

Using behavioural science to improve Australia's environmental regulation

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Abstract. Australia has many environmental regulations intended to alter the behaviour of rural landholders. One key issue relates to managing invasive plants and animals, where effective action requires sustained (and largely voluntary) action and sustained investment. Eliciting high levels of compliance is a difficult problem, because different landholders have widely different attitudes and motivations. What works with one group of people may not work with another, and indeed may be counterproductive.

This study demonstrates the use of contemporary psychological methods to identify groups of landholders who demonstrate different attitudes and behaviours in relation to weed control. It shows that identifiable segments do respond differently to different mixes of regulation, incentives and community action. It suggests that some commonly promoted interventions may actually be counterproductive in encouraging desirable action with some groups.

The study shows that behavioural precision is important in creating effective compliance strategies in weeds management, and it demonstrates some of the methods that may be used to achieve that precision.

Additional keywords: behaviour change, compliance, gamification, invasive species, psychology, regulation, segmentation, weeds management.

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Introduction

Regulation is a tactic to change peoples' behaviour, to achieve socio-ecological aims such as the sustainable and equitable use of the environment, and the protection of natural values. Different forms of environmental law help to: control socially illegitimate pollution or over-consumption (viz. criminal or administrative law); enable authorised uses of the environment (viz. administrative law); or protect environmental assets (viz. conservation laws). Controlling clearly antisocial behaviours such as taking or killing rare iconic species, and many forms of pollution, are common examples of how the law is used in these ways. However, many things that harm biodiversity, such as overconsumption and waste, can be caused by behaviour that is considered to be normal by the general public. In such situations, using laws to control behaviour can be politically or socially difficult, because there may not be support for the norm. For example, prohibiting long established fishing or farming practices, or limiting access to public lands to enable conservation can present problems of legitimacy, practicality and politics. These issues can undermine the effectiveness of the law (Barclay and Bartel 2011a) and has fueled disputes, highlighted in the popular media (Australian Broadcasting Commission Radio National 2016a, 2016b). The polarised attitudes to controls over farm land clearing have also been collected by a survey undertaken by Harris-Adams *et al.* (2012).

Environmental harm-doing is often systemic, involving many transactions carried out by many people and organisations (Coutts *et al.* 2013; Thompson *et al.* 2013; Martin and Gunningham 2014; Farrier *et al.* 2017). Limiting harm can thus involve many different types of law and other policy intervention to target a variety of behaviours carried out by different actors. The law itself involves the behaviour of many people in its design, implementation and compliance. Governance action occurs within a very complex context that also includes the operation of markets, politics, and social networks (Martin and Verbeek 2006; Cane *et al.* 2012). To effectively address environmental issues often will require a range of legal and other instruments, including regulation, incentives, administrative instruments, and public education. The systemic linkages between different behaviour intervention types are explored in Michie *et al.* (2011) and Cane *et al.* (2012). The literatures on 'smart regulation', 'reflexive regulation', 'governance systems', and environmental 'policy mixes' also point to multi-instrument approaches. Whether regulation is effective or not thus concerns the operation of a system that involves many behaviours of many people and organisations, and many other factors outside of the law.

The behavioural effectiveness challenge

Over-consumption and environmental deterioration continue, notwithstanding an increasing number of laws and other policy

instruments. The international Ecolx database shows ~180 global or regional instruments and over 1200 pieces of legislation relevant to Australia. However, the Environment Australia and State of the Environment Advisory Council, 'Australia State of the Environment,' 2016 shows continuing underperformance in the protection or restoration of natural environments (see Hannam 2016). The law (along with market or social instruments) has not been sufficiently effective in managing harmful behaviour. Rules are only one of the tools that shape behaviour, and public statutes are only one form of rules in society. Considerations such as personal motivations, social context, limits to economic and human capacity; and the impact of the many institutions that are involved in all these things, shape what behavioural outcomes can be achieved using the law. A body of research suggests that effective approaches are likely to involve combinations of social, legal, economic and other instruments, in order to account for the many actors and the diverse drivers or and constraints on their behaviour (Martin *et al.* 2007; Kennedy 2010; Michie *et al.* 2011; Weber *et al.* 2013). It is logical to consider legal outcomes as the result of a governance system rather than of legal instruments, approaching implementation as a multifaceted change program (Martin *et al.* 2007; Sousa Lourenço *et al.* 2016).

Concepts such as 'smart regulation' or 'responsive regulation', or system approaches to governance suggest that holistic approaches to using the law along with other interventions should be more effective than narrower legal strategies (Gunningham and Grabosky 1998; Weber *et al.* 2013). However, environmental law scholarship seems to have been remarkably non-inquisitive about the behavioural aspects of regulation, including about how to optimise the proposed integration of law and non-law interventions (Vandenbergh 2004; Dernbach 2007; Vandenbergh and Steinemann 2007).

Decisions to comply or not with the law are based on many variables: expectations of outcomes, the ability to comply, value judgements about the legitimacy of the rules or other factors, attitudes and beliefs and knowledge (Jolls *et al.* 1998). However, social interventions (including the law) can really only manipulate two extrinsic variables, and through these shape intrinsic variables like knowledge, beliefs or culture (Martin and Verbeek 2006; Martin *et al.* 2012a). One is the flow of resources. Darwinian theory highlights that the pursuit of resources is what drives adaptation and thus the fundamental characteristics of living beings, and economics theorises that the pursuit of resources to satisfy desires is what drives human behaviour. The second possible focus of interventions to change behaviour is the flow of information (or signals), with modern science suggesting that even living cells can be understood as signal processing instruments. Information is the feedstock of decisions and the means through which coordination occurs. Luhmann and Teubner both highlight particularly that the law is a social system driven by communications (Luhmann 1984; Teubner 2005). People and organisations interpret and structure the information they have and attach value to potential gains or losses of resources, and they learn practices and develop beliefs as a result of prior information and the patterns of resource gains and loss that they perceive.

Applying psychological methods to a compliance problem

Psychology may provide insights into effective behaviour change (Kazdin 2009). Stern observes:

'Psychology brings important strengths to an interdisciplinary science of human-environment interactions. (It) is the preeminent science for understanding individual behaviour (and) is uniquely positioned for replacing unexamined beliefs about human behaviour with findings based on solid empirical analysis . . . it is strong in the use of experimentation and thus is in the best position to clarify issues of cause and effect. Theoretically, it is the source of useful ways of understanding how people interpret information about their environments and how they respond on the basis of these understandings' (Stern 2000).

This paper reports on two empirical studies that explore the application of contemporary psychological techniques to provide useful insights into improving compliance with a legal obligation of environmental stewardship. Modern business often uses psychology-informed marketing and communication techniques to great effect to promote purchasing and consumption. Targeted marketing strategies have been commonplace since the 1950s with companies carefully selecting advertising messaging strategies that are most likely to reach and persuade segments of the population who are most likely to purchase the products on offer (Smith 1956; Demby 1974; Mitchell 1983). In the Internet age, online advertisements can be precisely targeted to individuals, based on their search histories and social media habits (O'Neil 2016). Such sophisticated methods have not permeated environmental governance to any great degree, although recently has been some movement in this general direction (Hine *et al.* 2014). In this research we investigated the potential utility of techniques that might be more familiarly found in commercial marketing to support the achievement of legal land stewardship obligations: statistical analyses to segment the market; and 'gamification' of consumer decisions to identify what stimuli are most likely to trigger desired behaviours in the identified 'market' segments.

The regulatory issue we investigated is compliance with the statutory responsibility of landholders to control particularly problematic invasive plants on their properties. The techniques we tested were: (1) psychographic segmentation using statistical tools to target communications to potentially affected landholders; and (2) online 'gamification' to identify combinations of interventions in resource flows (such as variations in the levels of government and community engagement) and messages that are most likely to be behaviourally effective, given the characteristics of different segments. Together, these two studies support the general proposition that principles and methods from contemporary behavioural science can help identify with precision what mixes of signals and resources flows are most likely to make citizen behaviour more compliant with the law. In other words, psychology-based methods have a potential role to help improve the effectiveness of environmental law.

Prior research has identified that farmers' land management behaviour typically reflects varied norms, the holders of which can be objectively segmented using scientific methods (Emtage *et al.* 2007). This can help focus practice change

initiatives by taking into account different farming styles and the motivations that may cause people to change these farming practices to better meet policy goals. However, despite the theoretical potential of a targeted and segmented approach to support behaviour change, precise targeting of farmers to improve compliance with environmental laws has not been discussed in the environmental nor in the psychology literature. This paper reports a two-stage empirical test of how the theoretical potential might be realised in practice. We first used statistical methods to identify specific behavioural segments within the landholder population. Then (based on a different segmentation that had been more exhaustively verified) we tested potential responses to segment-targeted mixes of government interventions and a range of other social/environmental context features. Thus the studies addressed two interrelated, but distinct, aspects of behavioural segmentation and regulatory effectiveness: (1) creating a segmentation profile that can target interventions to improve landholder motivations to comply with environmental laws and policies (in this instance invasive species regulation), and (2) testing whether a targeted approach based on segmentation is likely to improve the choice and deployment of instruments that could comprise a 'smart' regulatory cocktail (Gunningham and Grabosky 1998).

Our preliminary results, though yet to be verified by studies with the large sample sizes needed for statistical validation, have important implications for environmental governance. They suggest that behavioural precision in environmental governance strategies should indeed help improve their effectiveness. They suggest that different types of interventions (social appeals, government incentives or regulatory enforcement) may have markedly different effects on different segments, consistent with previous farm extension research about land-manager behaviour change (Llewellyn *et al.* 2005). They also suggest strategies that increase legal compliance behaviour in one segment can have counterproductive effects on other segments, mirroring previous findings by Bartel and Barclay (2011b). These findings indicate significant opportunities to strengthen compliance and to conserve governance resources through precise targeting of interventions. Finally, unexpectedly, the findings provide insights into whether public funding actually does, or does not, 'crowd out' voluntary citizen action. Whether crowding out occurs has been contested in policy circles, partly because of its implications for public environmental investment. The crowding out hypothesis is discussed in Reeson (2008). Our investigation suggests that the question whether public investment crowds out of voluntary effort does not have a simple 'yes/no' answer – the outcome depends on the specific behavioural segment and the specific intervention. For one segment, crowding out of voluntary action is a risk from government action or government funding, but for another segment government involvement further motivates voluntary action. This response indicates that precise behavioural research could unlock insights about optimising the outcomes of public investment, and may indicate situations where government investment might be counterproductive.

The behavioural challenge with invasive species

Invasive species are 16 of the 21 'key threatening processes' affecting biodiversity that have been identified by the Australian

Government, and are one of the three biodiversity challenges targeted by Australia's national biodiversity strategy (Natural Resources Management Ministerial Council 2010). Weeds also have a very high economic cost (Hafi *et al.* 2015; Llewellyn *et al.* 2016). Invasive plant regulations create a duty on landholders to control some weeds, historically by required control of specific 'noxious' species or in modern times under a general stewardship duty (Biosecurity Queensland 2016; NSW Natural Resources Commission 2016; Queensland Government Department of Agriculture Forestry and Fisheries 2016; Craik *et al.* 2017). Though legal requirements to control weeds have existed for years and are well known, invasive species control is a chronic environmental failing with a significant economic and ecological impact in Australia. Relevant to our research are that: weeds cause significant economic impacts, many stakeholders have an interest in more effective rules; compliance involves many behaviours; a variety of interventions have not proven to be sufficiently effective to achieve policy compliance, and (because many people are involved) sufficient sample sizes are available to use statistical tools to test the effectiveness of interventions. Weeds are also an issue where environmental and farming stakeholders largely have a shared interest in effective control, minimising the risk that political conflicts, such as those related to habitat protection or water resource management, could complicate the research. However, there is often not a consensus about what weeds should be controlled, how action should be resourced, who should be responsible and what legal and other obligations should be imposed. For garden plants that are also weeds or weeds with economic value, consensus may also be problematic.

Australia uses many legal instruments in its attempts to control invasive plants (and animals) (Bio Intelligence Service 2011). However, their effectiveness is contestable. The 2011 State of the Environment Report (SoE 2011) (Hatton *et al.* 2011) was pessimistic about Australia's management of invasive species. The report evaluated in relation to inland waters that the impacts of invasive species (both plant and animal) are 'high' and conditions are deteriorating; and in relation to biodiversity that the impacts are 'high' to 'very high' and conditions are deteriorating. SoE 2011 also noted that '(T)here are very limited data on which to assess whether efforts to address problems are having an impact' (p. 641).

The 2011 SoE 2011 expands this observation with the statement:

'It is extremely difficult to assess the effectiveness of management in relation to invasive species and pathogens from SoE reports from most states and territories. These reports mostly list plans, strategies and inputs to management, but rarely report on the effectiveness of processes or on outputs and outcomes. Some SoE reports state that actions are not achieving desired results, while this conclusion is implicit in other SoE reports since the effects of invasive species are assessed as getting worse. Some SoE reports conclude that there is not enough information to assess trends or the magnitude of effects.' (p. 665)

At pages 666–7 the report notes that for invasive species and pathogen control:

- (1) 'Understanding' is substantially ineffective but improving;
- (2) 'Planning' is substantially ineffective but improving;
- (3) 'Inputs' into control are both ineffective and declining;
- (4) 'Processes' are ineffective but improving; and
- (5) 'Outcomes' are ineffective but improving.

The 2016 Australia State of the Environment report (Environment Australia and State of the Environment Advisory Council 2016) was structured into separate documents for land and for biodiversity. In relation to Land the committee noted that the number of invasive species has increased and that 'invasive species pose a major risk to the environment, industry and health: Invasive species—pests, diseases and weeds—threaten agriculture and forestry, native species, natural regeneration and ecosystem resilience. They already have a massive environmental, social and economic impact, and climate change is likely to enable new invasive species to thrive' (Metcalf and Bui 2017, p. v).

In a detailed discussion the authors note that 'invasive species represent one of the most potent, persistent and widespread threats to the Australian environment. They have a direct negative impact on species through predation, displacement and competition, and also have enormous detrimental effects on the health, viability and functioning of communities, ecosystems and landscapes' (Metcalf and Bui 2017, p. 24). The committee affirmed the conclusions of the 2011 report, that the trend continues to be adverse (Metcalf and Bui 2017, p. 36). The Biodiversity report concludes that 'invasive species, particularly feral animals, are unequivocally increasing the pressure they exert on Australia's biodiversity' (Cresswell and Murphy 2017, p. v) and affirm that invasive species pressures have not decreased since the 2011 report, noting particularly that 'impacts of invasive species have increased in importance as key threatening processes at both national and state/territory levels' (Cresswell and Murphy 2017, p. vi). The report contains a state by state analysis that suggests no jurisdiction has found a way to reshape land use and other behaviours sufficiently to control the growth of the problem.

As with many environment matters, issues that seem initially simple emerge as very complex after more careful examination (Conklin 2005; Martin 2017). The pathway through which harmful plants enter the country, become established, naturalise and spread involves many transactions and human actors, with governance of the transactions involving many specialist institutions (Sindel *et al.* 2008; Thompson *et al.* 2013). These include those involved in prevention (e.g. regulatory science and customs approvals and control, and early response) and for the control of established species (e.g. environmental regulators, state and local government inspection and enforcement agencies, and a variety of extension, education and community action bodies). Governance is a behaviour management system, with many cogs and levers that might be deployed to change its outcomes. Public governance interventions for the management of already established weed species include regulation and enforcement, community education, farming and other extension, direct control actions, and support for community action. In the private sphere, governance interventions include private regulation (e.g. industry codes and standards), social persuasion and sanctions, industry or community segment education and

extension, private investment in control, and voluntary projects (Cattanach *et al.* 2013; Quinn *et al.* 2013; Thompson *et al.* 2013). Public regulation is thus only one part of a complex suite of interventions: private regulation, economic influences, and social dynamics are among the governance mechanisms.

The biophysical characteristics of weeds create unique governance challenges. Once introduced, plants breed and grow, and adapt to their context. Some species can spread great distances through the influence of wind, water, animals, or by trade; making control much more difficult. Some species adapt and thus exploit new environmental niches, or frustrate control. Some adaptation is facilitated by human action (e.g. the spread of genetically modified plants or herbicide resistance) (Martin and Williams 2016). These characteristics all add to the management challenge of controlling weed impacts.

Unpaid action by citizens is typically essential for the control of the biodiversity (and economic) costs of weeds (Hawke 2009; Cattanach *et al.* 2013; Goldson *et al.* 2015; National Biosecurity Committee 2015). Even compliance with legal rules is to some degree a voluntary choice, given the limited capacity of public agencies to supervise and intervene on private lands.

A central governance challenge is thus to create instruments and strategies that can generate voluntary pro-environment behaviour. The diversity of human activities in the landscape and the harms that are caused by weeds complicate the behaviour management situation: native burrs that are a problem for woolgrowers are not a problem for a beef producer or an environmentalist, and a weed that produces prolific vegetation may be useful to a grazier but pernicious to an environmentalist because it crowds out native vegetation. There are different institutional responses to plants that harm human or animal health (e.g. allergenic or poisonous plants), outcompete aesthetically desired plants, contaminate products or reduce agricultural production, or harm biodiversity or aesthetic values of nature. Different agencies and actors are likely to be involved, and action can involve different laws and different approaches because the problems are defined as being about 'health', 'welfare', or 'farm productivity'. Weed management is a complex social problem partly because of these diverse interests and situations, and the many transactions and transacting parties.

Policy documents simplistically refer to the need for 'community engagement' or 'shared responsibility', but many considerations and interventions and specialisations are involved to create an effective governance 'cocktail' to convert slogans into voluntary hard work and investment (Natural Resources Management Ministerial Council 2010; Australian Senate Environment and Communications References Committee 2015; Martin *et al.* 2016; NSW Natural Resources Commission 2016). Though compliance may seem to be a simple behavioural issue, widespread weed control is behaviourally complex for at least six reasons.

- (1) Though the introduction of new invaders often involves a human vector, the spread of established weeds occurs naturally. As seeds remain viable for many years in the soil, even apparently effective control may be illusory. As a result control often requires human effort and investment over many years. This type of sustained investment is difficult motivationally, and involves practical constraints as

landholder conditions vary over time (Martin and Williams 2016).

- (2) Early detection and control is generally the most efficient control strategy. This depends on citizen awareness and acuity, and a willingness to take action often before the harm potential of the plant is fully understood by the general community. Risk perception is behaviourally complex (Botterill and Mazur 2004; Slimak and Dietz 2006).
- (3) For species that spread widely and easily, such as airborne or waterborne weeds, effective control may require well coordinated action, sometimes over large areas. Institutionally, private property rights limit enforcement capacity and social norms can restrict the ability to achieve coordinated action.
- (4) The private incentive to control weeds is often weak compared with the control cost. This varies between individuals involved in different land activities (and thus different harm exposure), susceptibilities (e.g. enterprise or management regime, allergies), preferences and values. For this reason effective governance depends on sufficient citizens being intrinsically motivated to do the right thing, even if this is to their private disadvantage.
- (5) The capacity of landholders to control the problem varies due to physical factors, economic resources, knowledge, and access to specialised resources or services. Even if motivated to comply, practical constraints may prevent effective action (Hagenaars and McCutcheon 2002; Vermunt and Magidson 2004; Collins and Lanza 2013). Practical issues of citizen resourcing and capacity are part of the behaviour mix that must be managed for effective management.
- (6) For reasons including insufficient legal powers or financial capacity, government often must rely on citizen action to detect the problem and take action. Although regulation help to generate stronger incentives to take action, it is an unreliable motivator, and is generally unable to motivate action beyond minimal compliance.

This suggests that compliance is more likely using approaches that address multiple drivers of behaviour, and these drivers will vary among individuals (Winter and May 2001; Vandenbergh 2004; Dernbach 2007; Vandenbergh and Steinemann 2007). Weed control behaviour is, like all behaviour, a response to intrinsic and extrinsic factors. Intrinsic factors include beliefs and attitudes, perceptions of weed risks, knowledge and personal capacity to do what is required. Extrinsic factors include economic incentives that support or oppose the desired behaviour, social pressures, collective capacity within communities, politics and many other matters. Even if an individual wants to do the right thing their capacity and context may make it impossible to act as they wish (Hagenaars and McCutcheon 2002; Vermunt and Magidson 2004; Collins and Lanza 2013).

Institutions significantly shape actor behaviour but they also behave in response to their drivers and constraints. Institutionally intrinsic factors include culture, (which embodies beliefs), decision structures and decision rules (often heuristic), power relations, and institutional resources and rewards. Extrinsic factors include the rules that control the organisation, the resources that are available to it, and its political context.

The institutional arrangements needed to motivate or support the behaviours that control invasive species including weeds are complicated (Martin *et al.* 2012b; Thompson *et al.* 2013; Martin *et al.* 2016). The institutional challenges include: the lack of an investment approach that can ensure sufficient resources; legal and political impediments to coordinated action; high transaction costs, confusion that frustrates citizen action; and the lack of a robust improvement process for policies and interventions (Martin *et al.* 2016).

In summary, to believe that any law will *per se* achieve a desired behavioural response is naïve. Compliance is a result of many variables and might usefully be considered to be largely voluntary, or at least contingent on circumstance. Despite beliefs that market or other interventions are more effective and more efficient than the law, no interventions, including regulation, market instruments, information, education or grants are intrinsically reliable. Economic modelling *ex ante* will often suggest the relative efficiency of economic instruments, but the limited comparative *ex post* data are far from convincing. There are ample indications of the failure of all types of instrument, and that effectiveness is substantially contextually determined (Stavins 2001). Some will be more effective for some segments, under some circumstances. All can fail, but each has a potential role. An important practical question, partly explored in this research, is ‘what role might different instruments optimally serve, alone or when combined with each other?’

Initial study – identifying landholder segments using latent profile analysis

The initial study used a multivariate statistical method, Latent Profile Analysis (LPA), to segment the landholders, a prerequisite for precise targeting of communications and other potential behaviour change interventions. The initial survey data were provided by a regional natural resource management (NRM) agency, the Namoi Catchment Management Authority (NMCA), an authority that ceased operation in 2013 (Australia’s Web Archive 2017), and which was responsible for coordinated catchment management for 42 000 km² of mainly primary production landscape, which also contained several regional cities and towns. The NCMA had been in operation for 10 years. Central to its strategy was a commitment to a comprehensive data ‘platform’ recording the natural, social and economic dimensions of the region. The NCMA commissioned telephone surveys about the attitudes, practices and activities of the ~100 000 residents of the region. Data from a social survey of 450 landholders in the Namoi Catchment area of northern New South Wales conducted during 2010 were provided to the researchers. LPA was used to identify audience segments that might be expected to respond in predictable patterns to messages about land stewardship, including weed management. The LPA is a sophisticated form of cluster analysis that identifies concealed (latent) subgroups, within the overall sample, which share similar values, beliefs, behaviours, and demographic characteristics, and compares the relative fit of competing solutions to identify the best solution (Vermunt and Magidson 2004; Collins and Lanza 2013).

Fives sets of questions assessed the views of respondents and were used to generate the four segments.

- (1) Rating of the importance of NRM;
- (2) Attitudes to the need for sacrifice and planning to create a sustainable future;
- (3) Scepticism about climate change;
- (4) Landholder natural resource quality rating;
- (5) Support for government to take NRM action.

The LPA analysis revealed four segments, labelled: 'Town-based' (not relevant for further analysis, 12% of total sample) 'Exploitative' (3%); 'Traditional Conservative' (21%); and 'Regenerative', 64%). The invasion pathways and the governance issues for domestic weeds are significantly different than for agricultural weeds with less than 8% of the Town-based segment were involved in agriculture.

Sixteen demographic and behavioural variables from the database were used to further explore and independently validate the segments. These indicators included:

- (1) Provides service to landholders;
- (2) Primary production/mixed farming land use;
- (3) Lifestyle/hobby farm land use;
- (4) Town/village resident;
- (5) Refers to television for NRM information;
- (6) Has attended NRM workshops;
- (7) Participated in local environmental improvement/protection projects;
- (8) Participated in bush regeneration;
- (9) Encourages others to change environmentally harmful practices;
- (10) Considers the environment when voting;
- (11) Has modified their business, or home with native plants;
- (12) Revegetated land in the past 5 years;
- (13) Fenced off native vegetation;
- (14) Provide alternative watering points for livestock;
- (15) Maintains filter strips around watercourses;
- (16) Reduces stocking rates when conditions are dry.

The more characteristics of the targets that are known, the more reliable targeting is likely to be. By combining attitudinal, demographic and behaviour variables it is possible to infer objective characteristics of the segment from expressed views, and vice versa. This intelligence should enable precise tailoring of interventions and communications to the characteristics of the group. The subjective/objective variables within each profile type conform to a predictable attitude-behaviour relationship. Survey participant behaviour was generally consistent with predictor values and attitudes from the statistical analysis.

The three segments that were relevant to weeds law are discussed in the following sections.

Exploitative segment

This segment consisted of only 13 people, and constituted the smallest segment. Just under half of those in this segment (40%) were service providers to landholders. Members of the exploitive segment possessed the least conservationist attitudes, beliefs and values. Their attitudes were reflected in their failure to participate in projects for environmental improvement or protection (only 15%), or participation in bush restoration. They were the least likely to consider the environment when voting or to encourage others to change their anti-environmental practices,

and the least likely to modify their businesses or homes using native plants.

Members of this segment also rated the importance of NRM and conservation practices significantly lower than other segments, and reported the lowest willingness to sacrifice and plan for a sustainable future. They were the most sceptical of climate change/global warming and expressed significantly lower support for government involvement in NRM than the other segments.

Given that members of this segment are not self-motivated by internalised pro-environmental values or norms, powerful regulatory interventions or significant economic incentives – both of which are likely to be costly to government – may be required to elicit compliance. Nevertheless, given the complexities associated with managing landholders with potentially defiant mindsets, such as those who explicitly resist regulations or are motivated to find ways around them (Bartel and Barclay 2011b), further investigation is warranted to enable more precise identification of what mix of messages and positive or negative incentives would be most effective for this segment.

Traditional conservative segment

People representing this segment were predominantly primary producers from mixed farming enterprises. They reported moderately high ratings for the perceived importance of NRM and conservation practices, but relatively low ratings for their willingness to sacrifice profits, or for the need for long-term planning. Members of this segment expressed a reluctance to change their practices, often holding the belief that farmers know best how to manage natural resources on their farms, and should be left alone.

Traditionalists also tended to be skeptical about climate change, believing that human activities have no significant impact on global warming. However, it should be noted that the survey data were collected in 2010, and that attitude shifts are possible since then. They report low support for government NRM action and few report that they consider the environment when voting. This segment is relatively sanguine about the local region's natural resources (a characteristic which they share with the 'exploitative' segment). They were also reluctant to modify their land-management behaviours to address non-production environmental issues, particularly if they perceive doing so may interfere with income production. They have significantly lower rates of re-vegetating native or riparian areas over the past 5 years than other farmers; do not use fencing to protect native vegetation, nor provide alternative watering points or create/maintain filter strips to protect riverine biodiversity. They are less inclined to reduce stocking rates in dry seasons or to modify their business or home with native plants than other farmers.

Though their expressed attitudes would suggest otherwise, members of traditional conservative segment are surprisingly active in hands-on environmentally oriented projects. They report higher participation rates in NRM workshops, local projects for environmental improvement and bush restoration than the 'exploitative' segment, but significantly lower than the 'regenerative' segment. This could reflect the social importance

of the Landcare movement in farming communities, as social influences may affect their practices. The link between landcare involvement and this voluntary engagement has not been tested in this research, but a body of research suggests this link (Cary *et al.* 2001; Colliver 2011; Ramsay 2011; Kilpatrick *et al.* 2013a; Kilpatrick *et al.* 2013b; Bradby *et al.* 2016).

These considerations suggest that potential productivity or income gains from better stewardship, couched as being about farming rather than conservation, may work better than appeals to a good stewardship ethos, for this segment. The profile also suggests that social rather than regulatory interventions might be the most effective approach to increased compliance. Given the attitudes of this segment 'threats' of regulatory enforcement could harden opposition, except if these are couched as protecting the interests of a responsible majority against economic costs introduced by an irresponsible minority. The profile data provide useful targeting indicators for more detailed investigation of the optimal mix of regulatory and other interventions.

Regenerative segment

The largest segment (63% of the population) possessed more pro-sustainability views than the other three segments. They are a similar mix of landholder types to the 'traditional' segment, with a higher lifestyle/hobby farmer component (15%). They rate the importance of NRM and conservation significantly higher than the other segments, and are supportive of the need for sacrifice and planning for a sustainable future.

Previous segmentation studies have found smaller proportions of landholders with high self-reported conservation beliefs and practices than we found in our sample (Emtage and Herbohn 2012; Morrison *et al.* 2012). This difference between our study and earlier ones could be due to many causes. It should also be noted that factors such as financial constraints and farming context can limit the ability of landholders to implement their positive intentions, even where these exist (Martin and Williams 2016). Further research would help build a comprehensive understanding of the segments and their behaviour, as the basis for targeted interventions.

Members of the 'regenerative' segment were less skeptical about climate change than the other segments, and tended to believe that farmers do not always know best about managing natural resources. They also held less positive views about the current health of the region's natural resources than the other segments. The members of this segment indicate acceptance of the need for innovation in NRM, admitting to being unsure about how to improve the environment. They support Government NRM initiatives significantly more than other segments.

This 'regenerative' segment attended more NRM workshops than the other segments (59%) and participated more in: bush restoration/planting (52%); local projects for environmental improvement protection (52%); and revegetation of native or riparian areas over the previous 5 years (47%). In terms of farming practices the 'regenerative' segment have significantly higher rates of fencing areas to protect native vegetation, providing alternative watering points, maintaining filter strips and they are more likely to reduce stocking rates when conditions are dry.

They encourage others to change non-sustainable practices and are more likely to consider the environment when voting

(70%). The profiles suggest that the attitudes, values and behaviours of this majority segment could be a platform to increase farmer pro-environmental attitudes and behaviours, potentially providing an important normative reference for the other segments. The data suggest that a strategy that reinforces their innate commitment might be the most appropriate approach in this region (Sheth and Frazier 1982). Normalising good stewardship through interventions such as public recognition, peer engagement or perhaps a market incentive would seem to be a desirable strategy. However, as noted above some landholders may be blocked from acting on positive motivations due to financial and/or practical constraints. Emtage and Herbohn (2012) suggest that landholders who have positive NRM attitudes but who are not practising those behaviours are 'prime prospects' where supports (rather than enforcement threats) would be the most efficient approach to strengthening stewardship practice.

Governments make substantial investments to shape landholder behaviour to comply with the legal obligation to control invasive species including weeds. Common interventions include landholder education, advertising, field days, research investment, and (occasionally) legal action. It seems that little of this is informed by behavioural science methods, including the advanced segmentation and targeting that is common in commercial marketing (Martin and Lingard 2017). This segmentation study demonstrated that behavioural science-based methods (in this case audience segmentation) can provide significant insights to enable more precise tailoring of messages and other interventions. This study suggests that interventions that work for one segment may be wasted or counterproductive (Ruttledge *et al.* 2015) for others, indicating the disutility and economic inefficiency of a non-targeted approach. Our second study was intended to provide a deeper empirical indication of whether members of different segments are likely to respond differently to government interventions and various other social/environmental factors related to weed control.

Second study – testing interventions with segments

There is substantial evidence in the literature that segmentation can provide insights about the behaviour of people for the purpose of designing interventions, and our initial profiling study supports this general proposition. This particular application of the method yielded credible (statistically supported) findings about the likely segments and their patterns of attitudes and behaviours. From this it was possible to hypothesise what communications and other interventions might be effective with each segment. Good scientific practice would suggest that the next step would be to empirically confirm the segments and the likely patterns of behaviour, and to test likely responses to a suite of possible interventions for their 'fit' with the segments. Further work would provide a higher level of confidence in the segmentation, but would require time and investment that was not available for this pilot project. For the second study, we explored the extent to which profile-based targeting could inform the design of a regulatory compliance program. It was hypothesised that different segments would have different responses to various interventions and contexts. If this is so, this would suggest that effectiveness and efficiency might be

enhanced by segmented strategies to maximise regulatory compliance.

Our original intention was to conduct a field experiment in the Namoi region using a conventional four quadrant controlled experiment design, to test responses to a mix of interventions including (1) pro-social 'good neighbour' messages and support (2) farming efficiency messages and support (3) reinforcement of legal obligation, using messages and property inspections. Due to organisational and financial reasons it was decided to conduct a pre-test of potential responses to alternative contexts and interventions using computer based 'gamification' to test possible responses, and through this to identify possible links to segments (Zichermann and Cunningham 2011; Kapp 2012). This provided an opportunity to refine the possible interventions and the hypotheses that were to be tested through a potential field experiment. Unfortunately, the NCMA ceased operation in 2013, before the conclusion of the pre-test research.

The second study was conducted using an online experiment and a general Australian sample sourced from a Qualtrics online panel (51% residing in rural communities). Participants first completed a copy of the New Environmental Paradigm scale, used to segment them into three environmental worldview types: Anthropocentric (i.e. nature should be used to benefit humans), Balanced, or Ecological (i.e. nature is inherently valuable and is under threat) (Dunlap *et al.* 2000). They then participated in a simulation of managing weeds on a public reserve over eight seasons. For each season, they were provided with feedback ~5 contextual factors: (1) level of weed infestation on public reserve, (2) level of weed infestation on respondents' private land, (3) number of neighbours participating in weeds management activities on public reserve (4) average dollar value of neighbours' weed management on public reserves, and (5) dollar value of Government contribution to weeds management on public reserve. Each of these contextual factors varied across seasons, and for each season participants were required to determine how much money they would personally allocate to managing weeds on the reserve.

Our results indicated that contextual changes elicited different behavioural responses from members of the Anthropocentric and Ecological worldview segments. This is illustrated in the Figs 1 and 2, derived from a multilevel regression analysis, which illustrate how respondents' financial commitments to manage weeds on public lands change as a function of financial contributions by government investment and neighbours. The meaning of the Figures are explained by the text that follows.

For the sample as a whole the value of neighbours' contribution predicted how much would be pledged by respondents. As it was indicated that neighbours spent more on public reserve weed control, the respondents overall increased their investment but segmentation showed interesting differences within the sample.

There were significant interactions between the responses to the interventions that were indicated and the values of the segments. Respondents with strong pro-environmental values indicated that they were likely to increase their commitment to control weeds on the public reserve when either: (1) they perceived that weed infestation on their own land increased, (2) when neighbours reportedly increased their contribution to weed control, (3) when the number of neighbours participating

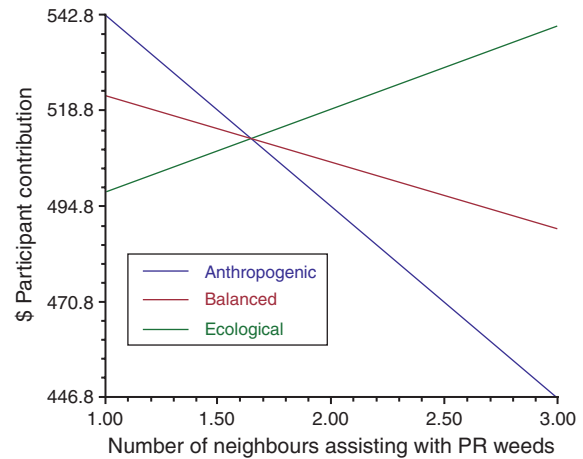


Fig. 1. Landholder investment intention for different levels of neighbour investment in weed control on public land.

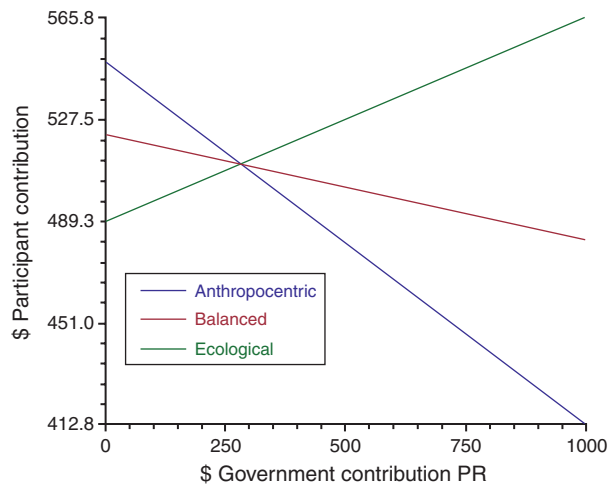


Fig. 2. Landholder investment intention for different levels of government contribution to weed control on public land.

in weed management activities reportedly increased, or when (4) government reportedly contributed more. These findings are broadly consistent with the idea that pro-environment and pro-social attitudes are often found together, and vice versa.

However, respondents with weaker environmental values indicated that they would commit fewer resources to control weeds on public lands if (1) they perceived that weed infestation on their lands increased, and/or (2) when they perceived that neighbours or the government committed further resources to this activity. Notably members of the Anthropocentric segment reduced their intended financial contribution when provided with feedback that their neighbours and government were more actively addressing the problem. Thus, government and neighbour intervention appeared to 'crowd out' Anthropocentric landholders' volunteer responses to an emerging weeds problem. The hypothesis that under certain situations government or philanthropic investment, or other activities in support of a public good, can lead some people to reduce their input, is explored empirically in Marshall *et al.* (2017). The theory has implications

for effective NRM policy. It suggests that public responses to new policies and interventions may vary dramatically depending on people's worldviews, beliefs, and attitudes, and that, in some instances, part of the public investment may be wasted because it will provide a 'cover' for the reduction of private effort.

This provides apparent support for the 'crowding out' hypothesis, but it seems that something more complicated is occurring. The characteristics of the segment likely to be 'crowded out' suggest that they are not likely to be volunteers for public good work. It seems unlikely that their reduced contribution will be significant to the overall effectiveness of control measures, though their withdrawal reduces the cost effectiveness of public intervention. At the same time the evidence from this stage is that public investment is likely to leverage further investment from other segments.

Conclusion

Improving the effectiveness of legal instruments for the environment is a significant public policy concern, in Australia and elsewhere. Despite myriad instruments and no small amount of investment, biodiversity outcomes fall well short of what is needed for sustainable ecosystem management. In short, what is being done is not sufficiently behaviourally effective to meet society's aspirations for good environmental governance. New and more effective approaches are clearly needed, but from what directions can these innovations come?

The two studies included in this paper provide a convincing argument for the value of behavioural science-based segmentation as a means for obtaining more precise insights to guide environmental public policy. The second study also demonstrated that 'gamification' of policy problems involving the target populations can provide new insights at low cost. In this instance the gamification was primitive (and low cost), but yielded insights that may not have emerged with more traditional methods.

The second experiment also validated the expectation that the most suitable mixes of government intervention and social feedback vary across landholder segments. Different segments varied considerably in their behavioural responses to different levels of government and community engagement. In some cases interventions that were likely to increase weed control action by one segment were likely to reduce engagement by another. This is a very important finding in terms of the efficiency and effectiveness of programs intended to build regulatory compliance.

Given the great deal of theoretical and applied knowledge that has been accumulated in academia and by industry about topics like market segmentation, behaviour change, advertising effectiveness and selling, it would be surprising if applied behavioural science did not contain much that could be applied to improve environmental governance. This paper demonstrates that useful insights are available from adapting this existing knowledge and known methods to the cause of environmental sustainability. This is one of several possible paths to help to significantly improve the effectiveness of public environmental governance.

The philosophy and science of law (jurisprudence) has followed many different paths over the centuries. It may perhaps

be time for environmental law to adopt a jurisprudence that embraces the behavioural sciences.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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