survey fatigue (Supporting Information).

The survey contained 50 structured questions that can be broadly classified into four categories: (1) respondent's organisation, motivations for undertaking restoration, planning and monitoring approaches and perceptions on factors influencing restoration success (11 questions); (2) case study on a restoration project (33 questions); (3) restoration projects that have not progressed as planned (4 questions); and (4) respondent's contact information and further participation in the research project (2 questions) (Supporting Information).

Sampling

We collated a national database of over 1000 stakeholders. Our study population included stakeholders with different roles in restoration across all states and territories of Australia, including volunteers from community groups and not-for-profit (NFP) organizations, landholders and practitioners from NFP organizations, Natural Resource Management (NRM) bodies and private organizations who undertake restoration, managers from government and NRM bodies who fund, prioritise, plan and/or facilitate restoration projects, and scientists from research institutions who undertake research on restoration projects. To identify stakeholders, we searched the Internet for relevant organizations and contacted these organizations to obtain contact information for individuals who undertake terrestrial restoration. We included recipients from federal and state government grants, and relevant individuals identified through our networks. We attempted to represent all stakeholder types for each state or territory in our sample. Details on the sample composition including proportion of stakeholders represented in the database by stakeholder type and region, and likely representation of the study population is in the Supporting Information (Table S1).

Data gathering

The survey was administered online through Qualtrics and opened on 7 November 2014. An invitation to participate in the survey (including a hyperlink to access the survey and Participant Information Sheet) was emailed to 1107 stakeholders on a staged basis; Queensland (QLD) and New South Wales (NSW) in November 2014, Victoria (VIC), Australian Capital Territory (ACT) and Tasmania (TAS) in February 2015, and South Australia (SA), Northern Territory (NT) and Western Australia (WA) in March 2015. We also advertised the survey to members of several restoration groups via newsletters and websites. Participants had the option of completing the survey anonymously, and were asked to provide their consent before commencing the survey. Participants could close and return to the survey as often as needed to complete it. They could also return to previous questions if they wished to make changes prior to submitting their response. A reminder email was sent two months after the initial invitation to all participants that had not yet completed the survey. Another reminder email was sent just before closing the survey to participants who had started the survey but not yet completed it. The survey was closed on 10 July 2015.

The survey adhered to the guidelines of the ethical review process of The University of Queensland and the National Statement on Ethical Conduct in Human Research.

In total we received 307 completed responses, which corresponds to a response rate of 28%. The majority of responses were from VIC (35%), followed by QLD (22%), NSW (18%), WA (17%) and SA (5%). Despite our efforts to sample all states and territories, there were few responses from the ACT, TAS and the NT (2, 8 and 15% response rate, respectively). Restoration using planting and seeding methods is relatively uncommon in NT, which probably explains the low response rate for this territory.

Individuals from a range of stakeholder types responded to the survey, mostly from community groups (28%), but also state government agencies (15%), local government agencies (14%), NFP organisations (15%), private organisations (13%), NRM bodies (6%) and landholders (8%). The response of landholders was improved from the initial sample size by reaching out to landholders via newsletters and websites of restoration groups. Despite our efforts to sample all stakeholder types, few responses were obtained from university or research institutes (1%) or federal government agencies (<1%) (both 7% response rate). Many researchers are not involved in on-ground restoration which may have prevented their participation, and commonwealth privacy laws may have reduced the response rate from federal government. Most respondents (77%) were involved solely in the practice of restoration. Only 2% were involved solely in scientific research, and 21% were involved in both.

A total of 220 respondents provided an example of a restoration project as a case study. The case studies covered 20 major vegetation groups across Australia, although some vegetation groups had only one representative case study. The majority of projects were restoration of eucalypt forests and woodlands (27%), rainforests and vine thickets (12%) and eucalypt open woodlands (11%).

Data analysis

Statistical analyses were performed in R version 3.2.2 (R Core Team 2015). Categorical variables (including motivations, stakeholder types and states) with less than five responses were excluded from analysis of all relevant questions. Respondents selecting 'don't know' or failing to select any of the options provided in a given question were also excluded from analysis of that question.

To identify general motivations to undertake restoration, we calculated the proportion of responses that selected each motivation category (Table 1). We analysed whether each motivation varies by stakeholder type and by region (state or territory) using generalised linear models with binomial errors and logit link functions. Post hoc Pearson's chi-square tests were used to assess overall differences among groups, and pairwise differences between groups were tested using the glht function in the multcomp package (Hothorn et al. 2016). For the analysis of motivations per stakeholder type, we removed three stakeholder types (federal government agencies, university and research institutes and other) and three motivations (scientific research, forest and wood products and other) due to small sample size. We also removed three regions (ACT, NT and TAS) and one motivation (other) for the analysis of motivations per state.

To identify the motivations of specific restoration case studies, we calculated the proportion of first and second ranked responses for each motivation category. We analysed whether primary and secondary motivation varies with landscape context using a chi-square test. We identified whether funding bodies influence the motivation by calculating the proportion of stakeholder categories choosing the primary motivation for case studies that received financial support.

To identify how planning and monitoring of restoration projects vary between motivations we calculated the proportion of responses that selected each planning and monitoring approach across the general motivations. We then calculated the proportion of case studies that selected each type of ecological objective (i.e. how the restoration will achieve ecosystem recovery), performance indicator (i.e. criteria for measuring success) and monitoring approach across the primary motivations of the case studies. Table 1 lists the response categorisations for each variable. We used generalised linear models with binomial errors and logit link function, followed by post-hoc pairwise tests (Hothorn et al. 2016), to compare differences between primary motivations for ecological objectives, performance indicators and monitoring approaches.

Results

To address our research questions, here we present results from the survey on: (1) restoration motivations including both general motivations of survey respondents and the primary and secondary motivations of specific case studies; (2) general motivations by stakeholder type and region, and primary motivations of case studies by landscape context; (3) funding of case studies and their primary motivations; (4) general motivations across planning approaches, and primary motivations among ecological objectives and performance indicators of case studies; and (5) general motivations across monitoring approaches, and primary motivations among monitoring approaches of case studies.

Restoration motivations

95% of respondents (n=303) undertook ecological restoration for the **biotic** motivation of biodiversity enhancement, followed by water quality improvements (**pragmatic** motivation) and social reasons (**idealistic** motivation) (both 55%). 41% of respondents undertook restoration for the **technocratic** motivation of biodiversity offsetting, but only 22% of respondents were motivated by carbon sequestration (**pragmatic** motivation). Similarly, 148 of the restoration case studies were primarily motivated by biodiversity enhancement (67%), followed by biodiversity offsetting (10%) and water quality improvements (7%) (Fig. 1).

Motivations by stakeholder type, region and landscape context

General motivations were found to vary by stakeholder type and by region, with several significant pairwise differences (α=0.05) identified (Table 2). Private organisations and state governments were motivated by biodiversity offsetting more than community groups and landowners; NFP organisations were motivated by water quality improvements more than landowners; and NFP organisations were motivated by carbon sequestration more than community groups. Community groups undertook restoration for social reasons more than landowners, private organisations and state government. Local government and NFP organisations also undertook restoration for social reasons more than landowners.

When motivations are compared by region, SA undertook restoration for the **pragmatic** motivation of salinity management more than QLD. SA and VIC were motivated by farm improvements (**pragmatic** motivation) more than QLD. NSW, SA and VIC undertook restoration for farm improvements more than WA. QLD was motivated by **technocratic** political reasons more than VIC and WA.

Landscape context varied across primary and secondary motivations of case studies (Fig. 2). A higher proportion of case studies that undertook restoration for **pragmatic** motivations (water quality, farm and soil improvements, and carbon sequestration) were located in rural than urban areas, whereas, a higher proportion of case studies motivated by **idealistic** (social, cultural and political) reasons were located in urban than rural areas. However, landscape context was not found to significantly influence primary (x^2=15.59, P=0.11) or secondary motivation (x^2=25.54, P=0.11).

Funding and motivations

Out of the case studies, 194 (85%) received financial support, including all or most projects primarily motivated by biodiversity enhancement, water quality improvements, farm improvements and social reasons, and the majority of projects primarily motivated by biodiversity offsetting (73%). Of these, only 5% considered that the funding body chose the motivation for the project. More commonly it was the organisation undertaking the project that chose the motivation (50%), followed by the landholder (14%), government (12%) and client (10%).

Planning and motivations

Across all general motivations, we found that most respondents assessed the ecological condition (86-100%) and land condition (71-89%) of the site when planning restoration projects. Most (71-89%) also undertook an informed site selection process, e.g. spatial mapping, analysis of site constraints and consideration of alternative sites. Less respondents (57-70%) defined indicators for measuring performance, except for respondents motivated by scientific research (83%). In terms of setting objectives, almost all respondents, regardless of general motivation, defined what is trying to be achieved by the restoration (93-100%) and how the restoration will be achieved (91-100%).

For the specific case studies, the objectives of reinstating pre-existing ecosystem attributes and function to the greatest possible extent or reinstating some ecological function were more common than restoring to a reference condition (either current or historical). In addition, ecological objectives varied with the primary motivations for restoration (Fig. 3a). For example, reinstating pre-existing ecosystem attributes and function to the greatest possible extent was the main objective of case studies motivated by biodiversity enhancement (41%) and biodiversity offsetting (36%), whereas reinstating some ecological function was the main objective of those motivated by water quality improvements (40%) and social reasons (60%), although no significant differences were identified between motivations for any objectives (model results in Table S2, Supporting Information). Furthermore, % plant survival or plant establishment (60-100%), % vegetation cover (20-63%), % species diversity (40-69%) and absence of weeds or pest animals (40-78%) were more common performance indicators than those involving intensive survey techniques, regardless of primary motivation (Fig. 3b). Those case studies that had more intensive survey techniques (e.g. fauna diversity and presence of threatened species as indicators) were mainly motivated by biodiversity enhancement (44 and 27%, respectively), although no significant differences were found between motivations for any indicators (model results in Table S2). Community support was described frequently as a target in the ‘other’ category.

Monitoring and motivations

Across all general motivation categories, more respondents undertook monitoring using visual observations of restoration progress (89-96%), photo-point monitoring (76-92%) and/or survival assessment (69-86%) than rigorous monitoring approaches, including evaluation of restoration outcomes against the objectives (47-64%), assessments against pre-defined indicators (30-57%), surveys of fauna diversity (other 21-54%) and quantitative, repeatable surveys (40-64%), except for respondents motivated by scientific research.

More case studies also undertook monitoring using visual observations (75-100%), photo-point monitoring (50-86%) and survival assessment (58-80%) than more rigorous monitoring approaches, including quantitative, repeatable surveys (20-45%), assessments against pre-defined indicators (none to 35%), and surveys of fauna diversity (none to 36%), regardless of primary motivation (Fig. 3c). Although visual observations and photo-point monitoring were lowest for case studies motivated by social reasons (40%) and farm improvements (40%) respectively, and quantitative surveys and use of indicators were highest for case studies motivated by biodiversity offsetting (35% and 45%, respectively), no significant differences were found between motivations for any monitoring approaches (model results in Table S2).

Discussion

Biodiversity enhancement is the main motivation for restoration in Australia, and the provision of ecosystem services (e.g. water quality improvements and social reasons) is a major secondary motivation, however our results may not fully represent all states and territories or all stakeholder types. Motivations were found to vary between stakeholder types, likely reflecting differences in business or personal objectives. For example, private organisations and state governments were motivated by biodiversity offsetting more than community groups and landowners. This reflects the increase in popularity of biodiversity offsetting with businesses and governments to compensate for negative impacts on species and habitats caused by development (Maron et al. 2015). In contrast, community groups were motivated by social reasons more than local government, NFP organisations and landowners. Community groups mainly comprise volunteers who are more likely to engage in restoration for social reasons, for example contributing to the community, social interaction, care for the environment and attachment to a particular place were found to be main volunteer motivations of environmental groups in Sydney and the Bass Coast (Measham & Barnett 2008).

Our findings reveal differences in motivations between regions and across different landscape contexts, which are likely due to differences in environmental issues, agricultural practices and political systems. For example, in SA, restoration was motivated by salinity management more than in QLD, presumably because salinity in the Murray River and its floodplains is an ongoing problem in south-eastern Australia (McLennan et al. 2013). As expected, **pragmatic** motivations (farm improvements, salinity management and carbon sequestration) were more evident in rural contexts, given agricultural practices and the threat of salinity in rural areas. Furthermore, **idealistic** motivations (social and political reasons) were more evident in urban contexts, reflecting the importance of community involvement and political support close to populated areas.

Regardless of the motive to restore, we found that few respondents defined performance measures (except for scientific research) and even fewer undertook monitoring using pre-defined indicators. As motivations define desired outcomes, explicitly identifying motivations and incorporating these in the planning of all restoration projects would help to define the most appropriate objectives and performance measures to achieve and evaluate desired outcomes. Where diverse stakeholders are involved, projects may benefit from structured decision making to identify and incorporate different motivations and preferences into cohesive restoration objectives (Guerrero et al. 2017). This would enhance the integration of ecological and socio-economic objectives, thereby increasing the potential for restoration projects to provide multiple benefits and meet international biodiversity commitments (Hobbs 2007; Aronson et al. 2010; Menz et al. 2013; Suding et al. 2015).

Aside from stakeholder preferences, achievable restoration depends heavily on the type and extent of damage to the ecosystem (Hobbs 2007). We found that the ecological and land condition of restoration sites were usually assessed during planning, regardless of the motivation. This potentially provides valuable information to diagnose ecosystem damage, identify abiotic and biotic thresholds and develop corrective methodologies to overcome such thresholds (Hobbs 2007; Cramer et al. 2008). In addition, prioritization of where and when ecosystems are restored can also help to ensure the cost effective delivery of desired outcomes (Wilson et al. 2011). We also found that planning of restoration projects, regardless of the motivation, usually included a site selection process based on spatial mapping, analysis of constraints and/or consideration of alternative sites. This is key information to estimate the relative costs of restoration at different sites and the likelihood of success (Wilson et al. 2011).

Setting realistic objectives in restoration planning is also important to ensure that restoration does not require intensive and ongoing interventions, and has adaptive capacity in the face of environmental change (Hobbs 2007; Choi et al. 2008; Suding 2011). This may include the restoration of novel ecosystems (Cramer et al. 2008; Seastedt et al. 2008; Hobbs et al. 2009). Our results reveal that restoration projects motivated by biodiversity enhancement and offsetting mostly aimed to restore pre-existing ecosystem attributes and function to the greatest possible extent. Whereas restoration motivated by water quality improvements and social reasons aimed to restore only some aspects of ecological function and thereby accept a less pristine ecological objective overall, which may impact on biodiversity values as shown in native timber plantations (Hsu et al. 2010; Law et al. 2014). However, restoration focused on enhancing biodiversity can also increase the provision of ecosystem services (Rey Benayas et al. 2009), for example native mixed-species plantings can provide comparable rates of carbon sequestration to eucalypt plantations with greater habitat values (Cunningham et al. 2015). Further research is required on the biodiversity values of restoration projects that aim to provide specific ecosystem services (and accept less pristine ecological objectives) to evaluate potential trade-offs and synergies between ecosystem service provision and biodiversity objectives.

Effective monitoring also requires reliable assessment of outcomes (Kapos et al. 2008). Our results reveal that it was common to monitor the implementation (inputs and outputs) of restoration projects (audit of work plan actions, visual observations of restoration progress, photo point monitoring and survival assessment), rather than the outcomes (quantitative repeatable surveys, use of indicators and fauna diversity), except for projects motivated by scientific research that assessed outcomes more frequently. Wider application of rigorous monitoring that objectively evaluate outcomes against proposed objectives, should more reliably predict longer-term success of restoration projects (Kapos et al. 2009) and inform more effective restoration strategies in the future (Suding 2011). However, this will require overcoming financial and logistical constraints, such as short-term funding and lack of administrative flexibility of government restoration programs (Ewing et al. 2013). Our results also reveal that the performance indicators defined in restoration projects focussed on ecological attributes. In addition to ecological indicators, socio-economic indicators should be clearly defined and evaluated to assess a more complete range of benefits that restoration can provide (Aronson et al. 2010; Shackelford et al. 2013; Wortley et al. 2013).

With the increasing demand for restoration to be undertaken for ecosystem service provision such as the Australian Government's Emissions Reduction Fund, future restoration programs in Australia should also acknowledge the strong inherent motivation of biodiversity enhancement to align the demand for, and supply of, restoration projects and avoid a potential mismatch between government policy and associated funding, and restoration outcomes. In addition, integrating different motivations with the most appropriate planning and monitoring approaches will provide a greater chance of ensuring restoration projects deliver multiple benefits, sought by international biodiversity and ecosystem service targets.

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Illustrations

Table 1: Survey response categorisations for motivations, planning approaches, monitoring approaches, ecological objectives and performance indicators.

Response	Categorisations
Motivations	Biodiversity enhancement; biodiversity offset; water supply improvements; water quality improvements; soil improvements; salinity management; farm improvements; carbon sequestration and/or offsets; forest products for harvest; scientific research; cultural reasons; social reasons; political reasons; other
Planning approaches	Consider relevant legislation, policies and/or strategies; assess current ecological condition of the revegetation site; assess current land condition of the revegetation site; define what is trying to be achieved by the revegetation; define how the revegetation will be achieved; undertake an informed site selection process; define performance measures or indicators for revegetation success; prepare work-plans for revegetation; other
Monitoring approaches	The proposed budget has been spent; the proposed work plan has been completed; visual observations of revegetation progress; photo point monitoring; collection of quantitative data using repeatable survey methods; measurements of performance indicators against a reference state; survival assessment; fauna monitoring; evaluation of revegetation outcomes against the proposed objectives; other
Ecological objectives	Restore to a historical reference condition; restore to a current reference condition; reinstate pre-existing ecosystem attributes (and function) to the greatest possible extent; reinstate some ecological function; other
Performance indicators	% survival of plants or plant establishment rate; % vegetation cover; % species diversity; fauna diversity; presence of threatened species; absence of weeds and/or pest animals; other

Table 2: Model results and significant pairwise differences (α=0.05) for restoration motivations and (a) stakeholder types, and (b) regions (state and territories). The comparisons indicate the direction of the difference. It was not possible to statistically analyse differences by stakeholder type within the ‘forest products’, ‘scientific research’ and ‘other’ motivation categories, or by region within the ‘other’ motivation category due to small sample size. *D* = deviance, *P* = probability, NA = not analysed, NS = not significant, ****P*<0.001, ***P*<0.01, **P*<0.05.

Motivation category	Motivation	(a) Stakeholder types			(b) Regions		
		n	*Model results*	Pairwise differences	*n*	*Model results*	Pairwise differences
Biotic	Biodiversity enhancement	283	*D*=17.48, *P*=0.008**	NS	279	*D*=5.99, *P*=0.20	NS
Technocratic	Biodiversity offset	120	*D*=29.85, *P*<0.001***	Private > community*** State gov > community* Private > landowner** State gov > landowner*	121	*D*=6.34, *P*=0.18	NS
Pragmatic	Water supply improvements	98	*D*=17.49, *P*=0.008**	NFP > local gov*	96	*D*=2.98, *P*=0.56	NS

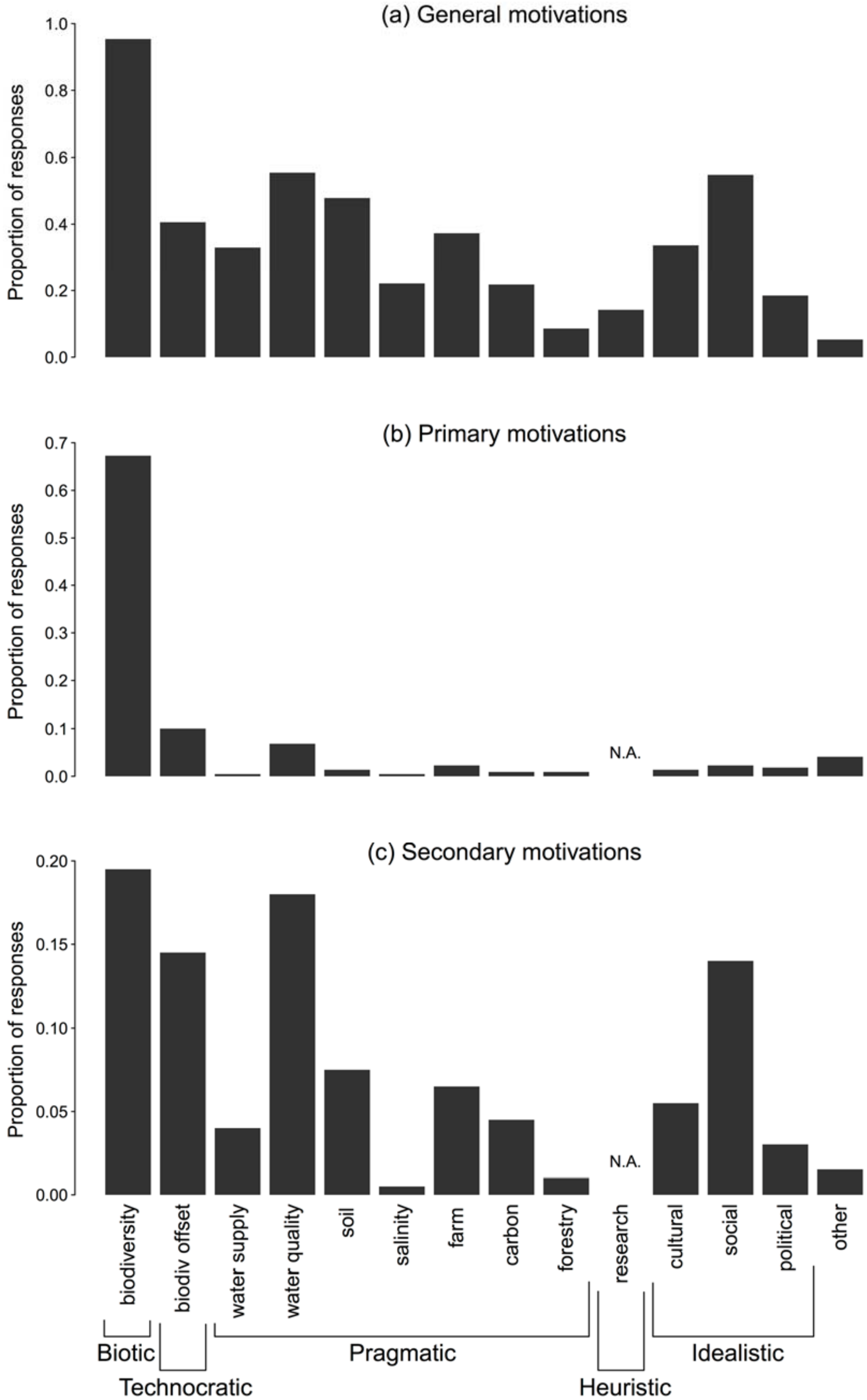
Motivation category	Motivation	(a) Stakeholder types			(b) Regions		
		n	*Model results*	Pairwise differences	*n*	*Model results*	Pairwise differences
	Water quality improvements	166	*D*=19.76, *P*=0.003**	NFP > landowner**	164	*D*=5.76, *P*=0.22	NS
	Soil improvements	143	*D*=9.42, *P*=0.15	NS	142	*D*=4.85, *P*=0.30	NS
	Salinity management	65	*D*=23.19, *P*=<0.001***	NRM > community** NRM > local gov*	65	*D*=13.60, *P*=0.008**	SA > QLD**
	Farm improvements	111	*D*=44.28, *P*<0.001***	Community > local gov* NFP > local gov*** NRM > local gov*** State gov > local gov** NFP > private* NRM > private*	110	*D*=32.72, *P*<0.001***	NSW > WA* SA > QLD** VIC > QLD* SA > WA*** VIC > WA**
	Carbon sequestration and/or offset	64	*D*=20.55, *P*=0.002**	NFP > community***	64	*D*=3.74, *P*=0.44	NS

Motivation category	Motivation	(a) Stakeholder types			(b) Regions		
		n	*Model results*	Pairwise differences	*n*	*Model results*	Pairwise differences
	Forest products	25	NA	NA	25	*D*=10.31, *P*=0.04*	NS
Heuristic	Scientific research	38	NA	NA	38	*D*=11.17, *P*=0.02*	SA > NSW*
Idealistic	Cultural reasons	99	*D*=2.10, *P*=0.91	NS	95	*D*=2.73, *P*=0.60	
	Social reasons	163	*D*=37.87, *P*<0.001***	Community > landowner*** Community > private* Community > state gov* Local gov. > landowner** NFP > landowner **	162	*D*=10.29, *P*=0.04*	NS
	Political reasons	55	*D*=6.82, *P*=0.34	NS	54	*D*=14.74, *P*=0.005**	QLD > VIC** QLD > WA*
	Other	16	NA	NA	14	NA	NA

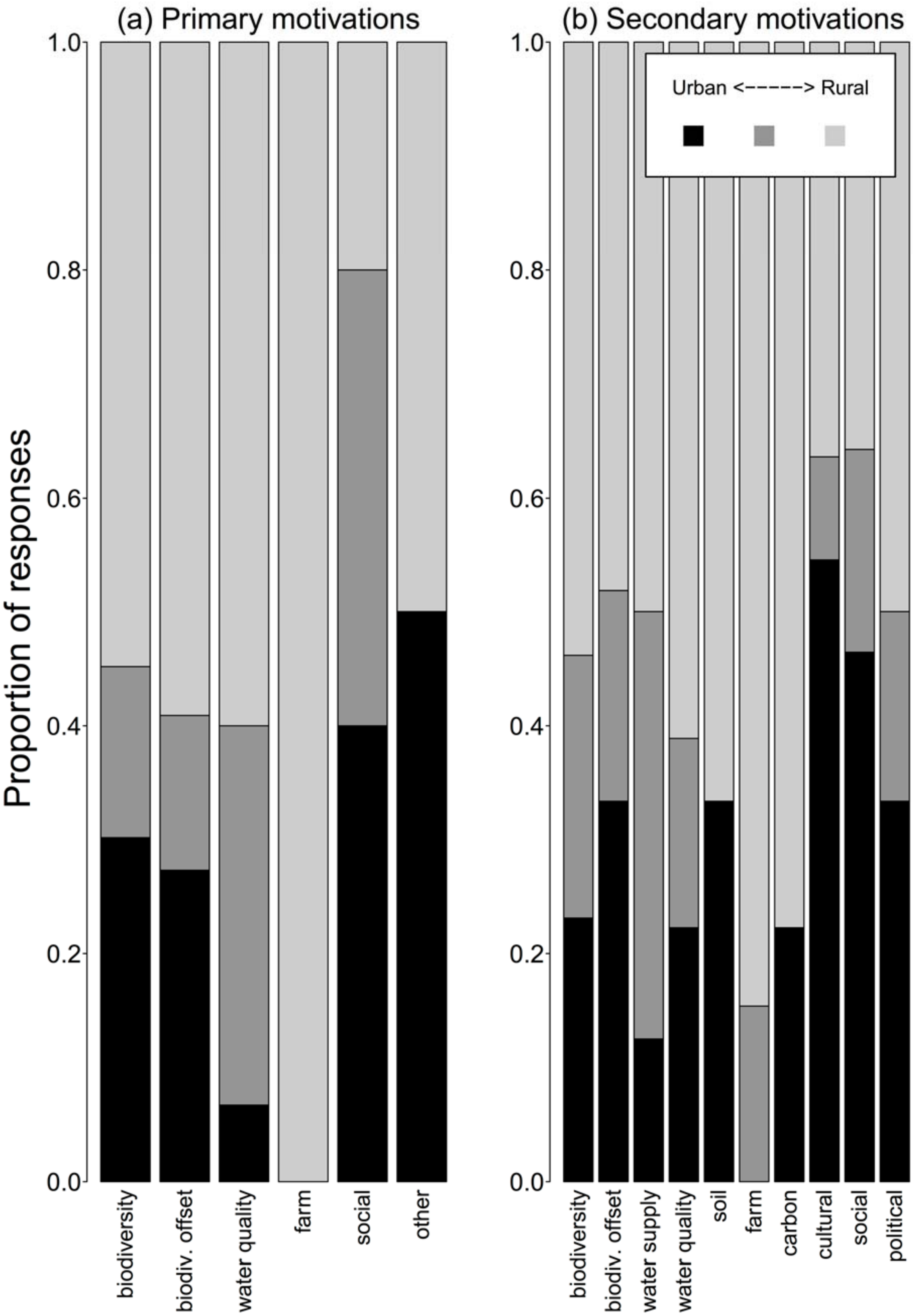
Figure 1: Frequency of restoration motivations showing (a) general motivations of survey respondents (n=303), (b) primary motivations of restoration case studies (n=220) and (c) secondary motivations of restoration case studies (n=200). For general motivations respondents could select more than one motivation category, therefore total proportion does not equal one. ‘Scientific research’ was not provided as a motivation category for the case studies.

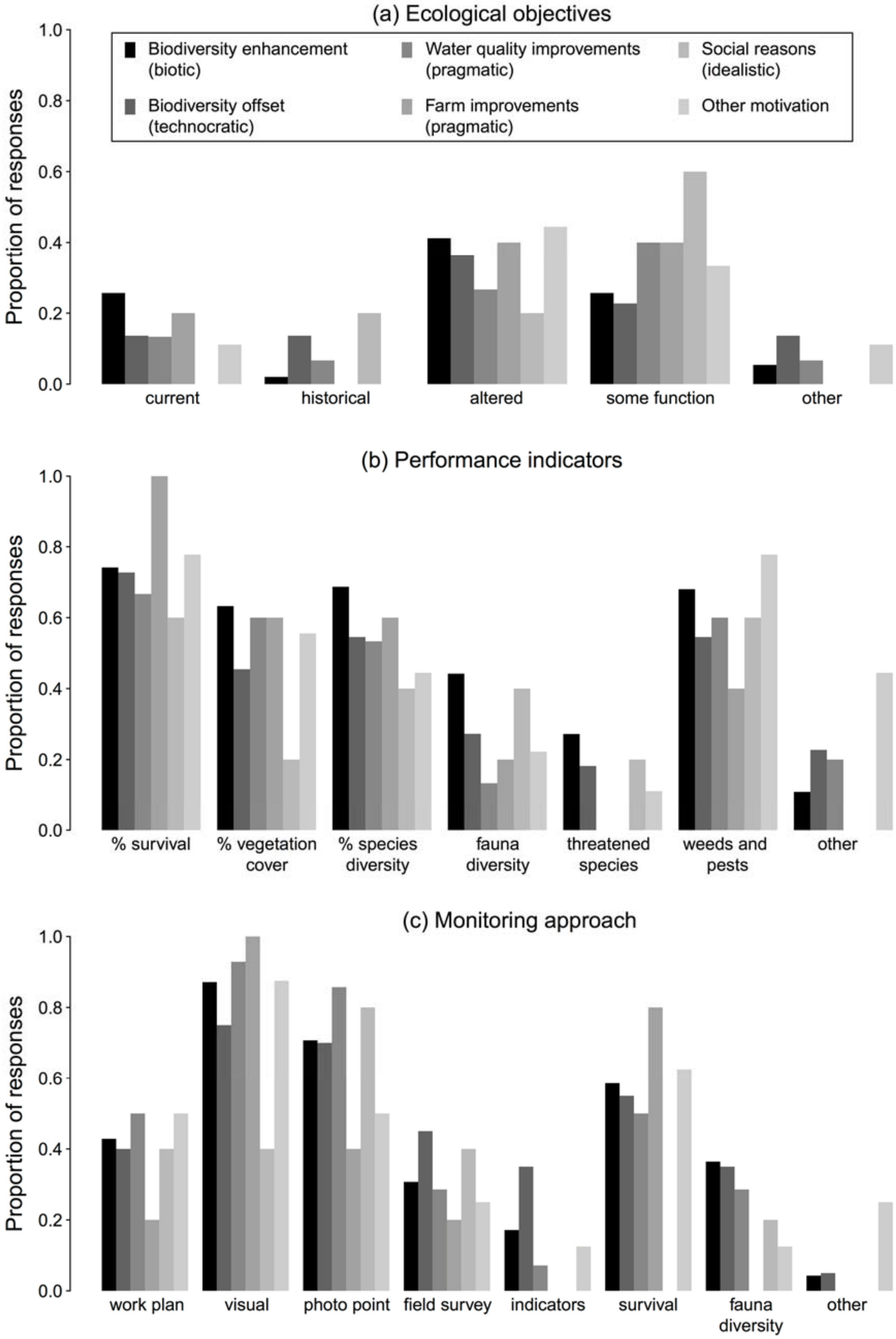
Figure 2: Distribution of landscape context (urban to rural) of restoration case studies per (a) primary motivation (biodiversity enhancement [n=148], biodiversity offset [n=22], water quality improvements [n=15], farm improvements [n=5], other [n=9]) and (b) secondary motivation (biodiversity enhancement [n=39], biodiversity offset [n=29], political reasons [n=6], water supply improvements [n=8], water quality improvements [n=36], soil improvements [n=15], farm improvements [n=13], carbon sequestration [n=9], cultural reasons [n=11], social reasons [n=28]) . ‘Other’ motivation in Fig. 2(a) relates to another motivation not covered under the list of motivation categories in Table 1.

Figure 3 Primary motivations of restoration case studies per (a) ecological objective (current [n=47], historical [n=8], altered [n=86], some function [n=64], other [n=16]), (b) performance indicator (% survival [n=150], % vegetation cover [n=121], % species diversity [n=130,], fauna diversity [n=78], threatened species [n=46], weeds or pests [n=133] and other [n=28] and (c) monitoring approach (work plan [n=82], visual observations [n=164], photo point [n=135], field survey [n=61], performance indicators [n=33], survival assessment [n=109], fauna diversity [n=64], other [n=9]. ‘Other’ motivation relates to another motivation not covered under the list of motivation categories in Table 1.


(a) General motivations
(b) Primary motivations
(c) Secondary motivations
Proportion of responses
1.0
0.8
0.6
0.4
0.2
0.0
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.20
0.15
0.10
0.05
0.00
N.A.
N.A.
biodiversity
biodiv offset
water supply
water quality
soil
salinity
farm
carbon
forestry
research
cultural
social
political
other
Biotic
Technocratic
Pragmatic
Heuristic
Idealistic

595


(a) Primary motivations
(b) Secondary motivations
Proportion of responses
1.0
0.8
0.6
0.4
0.2
0.0
Urban <------> Rural
biodiversity
biodiv. offset
water quality
farm
social
other
biodiversity
biodiv. offset
water supply
water quality
soil
farm
carbon
cultural
social
political


(a) Ecological objectives
Biodiversity enhancement (biotic)
Biodiversity offset (technocratic)
Water quality improvements (pragmatic)
Farm improvements (pragmatic)
Social reasons (idealistic)
Other motivation
Proportion of responses
1.0
0.8
0.6
0.4
0.2
0.0
current
historical
altered
some function
other
(b) Performance indicators
% survival
% vegetation cover
% species diversity
fauna diversity
threatened species
weeds and pests
other
(c) Monitoring approach
work plan
visual
photo point
field survey
indicators
survival
fauna diversity
other