Environmental Management (2019) 64:213–229
https://doi.org/10.1007/s00267-019-01176-5

Using Audience Segmentation to Understand Nonparticipation in Invasive Mammal Management in Australia

Lynette J. McLeod[1] · Donald W. Hine[1]

Received: 27 September 2018 / Accepted: 30 May 2019 / Published online: 17 June 2019

Abstract

Invasive mammals threaten agriculture, biodiversity, and community health. Yet many landholders fail to engage in control activities recommended by experts. We surveyed a representative sample of 731 Western Australian rural landholders. The survey assessed landholders' participation in a range of activities to control invasive mammals, as well as their capabilities, opportunities, and motivation for engaging in such activities. We found that over half of our respondents had not participated in any individual or group activities to control invasive mammals during the previous 12 months. Using latent profile analysis, we identified six homogeneous subgroups of nonparticipating landholders, each with their distinct psycho-graphic profiles: *Unaware, Unskilled, and Unmotivated, Aware but Unskilled and Doubtful, Unskilled and Time Poor, Disinterested, Skilled but Dismissive*, and *Capable but Unmotivated*. Our results indicate that engagement specialists should not treat nonparticipating landholders as a single homogeneous group. Nonparticipators differ considerably in terms of their capabilities, opportunities, and motivations, and require targeted engagement strategies informed by these differences.

Keywords Human behavioral change · Intervention design · Invasive species management · Pest management · Behavior change wheel

Introduction

In Australia, invasive mammals—including rabbits, foxes, wild dogs, feral pigs, and feral cats—pose a considerable threat to agriculture, biodiversity, and community health. Invasive mammals are estimated to cost the Australian agricultural industry $797 million per year (McLeod 2016). Until recently, managing these pests in rural areas has been treated primarily a technical matter, involving the application of science and technology to develop new and improved control strategies. Examples of techno-centric approach include: the development and release of a new strain of the Rabbit hemorrhagic disease virus (RHDV), the Hog-Hopper™ bait delivery system for feral pigs, spray tunnels for feral cats, a range of new bait products containing a newly registered toxin PAPP (Para-aminopropiophenone) for wild dogs and foxes, and monitoring tools such as wild dog alert (an automated recognition and messaging system), camera traps, and drone technology (detailed descriptions of these control strategies can be found at PestSmart Connect: www.pestsmart.org.au).

More recently, policy makers, scientists, and practitioners have recognized the importance of the social and human behavioral aspects of invasive mammal management (Ballard 2006; Miller 2009). Best-practice guides have been developed to influence individual-level management actions (Hine et al. 2015; Coleman et al. 2017; Hine et al. 2018), and landscape-scale, collaborative programs have been promoted for many invasive species such as foxes, wild dogs, and feral pigs (Braysher 2017). The success of both individual and group-level programs relies on the support and action by landholders and the general community—a major challenge not made any easier by urbanization and the increasing mixture of land uses in rural areas. Such sociodemographic changes have produced heterogeneous communities whose members sometimes vary considerably in terms of their values, beliefs, priorities, motivations, and abilities (Buckley et al. 2006; Klepeis et al. 2009). This change in rural inhabitants means that the established forms of agricultural extension focusing on improving farming production and profits may no longer suitable. New

✉ Lynette J. McLeod
lmcleod7@une.edu.au

[1] School of Psychology, University of New England, Armidale, NSW 2351, Australia

messages and communication pathways may be needed to encourage members of increasingly diverse communities to participate in desired management actions (e.g., Ison and Russell 2000; Salmon et al. 2006; Klepeis et al. 2009).

Social psychology and behavioral economics have generated an array of interventions and behavior change techniques designed to increase understanding, engagement, and ultimately adoption of desired behaviors across a broad range of target audiences (e.g., Gardner and Stern 2002; Darnton 2008; McKenzie-Mohr 2011; Michie et al. 2014; Schultz 2014; McLeod et al. 2015; Byerly et al. 2018). But, not all techniques are equally well suited for all potential audiences and situations (Hine et al. 2015; McLeod et al. 2019). To select the most effective techniques to facilitate behavior change, practitioners need to first identify the factors that drive their audiences' behavior, as well as those that impede an action from being performed. McLeod et al. (2015) demonstrated that most behavioral influencers relevant to invasive mammal management can be classified into the three general categories described by Michie et al. (2011) COM-B model of behavior:

1. Capability—an individual's physical and psychological capacity to engage in the behavior of interest. For example, does the landholder have the physical skills or ability to conduct control activities such as building enclosure fences or laying baits? Do they have the capacity to engage in the necessary mental activities to select appropriate control options? Controlling rabbits may seem like a straightforward exercise requiring few cognitive demands. However, there are many different methods to choose from (e.g., releasing RHDV, baiting using a choice of toxins and bait material, ripping warrens, warren fumigation, harbor destruction, and shooting), all with various strengths and limitations. In addition, most states have guidelines about how, where and when particular methods can be used, and some methods require specific training which can further complicate the process. Depending on the accessibility and complexity of relevant information, psychological capacity can be easily stretched.
2. Opportunity—factors external to the individual that enable or prompt the behavior to occur. This can refer to situational factors such as having relevant resources and/or control equipment readily available. It is difficult to control rabbits if bait material is not available locally or the contractor who supplies the equipment for ripping warrens has other commitments for the next six months. This can also refer to social factors where community or cultural values and norms can influence engagement. For example, landholders may be more compelled to participate in rabbit control if their surrounding neighbors are keen and actively involved.
3. Motivation—factors internal to the individual that boost or direct behavior. There are two main types of motivating factors: reflective and automatic[1]. Reflective motivation consists of conscious deliberation and reasoning, and often involves evaluating threats, planning, goal setting, and mentally simulating outcomes associated with various types of actions. For example, prior to initiating a particular rabbit control activity, a landholder may make a list of all the costs and benefits of conducting various methods, and select the option that they believe is most likely to produce the best outcome. Automatic motivation refers to mental processes that operate largely outside conscious control, including habits, impulses, and emotionally driven behavior. For example, a landholder's decision to participate in rabbit control may be driven by the negative emotional experiences resulting from the sight of a ruined garden or eroded dam catchment rather than from logical deliberation.

The pattern of factors influencing a given landholders' behavior often varies across the individuals within a community (e.g., Emtage and Herbohn 2012; Morrison et al. 2012). That is, all landholders within a geographic area are unlikely to view invasive mammal species, their impacts and preferred management approaches in the same way. Thus, engagement practitioners may not be dealing with a single target audience within a community, but rather several, with distinct psychographic profiles reflecting their own sets of values, beliefs, and current behaviors.

Audience segmentation involves dividing a target population into homogeneous subgroups based on audience characteristics such as demographics, behavioral influencers, and current behavior (Emtage et al. 2007; Hine et al. 2019). This information can then be used to make strategic decisions regarding who should be targeted, and the selection of optimal behavior change techniques for each audience segmentation as well as the type of messages, communication channels, and messengers (Emtage and Herbohn 2012; Hine et al. 2015, 2017). For example, some landholders may be unaware that invasive mammals are a problem in their region. These individuals could initially benefit from an awareness campaign focused on the negative impacts faced by their neighbors and community delivered by a local resident. Other landholders may already be motivated to act, but lack specific knowledge or skills about how to implement best management practices. These landholders don't need engagement initiatives aimed at

[1] These two factors are not necessarily mutually exclusive, and there are many examples that demonstrate that emotion can be a factor in all types of decision-making (e.g., Damasio 1994; Kahneman 2013).

"awareness raising", but would benefit more from skill-building or ready access to expert advice.

Aims of the Current Study

This study focused on Western Australian landholders and their participation/nonparticipation in control activities for wild dogs, foxes, rabbits, feral pigs, and feral cats. It aims to identify the most important behavioral influencers (capabilities, opportunities, and motivations) of participation in these control activities, both individually and also as part of broader coordinated group initiatives. Based on theory and past research (e.g., Ford-Thompson et al. 2012; Southwell et al. 2013; McLeod et al. 2015) we hypothesize that landholders with greater capability, opportunity, and motivation will be more likely to engage in both individual and group invasive mammal control activities. Our research builds on anecdotal evidence of nonparticipating landholder segments that have generally focused on single conceptual dimensions, such as type of commercial enterprise, property size, or amount of time spent on the property, by adopting a segmentation strategy that incorporates a much broader range of profiling variables based on behavioral capabilities, opportunities, and motivations. We predict that the profiles for capability, opportunity, and motivation will not be uniform across all participants and nonparticipants, and that multiple audience segments will be present. Identifying these different profiles will assist practitioners develop improved interventions to target and boost participation rates within their own local communities.

Methods

Study Area

This study was conducted within the South West Land Division and bordering regions of the Rangelands Division of Western Australia (WA) (Fig. 1). It included landholders from within each of the four rural Natural Resource Management (NRM) regions (Northern Agricultural Catchments NRM, Wheatbelt NRM, South Western Catchments NRM, South Coast NRM), as well as landholders from the Gascoyne, Murchison, and Goldfield-Nullabor sub-regions of the Rangelands NRM. At the time of the study there was an estimated adult population of 150,000 within this targeted area (51% male), with a median age of 53.9 years (Australian Bureau of Statistics 2016).

Respondents

Respondents were 731 rural landholders located within the study area, who owned or resided on a property 10 ha (25 acres) or greater, and were actively involved in land management decisions on that property. They were aged between 23 and 80 years (mean age = 58.2, SD = 11.8, 69% male). These respondents had lived on their properties from less than one year to 80 years (mean = 30.1, SD = 20.5), with 65% relying on their property for their main source of income. Mixed farming (cattle, sheep, and/or cropping) was the main enterprise type recorded (43%) followed by cattle only (20%), sheep only (12.5%), and cropping only (12.5%). Other enterprises, including horses, poultry, pigs, and goats, horticulture and boutique industries such as grapes, olives, aquaculture, and catering for tourists made up 6% of the sampled properties, with the remaining 6%, lifestyle or residential blocks (i.e., no enterprise/income).

Procedure

A random-digit-dial telephone survey, using both landline and mobile numbers, was conducted in June/July 2016 (response rate 50.1%). We chose a phone survey as it offered the best way to contact a representative sample of our diverse target population (Outwater 2011), some who lived in remote areas that did not have access to reliable internet coverage (19.8% reported no internet coverage – Australian Bureau of Statistics 2016). A maximum of 200 landholders were targeted from each of the described NRM areas.

A questionnaire was created to collect landholders' perceptions of invasive mammals, their self-reported participation in a range of individual (i.e., activities conducted solely on their property in isolation from surrounding landholders) and group control activities (i.e., activities that involved coordinating the timing of their activities with surrounding landholders, and in some cases such as fox battues, actually participating in activities on other landholder's properties), as well as capability, opportunity, and motivation behavioral (COM-B) factors that may potentially influence participation in each type of control activity. Sociodemographic information including age, gender, property size, enterprise type, and length of residence was collected from all respondents. The phone survey consisted of 43 items and took approximately 12 min to complete.

Measures

Landholders were asked how often they had participated in control activities for five invasive mammal species—wild dogs, foxes, feral cats, feral pigs, and rabbits—during the past 12 months, both individually and with a group. All responses were recorded using a 5-point Likert scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = very often).

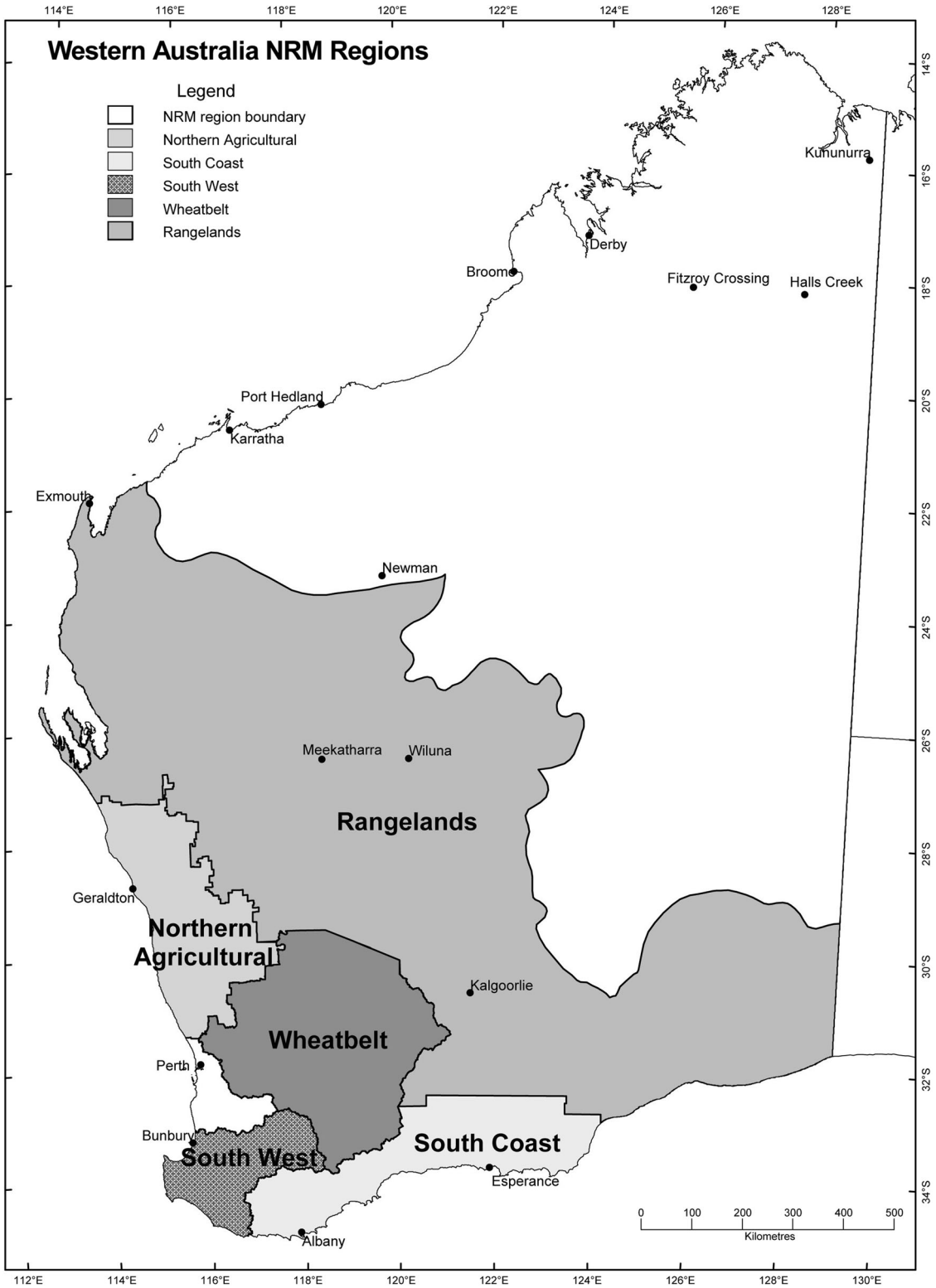

Fig. 1 The study site, showing the five Natural Resource Management regions within Western Australian that were sampled

We assembled our COM-B questions using factors identified from two main sources: (1) a review of the published literature and (2) the results from semi-structured interviews of stakeholders involved in wild dog management in WA (Howard et al. 2018). A wide range of general sources were searched as part of the literature review, using

the resources detailed below. Electronic searching was completed using the following databases, catalogs, and meta-search engines: CAB Abstracts, Dogpile, Google Scholar, ixquick, Science Direct, Scopus, and Web of Science. Searches for publications on statutory and non-statutory Australian organization websites were included, such as the relevant Australian State, Territory & Federal Government environmental and agricultural departments, NRM, Landcare and PestSmart Connect. Bibliographies of articles viewed at full text were searched for relevant additional articles. Although the review focused on Australian contexts, the search strategy covered worldwide literature for the purposes of collecting the broadest scope of information possible. The stakeholder interviews were conducted as part of an associated larger ongoing research project. Forty-one stakeholders, based in the South Coast NRM were interviewed. These included private and public land managers, industry facilitators, government officers, and private pest contractors. Further details of the methodology can be found in Howard et al. (2018).

The perceived severity scores for each of the five invasive mammals were computed by asking landholders rate the extent to which each animal was considered to be a problem on their property. Responses were recorded using the 5-point Likert scale (1 = not a problem, 2 = minor problem, 3 = moderate problem, 4 = severe problem, and 5 = very severe problem). There were 12 further variables covering the awareness of landholders (general detrimental impacts of invasive mammals), their capabilities to conduct the control activities (know-how, skills, cost), the opportunity to conduct the control activities (available time), their motivations including perceptions about the control activities (effectiveness and humanness), the perceived outcomes of the control activities (improved profit and improved sustainability), and social motivations (perceived biosecurity obligation to control, neighbor participation, and good manager recognition). All responses were recorded using a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree, with three items reversed scored). A copy of the survey is available in Appendix 1.

Statistical Analysis

Bivariate correlations were calculated to examine interrelationships among the main study variables. Stepwise multiple regression was used to identify the COM-B factors associated with participation in both individual and group invasive control activities. Latent profile analysis, using MPlus 7.0 (Muthén and Muthén 2014), was conducted to classify respondents into homogeneous subgroups based on their self-reported participation in various invasive mammal management activities, as well as to conduct a secondary profiling analysis to segment nonparticipants based on their perceptions of the COM-B factors associated with engaging in control activities for managing invasive mammals. Relative model fit was assessed using the Bayesian Information Criterion (BIC; Schwartz 1978), and relative entropy (Ramaswamy et al. 1993). In addition, the Lo–Mendell–Rubin (LRM) likelihood ratio test (Lo et al. 2001) was used to determine whether a given profile solution fit the data significantly better than the solution in which one fewer profile group was retained. Demographic differences across profile groups were tested using one-way ANOVA and Pearson's chi-squared test, and effect sizes were measured using Pearson's correlation coefficient (Cohen 1988). Unless otherwise specified, all analyses were conducted using SPSS v25 (IBM 2017).

Results

Descriptive Statistics

Means, standard deviations, and inter-correlations for the full sample and all variables are presented in Table 1. Landholder participation in individual control activities was strongly correlated with the perceived severity of the impact from invasive mammals, and moderately correlated with participation in group control activities. As expected the two participation variables were generally positively associated with an increase in the COM-B variables. Most of these correlations were weak in magnitude (Cohen 1988).

Segmentation of Full Sample Based on Behavioral Variables

We conducted an initial latent profile analysis to determine if landholders could be segmented into distinct groups based on the extent to which they considered invasive mammals (wild dogs, foxes, feral cats, feral pigs, and rabbits) to be a problem on their property and how they engaged in individual and group activities to control each of the species on their properties. Fit indices for the 2 through 6-profile solutions are shown in Table 2. The BIC values indicated that the fit of the models improved as the number of segments increased (i.e., the BIC value decreased). Although the 5-profile solution produced the highest entropy value (i.e., the highest classification certainty), the LMR test indicated that this solution did not fit the data significantly better than the 4-profile solution, hence we interpreted the 4-profile solution which is presented in Fig. 2. We labeled the four profiles as follows:

- *Noncontrollers* ($n = 363$): invasive mammals were not perceived as a problem. Landholders did not conduct

Table 1 Correlations, means, and standard deviations for all variables used in the study

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Individual participation	–														
2. Group participation	0.48**	–													
3. Severity rating	0.59**	0.25**	–												
4. Awareness of impacts	0.20**	0.08*	0.19**	–											
5. Have the know-how	0.16**	0.14**	0.02	0.10**	–										
6. Have the skills	0.21**	0.13**	0.04	0.14**	0.48**	–									
7. Have the time	0.13**	0.06	−0.08*	0.11**	0.28**	0.34**	–								
8. Not too expensive	0.01	0.05	−0.15**	0.10**	0.20**	0.26**	0.29**	–							
9. Perceived humanness	0.10**	0.07	0.06	0.21**	0.18**	0.20**	0.07	0.12**	–						
10. Control effective	0.02	0.05	−0.08*	0.05	0.24**	0.25**	0.27**	0.28**	0.12**	–					
11. Improve profit	0.19**	0.13**	0.11**	0.36**	0.22**	0.31**	0.18**	0.12**	0.21**	0.12**	–				
12. Improve sustainability	0.13**	0.04	0.11**	0.31**	0.13**	0.20**	0.12**	0.16**	0.18**	0.17**	0.35**	–			
13. Biosecurity obligation	−0.01	0.17**	−0.05	0.09*	0.20**	0.15**	0.16**	0.14**	0.06	0.19**	0.08*	0.12**	–		
14. Neighbors participate	0.10**	0.09*	0.01	0.02	0.12**	0.09*	0.09*	0.02	0.07	0.07	0.06	0.03	0.12**	–	
15. Seen as good manager	0.01	0.09*	0.01	−0.10**	−0.01	−0.06	0.00	−0.04	−0.09*	0.00	−0.12**	−0.17**	0.05	0.09*	–
Mean	2.14	1.55	2.23	4.05	3.94	3.82	3.45	3.68	4.18	3.21	4.01	4.02	3.38	3.80	2.60
SD	0.67	0.65	0.65	1.08	1.06	1.16	1.19	1.12	0.94	1.27	1.11	1.12	1.22	1.07	1.27

$N = 731$, range for all variables: minimum 1 to maximum 5, $*p < 0.05$, $**p < 0.01$

any individual or group control activities for any of the species listed in the survey.

- *Individual Controllers* ($n = 98$): invasive mammals were perceived as a problem, with landholders conducting most of their control activities independently, not in association with a group of neighbors/community members.
- *Group Controllers* ($n = 205$): invasive mammals were rated as a minor problem, with landholders conducting most of their control activities in association with a group of neighbors/community members.
- *Dual (Individual and Group) Controllers* ($n = 65$): invasive mammals were perceived as a problem, with landholders participating in both individual and group control activities.

The profile groups varied significantly across four of the demographic variables as indicated in Table 3. Participation profiles varied by age with landholders in the *Noncontrollers* profile being older than the other three profiles. *Dual Controllers* tended to have the largest property sizes and *Noncontrollers* and *Individual Controllers*, the smallest. Examination of the adjusted standardized residuals showed that, although the effect size was weak, *Noncontrollers* were more likely to run cattle only, 'other' types of enterprises, or no enterprise (i.e., residential and 'lifestyle' blocks), and less likely to run mixed (sheep, cattle, and/or cropping) or cropping only enterprises. *Group Controllers and Dual Controllers*, on the other hand, were more likely to run mixed enterprises, and less likely to run cattle only, other types of enterprises, or no enterprise. Landholders who earned their main income from their property were more likely to participate in group activities (*Group Controllers and Dual Controllers*) whereas those landholders who earned their main income from off-property sources were more likely to be *Noncontrollers*.

COM-B Variables for Participation

Stepwise multiple regression was conducted to identify the most important COM-B predictors of landholder participation in individual-level invasive mammal control activities on their properties. Results from these analyses are summarized in Table 4. Landholders were more likely to engage in individual control activities if they: (1) perceived the impacts of invasive mammals to be severe on their property, (2) believed they had the skill to carry out the control activities, (3) had the time to conduct the control activity, (4) believed it was their responsibility as landholders to conduct control activities (biosecurity obligation), and (5) aware that invasive mammal impacts were generally detrimental. Overall, the final regression model explained 40% of the variance in participation in individual control

Table 2 Model fit indices for 2 through 6 profile solutions

Profile solution	BIC	Entropy	LMR	*p*
2	4067.47	0.84	357.0	0.001
3	3952.40	0.67	136.29	0.221
4	3797.02	0.82	172.33	0.000
5	3743.51	0.85	76.97	0.576
6	3731.36	0.80	37.12	0.266

Entropy indicates classification certainty; a significant LMR test indicates that a given profile solution fits the data significantly better than the solution with one fewer profile groups; the smallest BIC value indicates the best-fitting model

BIC Bayesian information criteria, *LMR* Lo–Mendell–Rubin likelihood ratio test

activities. Perceived severity of negative impacts on their own property explained 32% of the unique variance in the regression, skills, time, biosecurity obligation, and general awareness of detrimental impacts each explained 1%.

A second stepwise regression was conducted to identify the COM-B factors that associated with group-level participation in invasive mammal control activities. Landholders were more likely to engage in such activities if: (1) they perceived the impacts of invasive mammals to be severe on their property, (2) their neighbors also participated in control activities, (3) they had the know-how to conduct a group control activity, (4) they valued recognition from others for being a good manager, and (5) they perceived the activity would improve their profit. Overall, the final model explained 12% of the variance in participation in group control activities. Perceived severity explained 6% of the unique variance in the regression, neighbor participation explained 2%, while know-how, good manager recognition, and profit improvement each explained 1%.

Segmentation of *Noncontrollers* Based on COM-B Variables

To develop the most effective policies and engagement strategies policy makers and engagement specialists need to know if all landholders who fail to participate in invasive mammal control are similar. Or whether there are multiple *Noncontroller* segments, each with a unique COM-B profile, which would imply that different strategies may be necessary to elicit increased participation within each audience segment. We conducted a second latent profile analysis of this *Noncontroller* subgroup ($n = 363$) using psychological variables associated with predicting participation in invasive mammal control activities to identify if any sub-groups existed. Six segments, based on these COM-B variables, were identified. The fit indices for the 2 through 7-profile solutions are shown in Table 5. A plot of the BIC values indicated that the curve of best-fit flattened

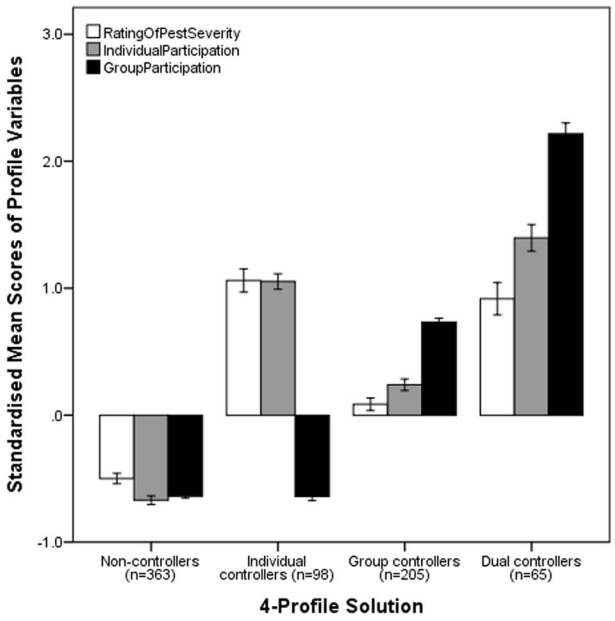

Fig. 2 Standardized means of the predictors for participation in invasive mammal management across four profiles. Error bars represent standard error (±1)

out between profiles 5 and 6. Although the 5-profile solution produced the highest entropy value (i.e., the highest classification certainty), we interpreted the 6-profile solution given that the LMR test indicated that this solution fit the data significantly better than the 5-profile solution.

The six *Noncontroller* segments are depicted in Fig. 3 and are described below:

- *Segment 1: Unaware, Unskilled and Unmotivated* ($n = 30$): These landholders were not aware of the general detrimental impacts of invasive mammals. They lacked the skills and opportunity to conduct the activities, perceived no positive benefits of control activities, did not have neighbors that participated in control, and were not sure of their biosecurity obligation to control these animals.
- *Segment 2: Aware but Unskilled and Doubtful* ($n = 5$): These landholders were aware of the general detrimental impacts of invasive mammals, although they did not perceive any severe impacts on their property. They lacked the capability (low know-how and skills) and opportunity (lack time and cost too great) to conduct the activities. They acknowledged the positive outcomes in sustainability that could be achieved from control activities, but were generally doubtful about the effectiveness and humaneness of control activities, and they did not see it as their responsibility (biosecurity obligation) to participate in control activities. On the other hand, they did have neighbors that participated in control and valued social recognition, two factors that

Table 3 Summary of demographic information for the four participation profiles

	Noncontrollers ($n = 363$)		*Individual Controllers* ($n = 98$)		*Group Controllers* ($n = 205$)		*Dual Controllers* ($n = 65$)		Group differences	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*F*	*r*
Age	59.5[a]	10.7	55.2[b]	12.4	55.5[b]	12.0	52.9[b]	11.7	10.41***	0.19
Property area (ha)	5273[a]	37,493	3739[a]	20,533	15,028[ab]	70,663	39,203[b]	253,324	3.08*	0.10
Years of residence	28.5	20.7	29.2	19.4	33.3	20.9	30.7	18.7	2.52	–
	%	Z_{Resid}	%	Z_{Resid}	%	Z_{Resid}	%	Z_{Resid}	χ^2 (df)	*r*
Gender:									2.90(3)	-
Female	32.0	0.8	34.7	1.0	26.3	−1.5	29.2	−0.2		
Male	68.0	−0.8	65.3	−1.0	73.7	1.5	70.8	0.2		
Enterprise type:									72.92(15)***	0.04
Mixed	32.0	−5.8	40.8	−0.4	55.1	4.3	64.6	3.8		
Cattle only	25.9	3.9	19.4	−0.2	14.1	−2.5	7.7	−2.6		
Sheep only	13.5	0.7	11.2	−0.4	12.7	0	9.2	−0.9		
Cropping only	10.2	−1.9	16.3	1.2	14.1	0.8	15.4	0.7		
Other	9.9	4.0	5.1	−0.5	2.4	−2.7	0	−2.2		
No enterprise	8.5	3.0	7.1	0.6	1.5	−3.2	3.1	−1.0		
Main income source:									44.22(3)***	0.24
Property	54.3	−5.8	61.2	−0.7	79.0	5.1	81.5	3.0		
Other	45.7	5.8	38.8	0.7	21.0	−5.1	18.5	−3.0		

Means with different subscripts (in rows) differ significantly at $p < 0.05$ Tukey HSD. r = Pearson's correlation coefficient; $r = 0.30$ indicates effect size is medium, $r = 0.10$ indicates effect size is small (Cohen 1988). Z_{Resid} = Adjusted standardized residual, where $Z_{Resid} > |2|$ is significant at $p < 0.05$

*$p < 0.05$, ***$p < 0.001$

Table 4 Summary of multiple regression analysis: COM-B factors predicting participation in individual and group invasive mammal control activities

Predictors	*R*	R^2	Adj. R^2	B	95% CI for B		*r*	sr^2
					LB	UB		
Individual control model	0.63*	0.40	0.40					
Severity rating				0.60	0.54	0.66	0.59	0.32
Have the skills				0.08	0.04	0.11	0.21	0.02
Have the time				0.07	0.04	0.11	0.13	0.01
Biosecurity obligation				0.05	0.01	0.08	0.10	0.01
Awareness of impacts				0.04	0.01	0.07	0.20	0.01
Group control model	0.35*	0.12	0.12					
Severity rating				0.25	0.18	0.32	0.25	0.06
Neighbors participate				0.08	0.04	0.12	0.17	0.02
Have the know-how				0.06	0.01	0.10	0.14	0.01
Seen as good manager				0.05	0.01	0.08	0.09	0.01
Improve profit				0.05	0.01	0.09	0.13	0.01

B unstandardized beta coefficients, *r* Pearson correlation coefficient, sr^2 squared semi-partial correlation (the proportion of unique variance in the DV explained by a predictor after controlling for the other predictors in the model)

*$p < 0.001$

Table 5 Model fit indices for 2 through 7 nonparticipation profile solutions

Profile solution	BIC	Entropy	LMR	*p*
2	14,119.13	0.91	328.69	0.000
3	14,066.76	0.79	133.27	0.540
4	14,029.25	0.83	118.60	0.595
5	13,913.58	0.89	173.44	0.079
6	13,962.49	0.90	33.20	0.016
7	14,018.74	0.90	23.48	0.524

Entropy indicates classification certainty; a significant LMR test indicates that a given profile solution fits the data significantly better than the solution with one fewer profile groups; the smallest BIC value indicates the best-fitting model

BIC Bayesian information criteria, *LMR* Lo-Mendell-Rubin likelihood ratio test

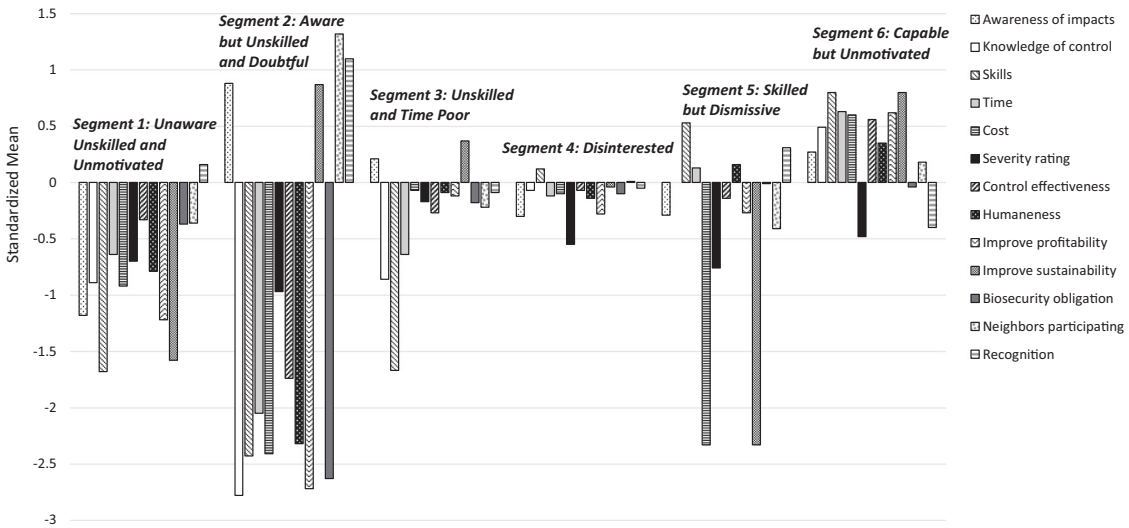

Fig. 3 Standardized means of the COM-B variables for *Noncontrollers* in invasive mammal management across six psychographic profiles

could be used to motivate them in the future. Note that this segment only contains a small number of landholders, so caution is advised when interpreting these results.

- *Segment 3: Unskilled and Time Poor* ($n = 62$): These landholders were only slightly aware of the general detrimental impacts of invasive mammals and the positive outcomes in sustainability that could be achieved from control activities, but predominantly did not have the knowledge, skill or time to participate in control activities.
- *Segment 4: Disinterested* ($n = 140$): These landholders were not acquainted with the general detrimental impacts of invasive mammals, did not perceive any severe impacts from invasive mammals on their property, and were relatively uncommitted in their views about control activities.
- *Segment 5: Skilled but Dismissive* ($n = 34$): These landholders had the capability to participate in control activities, but believed that these activities were too expensive and would not improve the sustainability of their property. They generally did not have neighbors that participated.
- *Segment 6: Capable but Unmotivated* ($n = 92$): These landholders were capable to participate in control activities, and had the opportunity to do so. They believed there were positive outcomes from the activities, but did not perceive any severe impacts from invasive mammals on their property, and were unsure about their biosecurity obligations.

Demographic information for each of the *Noncontroller* profile segments is presented in Table 6. Profile membership varied as a function of age, with landholders in the *Segment 2* (*Aware but Unskilled and Doubtful*) being older than the other profiles. Examination of the adjusted standardized residuals showed that *Segment 5* (*Skilled but Dismissive*) had significantly more males and fewer females than expected. *Segment 2* (*Aware but Unskilled and Doubtful*), *Segment 1* (*Unaware, Unskilled and*

Table 6 Summary of demographic information for the six *Noncontroller* profile segments

	Segment 1 ($n = 30$)		*Segment 2* ($n = 5$)		*Segment 3* ($n = 62$)		*Segment 4* ($n = 140$)		*Segment 5* ($n = 34$)		*Segment 6* ($n = 92$)		Segment differences	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*F*	*r*
Age	60.9^{b}	12.2	74.0^{a}	9.7	58.5^{b}	10.7	59.3^{b}	11.2	64.3^{b}	9.7	58.2^{b}	9.4	2.27*	0.03
Property area (ha)	411	833	202	55	908	1860	4294	26515	947	1844	13145	66491	1.21	–
Years of residence	24.8	18.0	35.0	15.4	25.1	18.5	28.7	21.4	35.3	23.7	29.3	20.7	1.35	–

	%	Z_{Resid}	%	Z_{Resid}	%	Z_{Resid}	%	Z_{Resid}	%	Z_{Resid}	%	Z_{Resid}	χ^2 (df)	*r*
Gender:													12.96(5)*	0.12
Female	43.3	1.5	60.0	1.5	40.3	1.6	30.7	−0.4	11.8	−2.7	30.4	−0.4		
Male	56.7	−1.5	40.0	−1.5	59.7	−1.6	69.1	0.4	88.2	2.7	69.6	0.4		
Enterprise type:													38.10(25)*	0.13
Mixed	20.0	−1.3	20.0	−0.7	21.0	−2.2	34.3	0.8	29.4	−0.3	41.3	2.2		
Cattle only	16.7	−1.4	40.0	1.7	27.4	0.4	28.6	0.9	29.4	0.5	21.7	−1.1		
Sheep only	6.7	−1.3	0.0	−0.4	14.5	0.1	12.9	−0.3	11.8	−0.3	17.4	1.3		
Cropping only	13.3	0.5	0.0	−0.3	12.9	0.7	10.7	0.3	17.6	1.5	4.3	−2.1		
Other	20.0	2.4	40.0	−0.3	12.9	1.2	5.7	−2.1	5.9	−0.8	10.9	0.4		
No income	23.3	2.8	0.0	−0.3	11.3	0.8	7.9	−0.4	5.9	−0.6	4.3	−1.7		
Main income source:													11.01(5)*	0.15
Property	33.3	−2.4	80.0	0.9	48.4	−0.8	52.9	−0.4	55.9	0.2	65.2	2.4		
Other	66.7	2.4	20.0	−0.9	51.6	0.8	47.1	0.4	44.1	−0.2	34.8	−2.4		

Means with different subscripts (in rows) differ significantly at $p < 0.05$ Tukey HSD. r = Pearson's correlation coefficient; $r = 0.30$ indicates effect size is medium, $r = 0.10$ indicates effect size is small (Cohen 1988). Z_{Resid} = Adjusted standardized residual, where $Z_{Resid} > |2|$ is significant at $p < 0.05$

*$p < 0.05$

Unmotivated) and *Segment 3* (*Unskilled and Time Poor*) all had slightly more females and fewer males than expected. *Segment 6* (*Capable but Unmotivated*) had more landholders who relied on their property as their main source of income, while *Segment 1* (*Unaware, Unskilled and Unmotivated*) had more landholders who relied on off-property sources of income. Profile membership also varied significantly across enterprise types with the adjusted standardized residuals revealing *Segment 1* (*Unaware, Unskilled, and Unmotivated*) had more other types and no enterprises than expected, *Segment 3* (*Unskilled and Time Poor*) had less mixed enterprises than expected, *Segment 4* (*Disinterested*) had less other types of enterprises than expected, and *Segment 6* (*Capable but Unmotivated*) had a higher number of mixed enterprises (sheep, cattle and/or cropping) and fewer cropping only enterprises.

Discussion

In this study, we aimed to better understand why landholders participate and fail to participate in activities to control invasive mammals on their properties. We surveyed a representative sample of Western Australian landholders, and found that over half had not implemented any control strategies for five widespread invasive species (i.e., wild dogs, foxes, feral cats, feral pigs, and rabbits) in the previous 12 months. We then assessed a broad range of capability, opportunity, and motivation (COM) factors to identify the strongest predictors of participation in invasive mammal control, and determine whether nonparticipators were best conceptualized as a single homogeneous group or as several distinct groups, with unique COM profiles, each requiring targeted engagement strategies that addressed their specific needs. Our main findings are summarized in the next sections, along with a discussion of practical implications and suggestions for future research.

What Predicts Participation in Individual and Group Activities to Control Invasive Mammals?

Participation individual control activities

Our analyses revealed that landholders engaged in more individual control activities if they perceived invasive mammals to be a serious problem, believed they had the skills and time to successfully conduct mammal control activities, and were aware of their biosecurity

responsibilities under state legislation. Landholders are unlikely to engage in invasive mammal control activities if they do not perceive a problem, are unaware of legal requirements, and lack self-efficacy to correctly implement control best practices.

Our findings reinforce that the importance of training workshops and learning communities to improve landholders' skills (e.g., Sewell et al. 2017). For landholders who identified time as an important limiting factor, the promotion and demonstration of time-saving practices and the long-term benefits of control activities may be a priority. An initial challenge for engagement specialists will be to capture these time-poor landholders' attention, using a range of communication channels and concise, attention grabbing messages (McKenzie-Mohr 2011; Hine et al. 2015). The use of demonstration sites to model best practices has also been shown to increase participation (Guerin and Guerin 1994; Fleming et al. 2006), as have memory prompts (e.g., fridge magnets, text messages, etc.) that remind landholder when to engage in control activities (McKenzie-Mohr 2011; Hine et al. 2015).

Our findings also highlight the importance of initiatives that educate landholder about their biosecurity responsibility to control invasive mammals. Under the *Biosecurity and Agriculture Management* Act 2007 individual landholders in Western Australia have an obligation to control declared invasive species present on their property (Part 2, Division 3, Section 30). Currently wild dogs, foxes, rabbits and feral pigs are among the declared species listed under this Act[2]. Although "duty to control" has long been a norm for traditional farming communities, the message seems to have diminished in recent times with the change in rural community composition (Klepeis et al. 2009). Engagement specialists should promote this pro-participation social norm within their community to increase the voluntary compliance to this legislative requirement. This could be done by empowering respected community messengers to employ social influence techniques from the behavioral sciences. This work suggests that messages combining descriptive norms (describing what most landholders do or what most landholders support) and injunctive norms (reflecting cultural or community standards about what actions are appropriate in a given situation) may be an effective strategy for eliciting behavior change for some individuals (Cialdini et al. 2006). Recent research by Kalnicky et al. (2019) has suggested that these normative approaches may be most effective for individuals who have only limited experience with control activities, but less effective for those who have previously participated and experienced disappointing outcomes.

[2] Feral cats are not yet listed in the Act. However the Western Australian Environmental Minister endorsed the National declaration of feral cats as pests in 2015, paving the way for this species to be listed in the near future

Participation in group control activities

As was the case with individual control, the strongest predictor of participation in coordinated group control activities was landholders' perceptions of the severity of invasive mammal incursions on their own properties. If landholders did not perceive their enterprise to be currently under threat, they were unlikely to act in either individual or group level control activities. It is unclear from our data whether these perceptions of "no immediate threat" were accurate or whether they reflect a perception-reality gap in which invasive mammals are present, but with landholders failing to recognize their current and/or potential future impacts.

It is worth noting that even if landholder perception of "no immediate threat" were accurate, it would still be beneficial for engagement specialists to educate landholders about the importance of both individual- and group-level preventive actions to protect individual properties, and the broader community, against future incursions (e.g., Niemiec et al. 2016). On the other hand, if landholder perceptions of immediate threat are not accurate (i.e., invasive mammals are present, but for some reason landholders are not aware of their presence or impacts, engagement strategies that narrow or eliminate the gap between reality and perception would be required. This could entail local demonstration projects that use camera or GPS technology to highlight invasive mammal movements (e.g., Mitchell et al. 2009), or predation impacts (e.g., Hernandez et al. 2018).

Beyond perceptions of immediate threat, we also identified four additional factors that predicted participation in coordinated group activities to control invasive mammals. First, landholders were more likely to participate in group activities if their neighbors also participated in such efforts. This, once again, highlights the potential power of social influence (Cialdini et al. 2006) in driving behavior. Landholders are more likely to engage in desirable behaviors, such as coordinated group control, if their peers are engaged in similar actions.

Second, landholders who valued being perceived, by their peers, as competent land managers were more likely to participate in group control activities. This suggests that a platform for the public recognition of individual participation might help sustain the interest in group activities and encourage future actions (McKenzie-Mohr 2011). Aside from acknowledging their achievements, engagement specialists might also reward the group as a whole for participation, or provide feedback on landholder's progress, and constructive advice for continuous improvement (Hine et al. 2018).

Third, we found that participation in group activities was predicted by landholders' confidence in their understanding of how to conduct group-led activities. This suggests that some landholders may avoid coordinated group-control initiatives if they are concerned about their competence to successfully complete such initiatives. This may be particularly relevant to newcomers in an area, or individuals living on lifestyle blocks who may have limited experience in pest management. Training materials need to be promoted across a broad range of communication networks to ensure that all landholders within a target area are aware of training and control activities. Activities just for newcomers or a particular segment may be beneficial to allow these people to feel comfortable and not judged (for example, an introductory shooting course for pest animal destruction and livestock euthanasia aimed at women on farms). Promotional materials should emphasize benefits to the whole community, and not focus solely on traditional message frames that emphasize economic loss or gains. Although such message frames may be effective for motivating landholders who rely on their properties for their primary source of income, they may be less effective for lifestylers who often have somewhat different values and priorities (Klepeis et al. 2009; Low Choy and Harding 2010).

Typology of Nonparticipators Based on Capability, Opportunity, and Motivation

We conducted an audience segmentation analysis to document and better understand the level of heterogeneity amongst landholders who did not participate in any individual or group invasive mammal control activities during the past 12 months. Our analysis revealed that "nonparticipators" did not constitute a single homogeneous group. Six segments were identified each characterized by a unique combination of capabilities, opportunities and motivations: (1) *Unaware, Unskilled and Unmotivated*, (2) *Aware but Unskilled and Doubtful*, (3) *Unskilled and Time Poor*, (4) *Disinterested*, (5) *Skilled but Dismissive*, and (6) *Capable but Unmotivated*. The identification of distinct segments of nonparticipators has important implications for engagement specialists. Given each segment had a unique COM profile, a more targeted engagement approach is required that takes each segment's unique needs into account.

An important initial goal for engaging those landholders in the *Skilled but Dismissive*, *Disinterested* and *Unaware, Unskilled and Unmotivated* segments would be to increase their awareness of the invasive mammal problems in their region. The challenge for engagement specialists will be to capture these audiences' attention, and provide information that is interesting and relevant, given that many of the individuals rely on off-property sources of income. The selection of the best persuasive communication techniques (such as message framing, emotional content, local messengers, narratives) and communication channels (such as social and printed media, local businesses, word-of-mouth, community events, road-side signs) to deliver, and reinforce their messages will be important (McKenzie-Mohr 2011; Michie et al. 2014; Hine et al. 2015); McLeod et al. 2017). For example, one possibility would be to identify a range of common social or leisure activity networks in which some of the nonmotivated landholders were engaged, such as sports, gardening clubs or even the local pub. Messages could be framed around the adverse impacts that invasive mammals have on these interests (Low Choy and Harding 2010), or alternatively motivated landholders or 'champions' could pass on relevant information through informal discussions with other members (e.g., Atherley 2006, Pint of Science 2019).

Members of those segments that were identified as not having the knowledge, skill or time to participate in control activities (e.g., *Unskilled and Time Poor*, *Aware but Unskilled and Doubtful*[3] and *Unaware, Unskilled and Unmotivated*) would benefit from basic education and training using actionable instructional information (i.e., information that explicitly directs the user about what to do next) (Halvorson and Rach 2012), to increase their understanding of control methods, enhance their skills, and boost their confidence and self-efficacy. The provision of specific support and/or technologies to target female interests might be beneficial (e.g., McGowan 2011). Those landholders in the *Aware but Unskilled and Doubtful* segment that were doubtful about the effectiveness and humaneness of certain control activities would require information about the full range of control options to take into account their preferences (e.g., Subroy et al. 2018). Given members in this segment also tended to be older than other groups, the provision of additional support and/or technologies to overcome physical limitations commonly associated with increasing age might also be beneficial.

Several motivational interventions that have been discussed in the previous section would be applicable across many of the nonparticipatory segments. Engagement strategies for the landholders in the *Capable but Unmotivated* and *Aware but Unskilled and Doubtful* segments could boost motivation by increasing awareness of the invasive mammal problems, and their legal obligations to manage such animals. Members of these segments often had neighbors who participated in control activities, therefore it would be beneficial to supplement general education efforts with social normative pressure by highlighting current

[3] As the segment *Aware but Unskilled and Doubtful* only contained a small number of individuals, generalizations of this group beyond this study should be done with caution.

efforts by neighbors and the broader community commitment to invasive mammal control. Landholders in *Aware but Unskilled and Doubtful* segment, along with landholders in the *Skilled but Dismissive* segment, valued social recognition, so an approach that formerly acknowledges participation and control-related achievements may be a useful motivation tool. In addition, landholders in the *Skilled but Dismissive* segment, who believed control activities were too expensive and would not achieve any positive gains for both profit and sustainability, may be further motivated by the provision of information on the benefits and cost-effectiveness of control options. Providing on-going monitoring and feedback about impacts of control work on incursions, and associated economic and ecological indicators can be an effective way to keep these landholders engaged.

Limitations and Future Research

This study employed a relatively large, representative sample of Western Australia landholders. However, generalizations beyond the sampling frame should be made with caution, in particular for the segments with only a small number of members. In addition, although we assessed wide range of behavioral predictors of landholder participation in invasive mammal control, the list was not comprehensive. Reviews of the social and health psychology literatures on behavior change (e.g., Darnton 2008; Michie et al. 2013) suggest other factors are important determinants of human behavior—such as values, habits, emotions—that were not directly addressed in our study. Practical limitations associated with the length of phone surveys prevented us from assessing a more comprehensive list of predictors.

The research described in this study represents a starting point for further work aimed at developing more effective invasive mammal management communication and behavior change interventions. Michie et al. (2011) COM-B model provided a practical, intuitive tool for engagement specialists to increase their understanding of behavior in context and design interventions that are most likely to be effective. However, it is important to acknowledge that behavior change is not a static process. For example, in the *Transtheoretical Model*, Prochaska et al. (1992) describe five distinct stages that individuals move through as they progress from unawareness for a need for change (*Precontemplation*) to growing awareness (*Contemplation*), deciding action is required (*Preparation*), adopting the new behavior (*Action*), then continuing to perform the behavior (*Maintenance*). Given that COM-B does not identify where individual landholders fall within the change process, future should investigate the feasibility of combining COM-B with the stages of change model to determine which specific drivers and barriers operate at each stage. This would help engagement specialists to design interventions that systematically guide landholders through the change process.

Also, it is important to acknowledge that applying COM-B is no "quick fix". Significant effort is required to organize and evaluate potential COM factors, and understand how these factors vary across context. An important next step is to develop and evaluate intervention strategies specifically designed to address the needs of each group. More specifically there is a need to improve our understanding of:

1. Relevant COM factors for different invasive mammal species and contexts
2. Which intervention tools are most effective for encouraging participation in invasive mammal control activities, and under what conditions.
3. The effectiveness of different delivery modes, in particular online vs face to face.

It is all too often the case that scientifically credible evidence about the effectiveness of a particular intervention is lacking. The effectiveness of behavior change interventions should be rigorously evaluated against program goals, using scientifically sound methods, such as treatment and control groups, random assignment and the use of appropriate statistical tests, to determine whether the intervention made a difference and worked as intended (Murnane and Willet 2010). Human behavior change is a complex process and the knowledge about what works in what contexts will be gained iteratively through a continuous loop of learning and improvement. This will only be achieved by researchers and engagement specialists sharing their knowledge and expertize.

Conclusion

Although it is widely recognized that invasive mammals pose a considerable threat to agriculture, biodiversity, and community health, many landholders (over 50% in our sample) fail to engage in recommended control activities. We identified how landholder engaged in individual and group activities, and the COM factors that strongly predicted this participation. Most importantly, we showed that those landholders who do not participate in control activities were not a single homogeneous group. Within our sample of Western Australian landholders we identified six segments, each characterized by a unique combination of capabilities, opportunities and motivations. Understanding these behavioral differences will allow engagement specialists to not only make strategic decisions regarding which audience segment to target, but also the means to design evidence-based engagement interventions.

Acknowledgements The authors acknowledge the funding support through the Royalties for Regions program and the Invasive Animals Cooperative Research Centre (IA CRC). We would like to thank the Western Australian Department of Primary Industries and Regional Development for their assistance throughout the project, and for supplying Fig. 1. We would also like to thank Myriad Research and Thinkfield for their assistance in the survey development and execution, all the landholders who took the time to be involved, and the two anonymous reviewers for their insightful comments on the first draft of this paper.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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 No HE16_107), 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.

Publisher's note: Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Appendix 1– Copy of Survey Questions

1. Is your property mainly used for *(read out)*

Cattle production	1	Mixed farming	5	Lifestyle	9
Dairy	2	Dryland cropping	6	Residential	10
Sheep production	3	Irrigated cropping	7	Other:	11
Other livestock:	4	Boutique enterprise:	8	Specify _____	
Specify _____		Specify _____			

2. Is your property your main source of income? Yes 1 No 2

3. How long have you lived on your property? _____ years

4. To what extent do you consider … *(from list below)* to be a problem on your property—on a scale of 1 to 5, where 5 = a very severe problem, 4 = severe problem, 3 = a moderate problem, 2 = minor problem, 1 = not a problem at all?

	Not a problem	Minor problem	Moderate problem	Severe problem	Very severe problem
a. Wild dogs	1	2	3	4	5
b. Foxes	1	2	3	4	5
c. Feral cats	1	2	3	4	5
d. Feral pigs	1	2	3	4	5
e. Rabbits	1	2	3	4	5

5. In the past how often have you conducted individual activities to manage … *(from list below)* on your property—on a scale of 1 to 5, where 5 = very often, 4 = often, 3 = sometimes, 2 = rarely, 1 = never?

	Never	Rarely	Sometimes	Often	Very often
a. Wild dogs	1	2	3	4	5
b. Foxes	1	2	3	4	5
c. Feral cats	1	2	3	4	5
d. Feral pigs	1	2	3	4	5
e. Rabbits	1	2	3	4	5

6. In the past how often have you participated in organized group activities with neighbors and other community members to manage … *(from list below)*

	Never	Rarely	Sometimes	Often	Very often
a. Wild dogs	1	2	3	4	5
b. Foxes	1	2	3	4	5
c. Feral cats	1	2	3	4	5
d. Feral pigs	1	2	3	4	5
e. Rabbits	1	2	3	4	5

7. People give many reasons why they do or don't conduct pest animal management activities. I am going to read out a list of these reasons. Please tell me to what extent to you agree or disagree with each statement—on a scale of 1 to 5, where 5 = strongly agree and 1 = strongly disagree.

	Disagree			*Agree*		
a. I do not know the best methods to control	1	2	3	4	5	NA

Table (continued)

	Disagree			*Agree*		
pest animals on my property						
b. I do not have the skill to carry out pest animal management activities correctly	1	2	3	4	5	NA
c. I do not have the time to carry out pest animal management activities when they are required	1	2	3	4	5	NA
d. It is too expensive to conduct pest animal management activities	1	2	3	4	5	NA
f. Most of my neighbors do not control pest animals on their properties	1	2	3	4	5	NA
g. In my community, landholders are expected to control pest animals on their properties	1	2	3	4	5	NA
h. Managing pest animals will not improve the profitability of my enterprise	1	2	3	4	5	NA
i. Managing pest animals will not improve the long-term sustainability of my property	1	2	3	4	5	NA
j. I do not think that the impacts of animals labeled as pests are as bad as they are made out to be	1	2	3	4	5	NA
k. I believe pest animal control methods are inhumane	1	2	3	4	5	NA
l. I seem to be wasting my time as the pest animals always come back	1	2	3	4	5	NA
m. Controlling pests and caring for my land are inseparable	1	2	3	4	5	NA
n. I control pest animals for the recognition I get for being a good land manager	1	2	3	4	5	NA

And just to finish off.

8. Can I just check your age range – are you	18–29	1		50–59	4	
		30–39	2		60–69	5
		40–49	3		70+	6
					declined	*7*
9. Gender (record automatically)		Male 1		Female 2		

References

Atherley KM (2006) Sport, localism and social capital in rural Western Australia. Geogr Res 44:348–360. https://doi.org/10.1111/j.1745-5871.2006.00406.x

Australian Bureau of Statistics (2016) Census of population and housing basic community profiles, Cat. no. 2001.0. https://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/509?opendocument. Accessed April 30 April 2019

Ballard G (ed.) (2006) Social drivers of the invasive animal control. In: Proceedings of the Invasive Animal CRC Workshop, Adelaide. Invasive Animal Cooperative Research Centre, Canberra, 26th–27th July 2006

Braysher M (2017) Managing Australia's pest animals. A guide to strategic planning and effective management. CSIRO Publishing, Canberra

Buckley R, Sander N, Ollenburg C, Warnken J (2006) Green change: inland amenity migration in Australia. In: Moss LAG (ed) The amenity migrants: seeking and sustaining mountains and their cultures. CABI Publishing, Cambridge, p 278–298

Byerly H, Balmford A, Ferraro PJ, Wagner CH, Palchak E, Polasky S et al. (2018) Nudging pro-environmental behavior: evidence and opportunities. Front Ecol Environ 16:159–168. https://doi.org/10.1002/fee.1777

Cialdini RB, Demaine LJ, Sagarin BJ, Barrett DW, Rhoads K, Winter PL (2006) Managing social norms for persuasive impact. Soc Influence 1:3–15. https://doi.org/10.1080/15534510500181459

Cohen J (1988) Statistical power analysis for the behavioral sciences. L. Erlbaum Associates, Hillsdale, N.J.

Coleman MJ, Sindel BM, Stayner RA (2017) Effectiveness of best practice management guides for improving invasive species management: a review. Rangeland J 39:39–48. https://doi.org/10.1071/RJ16087

Damasio, AR (1994) Descartes' error: Emotion, reason, and the human brain. Putnam Publishing, New York, US

Darnton A (2008) GSR behaviour change knowledge review. Practical guide: an overview of behaviour change models and their uses. Government Social Research Unit, HM Treasury, London

Emtage N, Herbohn J (2012) Assessing rural landholders diversity in the Wet Tropics region of Queensland, Australia in relation to natural resource management programs: a market segmentation approach. Agric Syst 110:107–118. https://doi.org/10.1016/j.agsy.2012.03.013

Emtage N, Herbohn J, Harrison S (2007) Landholder profiling and typologies for natural resource–management policy and program support: potential and constraints. Environ Manag 40:481–492. https://doi.org/10.1007/s00267-005-0359-z

Fleming PJS, Allen LR, Lapidge SJ, Robley A, Saunders GR, Thomson PC (2006) A strategic approach to mitigating the impacts of wild canids: proposed activities of the Invasive Animals Cooperative Research Centre. Aust J Exp Agric 46:753–762

Ford-Thompson AES, Snell C, Saunders G, White PCL (2012) Stakeholder participation in management of invasive vertebrates. Conserv Biol 26:345–356. https://doi.org/10.1111/j.1523-1739.2011.01819.x

Gardner GT, Stern PC (2002) Environmental problems and human behavior, 2nd edn. Pearson Custom Publishing, Boston

Guerin LJ, Guerin TF (1994) Constraints to the adoption of innovations in agricultural research and environmental management: a review. Aust J Exp Agr 34:549–571

Halvorson K, Rach M (2012) Content strategy for the web, 2nd edn. New Riders, Berkley, CA

Hernandez SM, Loyd KAT, Newton AN, Carswell BL, Abernathy KJ (2018) The use of point-of-view cameras (Kittycams) to quantify predation by colony cats (*Felis catus*) on wildlife. Wildlife Res 45:357–365. https://doi.org/10.1071/WR17155

Hine DW, McLeod LJ, Driver AB (2018) Designing behaviour change interventions for invasive animal control: a practical guide. Invasive Animal Cooperative Research Centre, Canberra

Hine DW, Phillips WJ, Driver AB, Morrison M (2017) Audience segmentation and climate change communication. Oxford handbook of climate change communication. Oxford University Press, Oxford, UK

Hine DW, Please P, McLeod L, Driver A (2015) Behaviourally effective communications for invasive animals management: a practical guide. Invasive Animal Cooperative Research Centre, Canberra

Hine DW, Sharp T, Driver AB (2019) Using audience segmentation and targeted social marketing to improve landholder management of invasive animals. In: Martin P, Alter T, Hine D & Howard T (eds), People managing pests: modern theories and practices for effective community-based control of invasive species. CSIRO Publishing, Canberra

Howard TM, Thompson LJ, Frumento P, Alter T (2018) Wild dog management in Australia: an interactional approach to case studies of community-led action. Hum Dim Wildlife 23:242–256. https://doi.org/10.1080/10871209.2017.1414337

IBM (2017) IBM SPSS statistics for windows version 25. IBM Corp, Armonk, NY

Ison R, Russell D (2000) Agricultural extension and rural development. Breaking out of traditions. Cambridge University Press, UK

Kahneman D (2013) Thinking, fast and slow. Farrar, Straus and Giroux, New York, NY

Kalnicky EA, Brunson MW, Beard KH (2019) Predictors of participation in invasive species cpontrol activities depend on prior experience with the species. Environ Manag 63:60–68. https://doi.org/10.1007/s00267-018-1126-2

Klepeis P, Gill N, Chisholm L (2009) Emerging amenity landscapes: invasive weeds and land subdivision in rural Australia. Land Use Policy 26:380–392. https://doi.org/10.1016/j.landusepol.2008.04.006

Lo Y, Mendell NR, Rubin DB (2001) Testing the number of components in a normal mixture. Biometrika 88:767–778

Low Choy D, Harding J (2010) UMCCC Peri-urban Weed Management Study. Exploring agents of change to peri-urban weed management. Land & Water Australia, Canberra

McGowan C (2011) Women in agriculture. In: Pannell D, Vanclay F (eds) Changing land management: adoption of new practices by rural landholders. CSIRO Publishing, Collingwood, Vic, p 141–152

McKenzie-Mohr D (2011) Fostering sustainable behaviour: An introduction to community-based social marketing, 3rd edn. New Society Publishers, BC, Canada

McLeod LJ, Driver AB, Bengsen AJ, Hine DW (2017) Refining online communication strategies for domestic cat management. Anthrozoos 30:635–649. https://doi.org/10.1080/08927936.2017.1370237

McLeod LJ, Hine DW, Please P (2019) Using human behaviour change strategy to improve the management of invasive species. In: Martin P, Alter D, Hine D & Howard T (eds), People managing pests: modern theories and practices for effective community-based control of invasive species. CSIRO Publishing, Canberra

McLeod LJ, Hine DW, Please P, Driver AB (2015) Applying behavioral theories to invasive animal management: towards an integrated framework. J Environ Manag 161:63–71. https://doi.org/10.1016/j.jenvman.2015.06.048

McLeod R (2016) Cost of pest animals in NSW and Australia, 2013–14. Report prepared for the NSW Natural Resources Commission, eSYS Development Pty Ltd.

Michie S, Atkins L, West R (2014) The behaviour change wheel. A guide to designing interventions. Silverback Publishing, UK

Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W et al. (2013) The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. Ann Behav Med 46:81–95. https://doi.org/10.1007/s12160-013-9486-6

Michie S, van Stralen MM, West R (2011) The behaviour change wheel: a new method for characterising and designing behaviour change interventions. Implement Sci 6:1–11. https://doi.org/10.1186/1748-5908-6-42

Miller KK (2009) Human dimension of wildlife population management in Australasia – history, approaches and directions. Wildlife Res 36:48–56. https://doi.org/10.1071/WR08006

Mitchell J, Dorney W, Mayer R, McIlroy J (2009) Migration of feral pigs (*Sus scrofa*) in rainforests of north Queensland: fact or fiction? Wildlife Res 36:110–116. https://doi.org/10.1071/WR06066

Morrison M, Durante J, Greig J, Ward J, Oczkowski E (2012) Segmenting landholders for improving the targeting of natural resource management expenditures. J Environ Plan Man 55:17–37. https://doi.org/10.1080/09640568.2011.575630

Murnane RJ, Willet JB (2010) Methods matter: improving causal inference in educational and social science research. Oxford University Press, New York, NY

Muthén LK, Muthén BO (2014) MPlus 7.0. Muthén & Muthén, Los Angeles, CA

Niemiec RM, Ardoin NM, Wharton CB, Asner GP (2016) Motivating residents to combat invasive species on private lands: social norms and community reciprocity. Ecol Soc 21:30–40. https://doi.org/10.5751/ES-08362-210230

Outwater M (2011) Telephone surveys. In: Lavrakas PJ (ed) Encyclopedia of survey research methodsSage Publications, Thousand Oaks, pp 885–886

Pint of Science (2019) Out of the lab and into the local. https://pintofscience.com.au/ Accessed 30 April 2019

Prochaska JO, DiClemente CC, Norcross JC (1992) In search of how people change. Applications to addictive behavior. Am Psychol 47:1102–1114. https://doi.org/10.1037/0003-066X.47.9.1102

Ramaswamy V, Desarbo WS, Reistein DJ, Robinson WT (1993) An empirical pooling approach for estimating marketing mix elasticities with PIMS data. Market Sci 12:103–124

Salmon O, Brunson M, Kuhns M (2006) Benefit-based audience segmentation: a tool for identifying nonindustrial private forest (NIPF) owner education needs. J For 104:419–425. https://doi.org/10.1093/jof/104.8.419

Schultz PW (2014) Strategies for promoting proenvironmental behavior. lots of tools but few instructions. Eur Psychol 19:107–117. https://doi.org/10.1027/1016-9040/a000163

Schwartz G (1978) Estimating the dimension of a model. Ann Stat 6:461–464

Sewell AM, Hartnett MK, Gray DI, Blair HT, Kemp PD, Kenyon PR et al. (2017) Using educational theory and research to refine agricultural extension: affordances and barriers for farmers' learning and practice change. J Agr Educ Ext 23:313–333. https://doi.org/10.1080/1389224x.2017.1314861

Southwell D, Boero V, Mewett O, McCowen S, Hennecke B (2013) Understanding the drivers and barriers to participation in wild canid management in Australia: implications for the adoption of a new toxin, para-aminopropiophenone. Int J Pest Manag 59:35–46. https://doi.org/10.1080/09670874.2012.744493

Subroy V, Rogers AA, Kragt ME (2018) To bait or not to bait: a discrete choice experiment on public preferences for native wildlife and conservation management in Western Australia. Ecol Econ 147:114–122. https://doi.org/10.1016/j.ecolecon.2017.12.031