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Wild dog management: understanding rural landholders' willingness to participate in coordinated control programs

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ABSTRACT

Wild dogs pose a major threat to agriculture, biodiversity and community health across many areas of Australia. Coordinated actions are considered one of the most effective methods to minimise this threat, yet many landholders fail to engage. We used a mixed methodology, interviewing 14 wild dog experts and surveying 198 landholders to identify and organise potential drivers and barriers to participation in coordinated actions using the Capability, Opportunity, Motivation (COM) Behavioural model. Landholders' willingness to participate in coordinated control was found to be influenced primarily by their awareness of wild dog problems and motivational factors to join a group. However, segmentation using latent profile analysis highlighted that landholders were not a homogenous group, with each of the identified segments exhibiting their own unique COM profile. The use of the COM model and associated Behaviour Change Wheel framework allowed us to recommend the most appropriate type of interventions to enable practitioners to connect and engage with targeted audiences within their own communities.

Introduction

Wild dogs (*Canis familiaris*) – which include feral domestic dogs, dingoes and their hybrids (Jackson et al. 2017) – are considered pest animals when they threaten livestock, pets, humans or endangered native wildlife (Fleming et al. 2014; Bryce 2021). In rural Australia, wild dogs are conservatively estimated to cost the economy upwards of $89 million per year in lost agricultural production and management costs (R. McLeod 2016). In areas where wild dog densities are high, landholders frequently have been forced out of small livestock production (e.g. sheep and goats) reducing jobs and incomes, with negative flow-on effects to local economies (Bell 2015). In addition to economic costs, wild dog attacks on livestock can cause serious emotional and psychological damage to rural families and their communities (Wicks et al. 2014; Ecker, Please, and Maybery 2017). Wild dog predation has also been linked to the decline of several wildlife species and native species are already under threat by habitat fragmentation, drought and/or bushfires (Letnic 2000; Allen 2011; Augusteyn et al. 2021).

In Australia, legislation for wild dog management varies from state to state, but generally specifies an obligation for individual landholders to manage wild canids on their properties. For example, in New South Wales (NSW), the current *Biosecurity Act 2015* imposes a general biosecurity duty which requires landholders to control wild dogs on their land and prevent them from causing problems on neighbouring lands (NSW Government 2022). A variety of lethal and non-lethal methods are approved for landholders to manage wild dogs. Lethal methods include shooting, leg-hold trapping and poison baiting (Fleming et al. 2014). Examples of non-lethal methods include the use of guardian animals (e.g. dogs, alpacas and llamas) (van Bommel 2010; Van Eeden et al. 2018) and exclusion fencing (Smith, King, and Allen 2020; Pacioni, Kennedy, and Ramsey 2021).

Given that wild dogs are highly mobile and can cause problems across multiple properties, management programs often focus on coordinated action to maximise effectiveness (National Wild Dog Action Plan 2020). These coordinated programs can involve both private and public landholders working collectively to address wild dog problems, and most often involve the use of lethal methods such as baiting (both ground and aerial) and shooting (Fleming et al. 2006; Ballard et al. 2020). The use of 'cell' or 'cluster' fencing, whereby groups of landholders enclose their properties in a single exclusion perimeter fence, also has increased over the past two decades (Smith, King, and Allen 2020; Pacioni, Kennedy, and Ramsey 2021). Participation in these coordinated programs is often promoted to be the simplest way for landholders to comply with their legal obligations, regardless of whether they are suffering directly from wild dog impacts, indirectly or not affected at all.

A primary goal of this article is to understand which factors encourage or discourage participation in coordinated control programs to manage wild dogs. Landholders' perception of the pest status of the animal and their negative impacts, particularly on their own enterprise, and the belief that it is their responsibility to act, have been found by many studies to be primary drivers for conducting wild dog management (Fitzgerald, Fitzgerald, and Davidson 2007; Fenton 2009; Binks, Kancans, and Stenekes 2015; Ecker et al. 2015; McLeod and Hine 2019). Acceptability of control methods, particularly lethal strategies (e.g. humanness and target specificity), perceived effectiveness, past experiences, the time and skill required to conduct control, along with the perceived economic cost can influence the choice of method (Fenton 2009; Fitzgerald 2009; Southwell et al. 2013; Ecker et al. 2015; McLeod and Hine 2019; Van Eeden et al. 2019; Carter et al. 2020; Díaz, Simonetti, and Zorondo-Rodríguez 2020).

Howard et al. (2018) described the complexity of social, political, economic and cultural contexts that influenced landholder participation in coordinated group programs. The increasing heterogeneity of rural inhabitants across a landscape stemming from the increasing mixture of land uses in rural areas (e.g. lifestyle blocks, absentee owners as well as working farms), and spreading urbanisation provide challenges to traditional drivers of coordinated actions such as rural social norms, shared experiences, neighbour relationships, trust and recognition of other perspectives (Buckley et al. 2006; Fenton 2009; Fitzgerald 2009; Klepeis, Gill, and Chisholm 2009; Howard et al. 2018). Barriers to ongoing group participation include maintaining landholder cooperation and motivation, demonstrating effectiveness, group leadership considerations and securing ongoing financial support (Ecker et al. 2015; Howard et al. 2016, 2018).

Although there has been considerable research on the factors influencing participation in wild dog management, the field has lacked an integrative framework for linking these

drivers and barriers directly to the most effective intervention strategy and policy solutions. In their review of behavioural theories relevant to invasive species management McLeod et al. (2015b) recommended the Behaviour Change Wheel (BCW) and associated integrative Capability-Opportunity-Motivation (COM) Behaviour model, initially developed by Michie and her colleagues for application in the health field (Michie, van Stralen, and West 2011; Michie, Atkins, and West 2014). The BCW framework can be used to identify the factors influencing behaviour, and then links these factors to appropriate behaviour change initiatives. The COM Behavioural model provides an overarching model to assist in the identification of factors that influence behaviour, and is divided into three components (Michie, van Stralen, and West 2011):

(1) Capability. An individual's physical and psychological ability to perform the behaviour of interest. For example, does the landholder have the physical skills required to lay leg-hold traps, do they possess the knowledge and cognitive skills to develop a property management plan? Interventions tackling these types of factors should incorporate techniques that educate, train and provide personal support.

(2) Opportunity. Physical and social factors external to the individual that prompt or enable the behaviour to occur. For example, does the landholder have access to the relevant equipment and resources to construct a dog exclusion fence, do they have the support from the family, neighbours and community to conduct a baiting program? Interventions tackling these types of factors should aim to provide access, enable, facilitate, prompt or constrain.

(3) Motivation. Factors internal to an individual that energise or direct behaviour, and can be either reflective (incorporating conscious deliberation and reasoning) or automatic (usually outside conscious control e.g. impulse, habitual or emotional) (Kahneman 2013). For example, a landholder's decision to conduct wild dog control may occur after careful cost–benefit deliberation of all the available options, after witnessing the mauling of their livestock or because that is what they have done every year. Interventions tackling these types of factors should be designed to inform, persuade, discuss, demonstrate, incentivise or coerce.

This framework has been applied successfully in understanding general participation in invasive mammal management in Western Australia (McLeod and Hine 2019), the management of domestic cats (McLeod, Hine, and Bengsen 2015b) and the reporting to authorities of wild dogs in peri-urban areas (Please et al. 2018; Hine, McLeod, and Please 2020). This will be the first study that has applied the framework to understanding participation in coordinated wild dog management programs.

Matching the content to specific audience needs can improve the behavioural impact of any identified behavioural intervention. As described above, not everyone views wild dogs, their impacts and management approaches in the same way, so the patterns of drivers and barriers influencing participation in coordinated wild dog management are likely to vary across individuals within a community. Interventions can be designed or targeted to best match the characteristics of segments with specific driver / barrier profiles (e.g. Kaine et al. 2005; Emtage, Herbohn, and Harrison 2007; Morrison et al. 2012; Hine, Sharp, and Driver 2019). Messages can also be crafted for specific individuals, as opposed to larger segments. This is referred to as message tailoring and is becoming

increasingly common with advances in Internet marketing (e.g. Hine et al. 2017; Morrison et al. 2017).

The objectives of this study were to:

(1) Identify the main drivers and barriers to participation in coordinated control programs and organise them according to the COM Behavioural model.
(2) Determine the importance of these COM items, along with the demographic variables in influencing current participation in coordinated control programs.
(3) Segment landholders according to their current participation in wild dog control to determine if there was any difference between the segments and the COM drivers and barriers.
(4) Identify leverage points that may be useful for targeting interventions to encourage participation using the BCW framework.

Methods

A mixed methods research design was used for this project. This included interviews of experts in wild dog management as well as a phone survey of NSW rural landholders.

Expert interviews

To assist in identifying a list of potential drivers and barriers to participation in coordinated control programs for use in the landholder survey, we interviewed 14 experts in wild dog management. These experts were initially recruited from members of the National Wild Dog Coordinator Network, along with their suggested recommendations including rural landholders who are impacted by wild dogs, and representatives from non-government, research and government organisations, whose duties were related to wild dog management. The interviews followed a semi-structured format, to allow for the exploration of their knowledge in their specific areas of expertise (Barriball and While 1994) and were conducted either by phone or face-to-face.

All interviews, which lasted between 30 and 60 minutes, were recorded (by consent) and later transcribed and summarised. The interviews were analysed based on the guidelines for thematic analysis recommended by Braun and Clarke (2006). After familiarisation with the transcript of each interview, the content was coded using shorthand descriptive labels. Using these codes, emerging patterns or 'themes' were generated around the identified driver and barrier factors to landholder participation in coordinated wild dog control programs. These themes were reviewed against the interview transcripts to ensure they were useful and accurate representations of the content, and defined to accurately reflect the types of driver and barrier factors they represented.

Rural landholder survey

A random digit phone survey of 198 NSW rural landholders within areas reported to have problems with wild dog (NSW Government 2022) was completed to assess the potential drivers of and barriers to participating in coordinated wild dog control programs. Information about the landholders' perceptions of wild dog problems on their

Table 1. Identified themes from the expert interviews and literature review and the 22 COM (Capability, Opportunity and Motivation) items used in the landholder survey.

Identified themes	Reliability (Cronbach α)
Awareness of local wild dog problem (2 items)	.71
1. Not aware of wild dog problems in their local area (reverse scored)	
2. Wild dogs are causing a problem on their property	
Capability to participate in coordinated control (5 items)	.73
3. Know best control methods to use	
4. Self-conscious of skill level to conduct control methods (reverse scored)	
5. Not confident in conducting control (reverse scored)	
6. Cooperation with other landholders not difficult	
7. Not aware when group programs happening (reverse scored)	
Opportunity to participate in coordinated control (5 items)	.66
8. Do not have the time to plan group programs (reverse scored)	
9. Convenient to participate at specified time	
10. Participation too costly (reverse scored)	
11. Other residences are too close to conduct methods (reverse scored)	
12. Family and friends support participation	
Motivation to participate in coordinated control (5 items)	.72
13. Believe group methods are ineffective (reverse scored)	
14. Prefer to do own control (reverse scored)	
15. Want to help the community with this problem	
16. Believe it's the government's responsibility (reverse-score)	
17. Neighbours do not participate in the program (reverse scored)	
Motivation to use available control methods (5 items)	.84
18. Believe wild dogs should not be harmed (reverse scored)	
19. Believe control methods used are inhumane (reverse scored)	
20. Believe control will not harm wildlife	
21. Prefer not to use baits (reverse scored)	
22. Believe control will harm working dogs (reverse scored)	

property, and participation in management behaviours was collected. Basic demographic information, including property size, main property uses, years of residence, main income source and age was also captured. Respondents were asked to rate their agreement (on a 5-point Likert scale) to 22 Capability, Opportunity and Motivation (COM) items that had been identified from the results from the expert interviews as well as from a review of previous research (Fenton 2009; Fitzgerald 2009; Southwell et al. 2013; Binks, Kancans, and Stenekes 2015; Ecker et al. 2015; Howard et al. 2018; McLeod and Hine 2019) (refer to Table 1).

Quantitative data analysis

As COM items were worded as either drivers or barriers in the survey, all barrier items were reversed scored for analysis (Table 1). All data was tested for compliance to the assumptions for parametric statistical analyses: normality, outliers, multicollinearity, non-linearity, homoscedasticity and non-independence assumptions. We treated data from Likert scales as interval data and used parametric tests (Sullivan and Artino 2013), following the common practice used in medical and psychological research. Internal consistency of the COM variables containing multiple items was tested using the Cronbach's Alpha Test (Tavakol and Dennick 2011). We performed a hierarchical multiple regression to identify the COM items and demographic variables associated with participation in current coordinated control programs.

We then conducted a Latent Profile Analysis (LPA) to classify landholders into homogenous segments based on their participation in a range of wild dog management

behaviours (baiting, shooting, trapping). Relative model fit was assessed using the Bayesian information criteria (BIC; Schwartz 1978) relative entropy (Ramaswamy et al. 1993) and the Lo–Mendell–Rubin likelihood ratio test (LMR; Lo, Mendell, and Rubin 2001). Differences between the identified segments and COM items, control behaviours and demographic variables were tested using either a one-way ANOVA or Pearson's chi-squared test. All analyses were conducted in SPSS 26 (IBM 2019) except the LPA which was conducted in MPlus 8.6 (Muthén and Muthén 2019).

Results

Expert interviews

Five main driver / barrier themes for participation in coordinated programs were identified from the expert interviews. These were 'Awareness of local wild dog problem', 'Capability to participate in coordinated control', 'Opportunity to participate in coordinated control', 'Motivation to participate in coordinated control' and 'Motivation to use available control methods'. The COM items used in the landholder survey for each of these themes are described in Table 1.

Landholder participants

During the period of our phone survey many targeted areas of NSW experienced catastrophic bushfires, reducing the number of responses that we could collect. Of 198 respondents who did participate, 54 per cent identified as male, 46 per cent as female. The average age was 60 years (range 18–93 years), which is older than the average age of 54 years recorded for the NSW Regional adult population (Australian Bureau of Statistics 2018). The average property size of respondents was 880 ha (range 8–47,000), and the average years of residence was 27 years (range 1–83 years). Eighty-two of the respondents (41 per cent) earned their main income from their property. Over three quarters of the respondents ($n = 151$) had some type of livestock enterprise on their property, mainly cattle, small livestock (such as sheep or goats), or horses. Thirty-seven (19 per cent) respondents categorised their property as lifestyle or hobby, and the remaining ten (five per cent) ran enterprises that did not involve livestock, such as horticulture, forestry, and providing public camping facilities.

A third of the respondents ($n = 66$) were not aware of wild dogs in their local area. A further third ($n = 66$) reported being aware of wild dogs in their local area but had not experienced any problems on their properties. The remaining third of respondents ($n = 66$) reported wild dog problems on their property. Of these, 32 (16 per cent) rated their problem as minor while the remaining 34 (17 per cent) experienced major problems.

Seventy-six respondents (38 per cent) indicated they had conducted wild dog control in the past three years. Those that had participated were more likely to have conducted independent control such as shooting ($n = 43$, 22 per cent) and baiting ($n = 21$, 11 per cent). The most popular coordinated control was baiting (Ground application: $n = 34$, 17 per cent, Aerial application: $n = 9$, five per cent), followed by shooting ($n = 15$, eight per cent). Only ten respondents had conducted independent leg-hold trapping (five

per cent) and four (two per cent) had participated in a coordinated trapping program. Seven respondents (four per cent) indicated they had exclusion fences on their property (all built independently and not part of a cluster), while three (two per cent) used guard animals.

Measure reliability

Cronbach's α for the multi-itemed COM items within each theme are shown in Table 1. The items within all five themes ('Awareness of local wild dog problem', 'Capability to participate in coordinated control', 'Opportunity to participate in coordinated control', 'Motivation to participate in coordinated control' and 'Motivation to use available control methods') reflected an adequate internal consistency of greater than .65 (Tavakol and Dennick 2011). Scale scores for each of these themes were computed by averaging the items which was then used for subsequent analysis.

Variables predicting participation in coordinated control programs

A hierarchical multiple regression was conducted to identify the most important predictors of current landholder participation in coordinated wild dog control. We were interested in two models: (1) demographic predictors – landholder age, property size, years of residence on their property, presence of small livestock (dichotomous: 0 = no small livestock, 1 = small livestock present), landholder type (dichotomous: 0 = run an enterprise, 1 = hobby / life-styler) and main income source (dichotomous: 0 = off-property, 1 = from property), and (2) demographic predictors and COM items. The results are summarised in Table 2.

Model 1 (demographics only) explained two per cent of the variance in current coordinated participation and was not significant. Model 2 (demographics and COM items) explained an additional 20 per cent of the variance in coordinated participation (overall 22 per cent). Both 'Motivation to participate in coordinated control' and 'Awareness of the wild dog problem' each explained three per cent of the unique variance in the regression, and years of residence on the property explained two per cent of the unique variance. Landholders' current participation in coordinated wild dog control was best predicted by 1. awareness of local wild dog problems, 2. motivation to participate in coordinated control programs, and 3. years of residence on their property.

Landholder segmentation

To develop the most effective policies and engagement interventions, practitioners not only need to understand why landholders are willing or not to participate in coordinated control, but also if these reasons are similar across all landholders. We conducted a Latent Profile Analysis (LPA) to classify landholders into homogenous segments based on their participation in wild dog baiting, shooting, or trapping over the previous three years. The results indicated that respondents could be classified into four COM profiles (Figure 1). Although the 5-profile solution produced the lowest BIC value, and the 3-profile solution had the highest entropy value, the LMR test indicated that the 4-profile solution (which had the second lowest BIC, and second highest entropy value) fitted the data significantly

Table 2. Summary of hierarchical regression analysis: Variables predicting current participation in coordinated wild dog management.

Predictors	R	R2	Adj R2	F (df)	p	B	95% CI of B		sr2	r
							LB	UB		
Model 1 (Demographics)	.22	.05	.02	1.60 (4,189)	.15					
Age						−.01	−.03	.01	.01	−.05
Property area						−.00	.00	.00	.00	−.02
Years of residence						.01	.00	.02	.02	.14
Presence of small livestock						.09	−.41	.59	.00	.01
Landholder type						.05	−.51	.60	.00	−.07
Main income source						.37	−.09	.82	.01	.17
Model 2 (Demographics & COM items)	.54	.29	.25	7.31 (10, 183)	< .001					
Age						−.01	−.03	.01	.00	−.05
Property area						−.00	−.00	.00	.00	−.02
Years of residence						.01	.00	.02	.01	.14
Presence of small livestock						.19	−.27	.64	.00	.01
Landholder type						.19	−.31	.69	.00	−.07
Main income source						.19	−.22	.60	.00	.17
Awareness of local wild dog problem						.26	.08	.43	.03	.41
Capability to participate in coordinated control						.04	−.23	.31	.00	.34
Opportunity to participate in coordinated control						.17	−.20	.54	.00	.36
Motivation to participate in coordinated control						.47	.12	.82	.03	.44
Motivation to use control methods						−.06	−30	.18	.00	.31

B unstandardised beta coefficient, CI confidence interval, LB lower bound, UB upper bound, sr2 squared semi-partial correlation, r Pearson correlation.
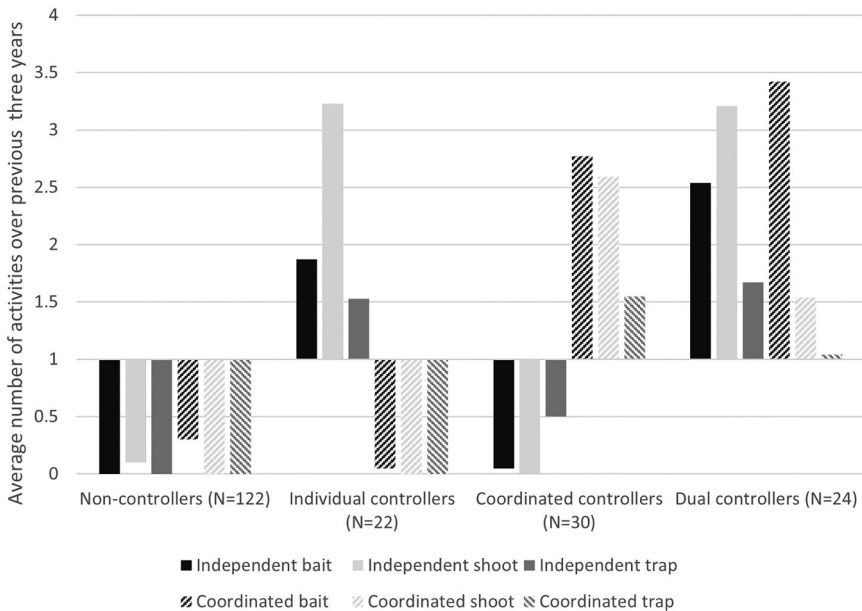

Figure 1. Four behaviour profiles based on respondents' participation in wild dog baiting, shooting and trapping over the previous three year.

Table 3. Model fit indices for the latent profile analysis solutions.

Profile solution	BIC	Entropy	LMR
2	1080.64	.98	$p = .01$
3	928.39	1.00	$p = .22$
4	902.44	.99	$p = .01$
5	893.13	.99	$p = .11$
6	897.68	.99	$p = .35$

Notes: BIC – Bayesian information criterion; LMR – Lo-Mendell-Rubin likelihood ratio test.

better than 3-profile solution, and that retaining an additional fifth profile did not significantly improve fit (Table 3).

The demographic and behavioural characteristics for each landholder segment are described below. For further detail refer to supplementary tables S1 and S2.

- *Non-Controllers* ($n = 122$, 61.6 per cent) had rarely participated in any wild dog baiting, shooting, trapping over the previous three years. They tended to be landholders who did not earn their main income from their property and had reported not experiencing any wild dog problems. They mainly identified as life-stylers or hobby farmers. Along with *Individual Controllers*, they had resided on their property the least number of years.
- *Individual Controllers* ($n = 30$, 15.2 per cent) had conducted independent wild dog baiting, shooting, and / or trapping over the previous three years, but rarely participated in coordinated programs with other landholders. They tended to have experienced either minor or major wild dog problems, and more likely to be running an enterprise on their property. Along with *Non-Controllers*, they had resided on their property the least number of years. Shooting was the most used control method, and members were more likely to rely on exclusion fencing on their property and guard animals for constant protection.
- *Coordinated Controllers* ($n = 22$, 11.1 per cent) had regularly participated in coordinated management activities such as baiting and shooting, and rarely did any activities by themselves. They tended to have experienced major wild dog problems and along with *Dual Controllers* had resided on their property the greatest number of years.
- *Dual Controllers* ($n = 24$, 12.1 per cent) participated in both coordinated management activities (mainly baiting), as well as conducted baiting, trapping and shooting independently. A small number also used fencing for constant protection. They tended to have experienced minor to major wild dog problems, and along with *Coordinated Controllers* had resided on their property the greatest number of years.

Our results revealed two landholder segments, *Non-Controllers* and *Individual Controllers*, whose members did not participate in coordinated wild dog control. To identify the specific drivers and barriers for participating in coordinated control, we compared the participants' responses to the five COM subscales ('Awareness of local wild dog problem', 'Capability to participate in coordinated control', 'Opportunity to participate in coordinated control', 'Motivation to participate in coordinated control' and 'Motivation to use available control methods') across the four segments. We found significant

differences between participators (i.e. *Coordinated* and *Dual Controllers*) and non-participators (*Non-Controllers* and *Individual Controllers*) across all COM items.

Tukey's post-hoc tests indicated that there were no differences between the means of the Individual, *Coordinated* and *Dual Controllers* for 'Awareness of local wild dog problems', 'Capability to participate in coordinated control', and 'Motivation to use available control methods', however, the mean decreased significantly to *Non-controllers* ($\eta2 = 0.3$, 0.2 and 0.1 respectively). There were no differences between the means of the Coordinated and Dual controllers for 'Opportunity to participate in coordinated control', and 'Motivation to participate in coordinated control', however, the means decreased significantly to both the *Individual Controllers* and *Non-Controllers* ($\eta2 = 0.2$ and 0.3 respectively). For further details refer to the supplementary Table S2.

These results illustrate that the patterns of drivers and barriers influencing participation in coordinated wild dog management vary across rural landholders depending on their behavioural dispositions. It adds nuances to the regression results which indicated that to improve participation in coordinated management programs interventions needed to primarily address landholders' awareness of local wild dog problems, and their motivation to support coordinated programs. Landholders who are already aware of wild dog problems and who are already capable and motivated to conduct their own control (i.e. *Individual controllers*) would need to be targeted with interventions that increase both their opportunity and motivation to participate in coordinated programs. Landholders who are not aware of wild dog problems in their local areas and not capable or motivated to conduct control (i.e. *Non-controllers*), would need to be initially targeted with an education-style intervention to improve their knowledge of local wild dog problems, before targeting them with interventions to increase their skills to conduct control, as well motivating them to participate in coordinated control programs.

Discussion

In Australia coordinated control programs across the landscape have been presented as the most effective way to manage the negative impacts of wild dogs (National Wild Dog Action Plan 2020). The aim of this study was to better understand the willingness of landholders, who live in areas that experience wild dog problems, to participate in coordinated control programs. We identified the main drivers and barriers to participation in coordinated control and organised them according to the Capability, Opportunity and Motivation (COM) Behavioural model. This research was the first to adopt the COM Behavioural model to identify specific drivers and barriers specifically for wild dog management. The types of drivers and barriers identified from our NSW study area were similar to those reported from other areas across Australia – landholders' awareness of wild dogs and their negative impacts, their capabilities and opportunities (both physical and social) to conduct control, their perceptions around their responsibility to act and the acceptability and effectiveness of control methods (e.g. Fitzgerald, Fitzgerald, and Davidson 2007; Fenton 2009; Southwell et al. 2013; Binks, Kancans, and Stenekes 2015; Howard et al. 2018; McLeod and Hine 2019).

Our results illustrate the complexity of factors encompassed in landholder willingness to participate in coordinated wild dog control and demonstrate the usefulness of the COM model in understanding the nature of specific drivers and barriers to landholders'

behaviour. While the Behaviour Change Wheel (BCW) and associated COM model have been successfully implemented in understanding and modifying health-related behaviour (e.g. De Winter and Gutman 2022; Garcia et al. 2022; Gingrich et al. 2022), its usefulness within other spaces such as transport (e.g. Dalton, Burke, and Jones 2022; Krusche et al. 2022), consumerism (e.g. Trent Grassian 2020; Sundaraja, Hine, and Lykins 2021; Allison et al. 2022; Golding et al. 2022), pro-environmental behaviour (e.g. Addo, Thoms, and Parsons 2018; McLeod, Hine, and Driver 2019; Kolodko et al. 2021) and agricultural practices (e.g. McLeod and Hine 2019; Ambrose-Oji et al. 2022; Irwin et al. 2022; Tensi, Ang, and van der Fels-Klerx 2022) are only beginning to be explored. Our main findings are summarised in the next sections, along with a discussion of the practical implications using the BCW framework to identify the main leverage points useful for targeting interventions to encourage participation.

Awareness of wild dog problems

A common barrier to landholder participation was lack of awareness about wild dogs and their impacts on one's property and local areas. Personal experience of the negative impacts of invasive animals such as wild dogs has been shown to be a strong motivator for conducting control (Fenton 2009; Binks, Kancans, and Stenekes 2015; Ecker et al. 2015; McLeod and Hine 2019). However not all landholders experience these negative impacts at the same level, and as our results indicate, many are not even aware of the problems experienced by others in their local community. According to the BCW, an effective way to increase awareness is by increasing knowledge through an education-style intervention (Michie, Atkins, and West 2014). Relating personal experiences and using a narrative-style approach could enhance this type of intervention by emotionally engaging its audience (Hine et al. 2015). Recent neuroscience research indicates that people's brains react similarly when reading about an experience and actually living the experience (Mar 2011), suggesting that stories can engage audiences in a fundamentally deeper way than more traditional fact and statistics-based approaches.

Capability to participate in coordinated programs

Lack of knowledge, skills and confidence to conduct wild dog control methods were also identified as important barriers to participation in wild dog control. The BCW suggests interventions that educate, train and support landholders are the most appropriate to address these types of factors (Michie, Atkins, and West 2014). Our findings reinforce the importance of training workshops and learning communities to improve landholder's skills (e.g. Sewell et al. 2017). Workshops targeting specific types of landholders, for example landholders with small-holdings or women, may provide a more inviting and supportive environment.

A common barrier to landholder participation in coordinated programs was their awareness of when these programs where occurring. As our survey was anonymous it is not possible to verify if the lack of awareness was due to shortcomings in the promotion of the programs, or whether in fact there were no actual programs being conducted in their area. However, if it is the former, the organisers might need to consider alternative networks, communication channels and messages that would be relevant and engage these

landholders (Aslin 2006). Keeping in mind that many identify as hobby farmers and 'life-stylers', traditional messages that emphasise economic loss or gains may catch the attention of landholders who rely on their properties for their primary source of income, but they may be less effective for those landholders who have different values and priorities (Klepeis, Gill, and Chisholm 2009; Low Choy and Harding 2010).

Opportunity to participate in coordinated programs

Having the opportunity to participate in a coordinated program was also another commonly identified barrier. Interventions to address participants' lack of opportunity should enable, provide, facilitate, offer and prompt participation, whilst constraining participation in less-desired behaviours (McKenzie-Mohr 2011; Michie, Atkins, and West 2014). For those landholders who identified time or perceived cost as import limiting factors, promotion and demonstration of timesaving or cost-saving practices, along with the long-term benefits of control activities may be a priority. Assistance with costs could be offered through group subsidies for required resources. For those landholders who cannot participate due to the restrictions placed on some control methods near residences, alternate ways to be involved or support those who are participating would enhance the social capital of the coordinated activity (Graham et al. 2019).

The convenience of participating at the specified time was also identified as a barrier to taking part in the coordinated control programs. The program organisers may need to explore this theme further in their local area to identify the more precise reasons behind the inconvenience. Was it because there were other on-farm tasks that were occurring at the same time making participation difficult? In that case advance planning and 'save the date' reminders might be beneficial so that landholders could manage their workload accordingly. Organisers might need to be more flexible with the timing of the coordinated programs, so they do not clash with important on-farm or off-farm activities.

Landholders can belong to a range of different social groups (e.g. family unit, geographic location, occupation), and these groups can shape their beliefs and behaviours (Tajfel and Turner 1986; Fielding et al. 2008). Our non-participants identified that they did not have the support from two common social groups that may be important to landholder's behaviour, family and neighbouring landholders. For example, McLeod and Hine (2019) identified that landholders were more likely to participate in coordinated activities to control invasive animals if their neighbours were also participating in such efforts. Organisers could promote landholder interaction within peer and local networks, to leverage the power of shared social identities and encourage participation in coordinated activities (Fielding et al. 2008; Niemiec et al. 2016). Messages using descriptive norms that describe how most landholders in the local area, or with similar interests, are doing may be an effective strategy (Cialdini et al. 2006).

Motivation to conduct wild dog control

Baiting, primarily with the toxin 1080 (sodium monofluoroacetate) is commonly employed in coordinated programs in most states of Australia as it is considered the most cost-effective method available (Fleming et al. 2006). Currently, if landholders express a wish not to use baits on their property, they do not take part in these

coordinated activities. One of the main barriers for these landholders is that the use of baits poses a huge risk to their working dogs. There have been several initiatives to overcome this barrier, including the registration in 2016 of a new toxin for wild dog baits (Para-aminopropiophenone, commonly known as PAPP) which has a more humane action and an antidote (McLeod and Saunders 2013), and the promotion of muzzles for working dogs (e.g. Using muzzles for working dog safety video) (Anon 2020). Some landholders, however, have other concerns about baiting (e.g. that it is inhumane or will harm other wildlife), which are value-based and cannot be addressed by such initiatives. In these cases, organisers may need to weigh up the benefits of having a truly coordinated program which incorporates all landholders sharing in the responsibility on the one hand, and the use of only one control method (albeit the most cost-effective one) on the other. By offering alternate ways to be involved (e.g. trapping or shooting at the same time, or other means of supporting those who are baiting) a coordinated program has the potential to be more inclusive and improve its social capital through increasing trust, reciprocity, and shared values (Alter et al. 2017; Graham et al. 2019).

Motivation to participate in coordinated programs

It is often assumed that landholders who are suffering direct impacts from wild dogs will either make a rational or economic decision to conduct wild dog control, or alternatively be emotionally stirred to act. For those landholders who are not directly impacted, participation in coordinated actions is commonly garnered through appeals to their 'good neighbour', 'community spirit' or 'environmental' values (Binks, Kancans, and Stenekes 2015). Non-participating landholders in our study however indicated that helping the community was not necessarily a motivation for being involved in the coordinated activities. The 'good neighbour', or 'community spirit' appeals may not be effective, at least in the current context.

Our findings also highlighted that willingness to engage in coordinated wild dog control activities was linked to an individual's attachment to their home and community. On average, landholders who participated in coordinated control had resided on their properties longer than landholders not involved. However, it is important to also acknowledge that for other activities unrelated to the management of invasive animals, the effects of place attachment on pro-environmental behaviour can be mediated or moderated by many factors such as the type of attachment (e.g. natural versus civic), the relationships and trust among people (social capital), as well as the actual social norms within the community and an individual's willingness to adopt those norms (e.g. rural versus amenity landholder) (Brehm, Eisenhauer, and Krannich 2006; Jorgensen and Stedman 2006; Scannell and Gifford 2010; Lewicka 2011). The role of place attachment in influencing participation in coordinated wild dog control activities requires further investigation to fully understand these nuances.

Limitations of this research

Owing to the severity of the wide-spread bushfire situation across NSW at the time of this study, our sample was not necessarily representative of rural landholders so

generalisations from our findings should be made with caution. Although we assessed a wide range of behavioural predictors of landholder participation in wild dog coordinated control, practical limitations associated with the length of phone surveys prevented us from assessing a more comprehensive list. The research described in this study represents a starting point for further work aimed at developing more effective wild dog management communication and behaviour change interventions.

The BCW and COM Behavioural model provides a practical, intuitive tool to increase the understanding of behaviour in context and design interventions that are most likely to be effective. However, it is important to acknowledge that applying this framework is no 'quick fix'. Significant effort is required to organise and evaluate potential COM factors and understand how these factors vary across context. An important next step is to rigorously evaluate the interventions. Changing human behaviour can be complex, and it is all too often the case that scientifically credible evidence about the effectiveness of a particular intervention is lacking. Knowledge about what works in what contexts will only be gained iteratively through a continuous loop of learning and improvement.

Conclusion

The research described in this study represents a starting point for understanding landholder behaviour and involvement in coordinated wild dog control programs. We identified drivers and barriers to participation in coordinated control programs, organised them according to the COM Behavioural model, and found that landholders' willingness to participate to participate in coordinated control was influenced by their awareness of wild dog problems and motivational factors to do so. However, segmentation using behavioural factors highlighted that landholders were not a homogenous group, with each of the segments identified exhibiting their own unique COM profile. Using the BCW framework we were able to recommend the most appropriate type of intervention that would connect and engage with the targeted audience. The use of the BCW and its underlying COM Behavioural model of Michie, Atkins, and West (2014) provides a practical, easy-to-employ tool for practitioners to increase their understanding of landholder behaviour and assist them in developing improved interventions to target and boost participation rates within their own local communities.

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Disclosure statement

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Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Human Research Ethics Committee of the University of New England (Approval Nos HE18-182 & HE19-241), and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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