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Research article

What drives private landowner decisions? Exploring non-native grass management in the eastern Great Plains

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ABSTRACT

Non-native grasses used as forage for domestic livestock can negatively impact ecosystem services provided by grasslands. In the U.S., most grazed grasslands are privately owned so the introduction and reduction of non-native grasses are both driven by landowner behavior. Yet, the social factors that shape non-native grass management are rarely explored. To address this knowledge gap, we evaluated how decisions to reduce these grasses through practices such as herbicide application, prescribed fire, and physical removal are influenced by attitudes, norms, and perceived ability. We administered a mixed mode (mailback and online) survey in 2017 to landowners in the eastern Great Plains of the U.S., in a region where cattle production remains the predominant land-use. Using structural equation modeling with parceling, we tested hypotheses related to management decisions derived from a model integrating two theories – the Theory of Planned Behavior and the Norm Activation Model. In this analysis, we identified perceived ability (i.e., access to time, skills, or other necessary resources) as a barrier to adoption for landowners who were already willing to manage non-native grasses. Positive attitudes toward management and increased social norm pressures were both associated with increased sentiments of moral responsibility to reduce non-native grasses. These personal norms, together with attitudes, positively influenced willingness to control non-native grasses. Further, we observed that social norms related to expectations of neighbors had more influence on personal norms than the social norms from natural resource agencies. The power of norms to explain individual management decisions suggests that landowners could be engaged in landscape-scale initiatives by leveraging moral responsibility and influential social groups.

1. Introduction

Approximately 30% of land in the United States is dedicated to grazing livestock, and 63% of grazed grasslands are in private ownerships (Bigelow and Borchers, 2017). These private grazing lands, in comparison to more intensive agricultural uses, have great potential to support livelihoods, biodiversity, and soil and water conservation (Maczko et al., 2011). However, ecosystem services provided by grasslands are threatened by extensive modifications that have transformed historic rangelands to pastures dominated by non-native forage grasses (Briske, 2017; Godfree et al., 2017). In the tallgrass prairie ecoregion, this transformation has led to extensive displacement of native assemblages (DiTomaso, 2000). These ecological problems have led to efforts to reduce the prevalence of non-native grasses and re-establish native plants through herbicide application, grazing manipulations, physical removal, or prescribed fire (Madison et al., 2001). Because landowner decisions to implement management practices are a dominant force shaping ecosystem services in grasslands, exploring the social factors that influence decisions to reduce non-native grasses is critical to conservation of these threatened ecosystems.

Although evidence for threats to ecosystem services has been accumulating, non-native grasses have served valuable agronomic functions throughout the U.S. Great Plains for over a century. After being introduced to provide forage resilient to heavy grazing (Kennedy, 1900; Phillips and Coleman, 1995), non-native grasses have also been used to revegetate agricultural land to create wildlife habitat and prevent

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erosion (Ewel and Putz, 2004; Schlaepfer et al., 2011). However, traits that make these grasses valuable–such as high stress tolerance–are the same traits that have led to some species aggressively spreading into new areas (Stotz et al., 2019). Such grasses are often considered invasive, out-competing native plants and reducing habitat quality for birds, mammals, insects, and other taxa (Marshall et al., 2012; Barnes et al., 2013; Schirmel et al., 2016). In addition to harming biodiversity, non-native grasses can negatively impact other ecosystem services, for example by reducing rates of nutrient cycling and carbon sequestration (Christian and Wilson, 1999) and decreasing forage quality (Terry and Tilley, 1964; Maresh Nelson et al., 2019). Notwithstanding negative consequences, cattle producers and other landowners still heavily rely upon non-native grasses, and for this reason some researchers consider them permanent fixtures in the landscape (e.g., Barnes et al., 2013; Kitchen, 2014).

Decisions to implement practices that reduce the dominance of non-native grasses are context-dependent and involve weighing complex social and ecological factors (Kettenring and Adams, 2011; Skurski et al., 2013). For instance, some non-native plants have unknown, neutral, or even positive social or ecological impacts Davis et al. (2011); Nelson et al. (2017); Shackleton et al. (2019a). But if a non-native plant has been deemed agronomically or ecologically harmful by land management agencies, management guidelines often suggest reducing its prevalence and restoring native plants (Godfree et al., 2017). In many cases, complete eradication is not achievable or even desirable depending on the views and values of the people managing a particular landscape (Epanchin-Niell et al., 2010; Grice et al., 2012). Landowners may be concerned about the time or effort involved in control measures or the non-target impacts of control methods like herbicide or prescribed fire on wildlife habitat or pasture productivity (Freemark and Boutin, 1995; Harr et al., 2014). Perhaps due to the tradeoffs involved, coordinated efforts to manage non-native plants have mostly taken place on public land in the western U.S. (Epanchin-Niell et al., 2010; Midwest Invasive Plant Network, 2011). By comparison, coordinating management of non-native plants in the eastern Great Plains is considered more difficult because public lands are less common, resulting in responsibilities and practices diffused across many autonomously-managed properties (Klepeis et al., 2009; Epanchin-Niell and Wilen, 2015).

Although private landowners play an essential role as stewards of grassland quality at broad scales (Miller et al., 2012), there are few non-native plant management programs aimed at private land, and we know little about the social drivers of control practices (Johnson et al., 2011; Marshall et al., 2011). It is thus unsurprising that less than 5% of the invasive species literature falls within social science disciplines (Vaz et al., 2017). In particular, there is little research on social factors likely to impact decisions of individual landowners regarding invasive plants, and even less attention has been spent on non-native grasses, despite their near ubiquitous range and large ecological impact (Toledo et al., 2014). Further, the emphasis has tended toward economic factors (Marshall et al., 2011), despite growing evidence that human behavior is strongly influenced by a variety of internal and external factors in addition to economic constraints (van Riper et al., 2017). For example, both an individual's ability to adopt control practices given access to equipment required for management *and* their attitudes toward that management can influence behavior (García-Llorente et al., 2008; Prinbeck et al., 2011; Shackleton et al., 2019b). Understanding how internal and external drivers together influence management can inform more effective cooperation between managers, researchers, and landowners working to reduce the prevalence of non-native plant species (Bremner and Park, 2007; Sharp et al., 2011; Estévez et al., 2015).

In this study, we examine the underlying attitudes, norms, and abilities that influence landowner willingness to control and limit the spread of non-native grasses. We evaluate these internal and external variables in an eastern Great Plains context. To this end, we merged two complementary frameworks –The Theory of Planned Behavior (Ajzen, 1991) and the Norm Activation Model (Schwartz, 1977) – to evaluate how *attitudes* and *personal norms* (i.e., internal variables), and *perceived ability* and *social norms* (i.e., external factors) influence landowner *willingness*, and how these relationships, in turn, influence implementation of non-native plant management (i.e., *reported behavior*). Given the urgent need to understand behavior and perceptions tied to biological invasions (Shackleton et al., 2019c), this research is aimed at advancing knowledge of behavioral drivers that can be used to facilitate more effective control of problematic non-native grasses on private lands.

1.1. Theoretical frameworks

Non-native species management can be understood through the lenses of utilitarian decision-making that draws on cost-benefit analyses (Venkatachalam, 2008) or moral decision-making related to internal processes (Schwartz, 1977). As a complement to previous research in these areas, there is support for exploring how perceptions of internal and external factors impact rural landowner behavior (Edwards-Jones, 2006; Reimer et al., 2014). One framework that can be used to examine both internal and external factors influence management is the Theory of Planned Behavior (TPB; Fig. 1A; Ajzen, 1991). Previous research has drawn on the TPB to provide empirical insight on a wide variety of behaviors, including choices to take public transportation (Bamberg et al., 2003), selection of hotel accommodations (Han et al., 2010), and improvements in grassland quality (Borges et al., 2014).

In the case of non-native grass management, we define *reported behavior* as the frequency with which landowners report using practices that reduce non-native grasses on their properties. In grasslands, such practices can include herbicide application, prescribed fire, grazing manipulations, and/or physical removal via disking (Madison et al., 2001). An individual's determination to implement a given practice is referred to as *intention* in most studies guided by the TPB. Yet, recent TPB studies have also conceptualized this construct using survey items that include language related to *willingness* ('I am willing to manage non-native grasses'; López-Mosquera et al., 2014; von Lindern and Mosler, 2014; compared to 'I intend to manage non-native grasses'). Although these constructs are closely related (Ajzen and Fishbein, 2005), there is empirical evidence that differences exist. In particular, *willingness* may capture a landowner's initial openness to undertaking non-native grass management because *willingness* involves less consideration of risk or effort versus *intention* (Gibbons et al., 2000). Risk is highly relevant to practices like herbicide or prescribed fire which are sometimes thought to endanger environmental or human health (Morton et al., 2010; Coon et al., 2018).

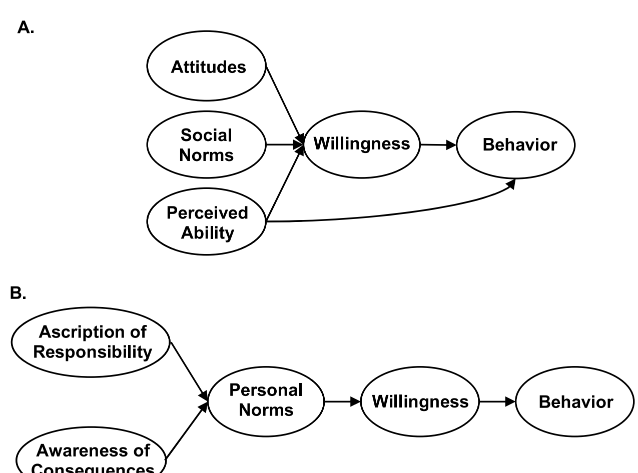

Fig. 1. Ajzen's Theory of Planned Behavior (A) and the Schwartz's Norm Activation Model (B). Note that 'willingness' is also often depicted as 'intention'.

According to the TPB, an individual's determination to undertake a particular behavior is influenced by factors related to effort, self-efficacy, and controllability that are captured by *perceived ability* (*perceived behavioral control in TPB parlance;* Ajzen, 1991). The relationships among *perceived ability*, *intention/willingness*, and *behavior* have not been explored in the context of non-native grass management, but in general, access to resources and relevant knowledge influences adoption of conservation practices (Prinbeck et al., 2011; Baumgart-Getz et al., 2012; Niemiec et al., 2016).

In addition to *perceived ability,* an individual's *intention* is also predicted by *attitudes* and *social norms.* We define *attitudes* as respondents' positive or negative evaluations of non-native grass management, following recommendations to define behavior-specific *attitudes* based on study context (Harland et al., 1999; Ajzen and Fishbein, 2005). *Attitudes* toward invasive species can influence decisions to prevent range expansions using behaviors such as rinsing off boats after leaving invaded areas or physically removing the invasive species (Bremner and Park, 2007; Prinbeck et al., 2011; Kemp et al., 2017; Kalnicky et al., 2019), and positive *attitudes* consistently increase farmer adoption of conservation practices (Prokopy et al., 2019). However, in the context of rural land management, the influence of *attitudes* on adoption of conservation practices is often measured inconsistently (Baumgart-Getz et al., 2012), and there is little information available on how *attitudes* influence decisions to manage non-native grasses.

In the TPB, decisions are also influenced by *subjective norms*, defined as perceived expectations of people significant to the individual (Ajzen, 1991). *Subjective norms* are a type of *social norm* (Cialdini et al., 1990; Nolan, 2017). One way that *social norms* can motivate behavior is through observation of these significant people. In our case, an individual might be motivated to manage non-native grasses after observing their neighbors doing the same. This social pressure can also originate from perceived opinions held by people. For example, an individual might be more likely to adopt non-native grass management if they believe agencies or other landowners support these efforts. Various conceptions of *social norms* have been found to influence landowners' behaviors through social networks, but *social norms* are generally missing from the literature on adoption of conservation practices (Prokopy et al., 2019).

A framework complementary to the TPB also used to explain environmental behavior is Schwartz (1977) Norm Activation Model (NAM; Fig. 1B). In contrast to the TPB, the NAM includes *personal norms*, or moral self-expectations (Harland et al., 1999). When *personal norms* are activated, a person is more likely to be aware of the consequences of their actions and feel responsible for them (De Groot and Steg, 2009). Such feelings of morality are influenced by *social norms*, in that an individual first draws on their perception of external social expectations, which then influences their personal moral views (Schwartz, 1977; Bamberg et al., 2007; Wall et al., 2007). A meta-analysis by Klöckner (2013) found strong empirical support for *personal norms* predicting *behavior* through *intention*, and that *personal norms* were in turn predicted by *social norms*. These relationships are supported by two recent studies that found *social norms* predicted *personal norms* related to environmentally conscious consumer choices (Hynes and Wilson, 2016) and decisions to drive less (Olsson et al., 2018). However, there is uncertainty around relationship between *personal norms* and *attitudes* (Klöckner, 2013, but see Harland et al., 1999). Some studies have argued *attitudes* are influenced by *personal norms* (Mastrangelo et al., 2014), whereas others have posited opposing relationships (Klöckner, 2013; López-Mosquera et al., 2014). In the current study, we test whether *attitudes* influence the development of moral obligation to perform a behavior, following Stern et al. (1999) who theorize that *personal norms* can be activated when an individual belives they can solve a problem.

Personal norms are particularly relevant to non-native grass management, where moral considerations include those related to 'alienness' and human responsibility. If an individual views non-native species as 'less natural' and believes that introductions have 'degraded' the environment, that individual may be more likely to engage in control efforts due to moral obligation (Selge et al., 2011). These conceptions of 'alienness' and obligations to eradicate non-native species are a prominent part of philosophical conversations in the invasion biology literature (Larson, 2007; Warren, 2007; Davis et al., 2011) and in public discourse on the topic (Selge et al., 2011). Given the likely role that moral concerns play in decisions surrounding non-native species, there is a clear need to address how *personal norms* influence decisions to manage non-native grasses.

1.2. Hypotheses

Hypotheses were derived from combining the TPB and NAM by including *personal norms* alongside the usual TPB constructs (Fig. 2). Drawing on these two frameworks, we examined how internal (i.e., *attitudes, personal norms*) and external (i.e., *perceived ability, social norms*) factors influence non-native grass management in the eastern Great Plains. In this model, we examined how these factors influenced *willingness* to manage non-native grasses, and how *willingness* impacted *reported behavior*. We examined *willingness* rather than *intention* because willingness was better suited to assess openness to management, particularly given that management practices were considered risky.

Hypothesis 1. Greater willingness to manage non-native grasses increases reported behavior.

Hypothesis 2. Greater perceived ability to manage non-native grasses increases reported behavior.

Hypothesis 3. Positive attitudes toward non-native grass management increase an individual's willingness to implement control practices on their land.

Hypothesis 4. Greater personal norms correspond to an individual's increased willingness to implement control practices on their land.

Hypothesis 5. Greater perceived ability to manage non-native grasses increases an individual's willingness to implement control practices on their land.

Hypothesis 6. Positive attitudes toward management increase an individual's personal norms related to non-native grass control.

Hypothesis 7. Stronger social norms to manage non-native grasses increase an individual's personal norms related to non-native grass control.

Hypothesis 8. (indirect): Positive attitudes toward management increase an individual's willingness to control non-native grasses by activating personal norms.

Hypothesis 9. (indirect): Increased *perceived ability* to manage increase *reported behavior* by increasing *willingness.*

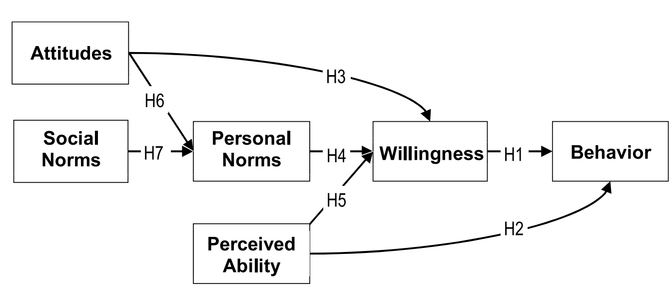

Fig. 2. Hypothesized model that merges the Theory of Planned Behavior and Norm Activation Model. 'H1' corresponds to Hypothesis 1. Indirect effects are not depicted in this figure.

2. Methods

2.1. Study area

This study was conducted in the Grand River Grasslands (Fig. 3), a 62,000-ha conservation priority area on the Iowa-Missouri border (Miller et al., 2012). Although nearly 15% of the region is composed of protected areas, most land is in private ownership used for cattle production (Coon et al., 2018). Because of the relatively large remaining grassland area in the region compared to the rest of the eastern Great Plains, in 2008 the Nature Conservancy identified the Grand River Grasslands as the best-known opportunity to restore a working tallgrass prairie (The Nature Conservancy, 2008). Private grasslands here are dominated by non-native forage grasses (Raynor et al., 2019), including tall fescue (*Schedonorus arundinaceus*), brome (*Bromus* spp.), orchard grass (*Dactylis glomerata*), and Kentucky bluegrass (*Poa pratensis*).

2.2. Sampling design

To explore the internal and external drivers of non-native plant management, we mailed a survey to all landowners owning >8 ha in the six townships within and overlapping the boundaries of the Grand River Grasslands (Fig. 3). This 8-ha ownership size follows past work in the study region (e.g., Morton et al., 2010) and was chosen in collaboration with local land managers to engage individuals living outside small towns. Landowners meeting these criteria (n = 514) were identified using county plat maps purchased from Farm and Home Publishers (Belmond, IA). The questionnaire included sections on landowner demographics, land management, ownership history, and non-native grasses. Prior to survey administration, we discussed the project with natural resource agency personnel working in the region to ensure our approach and survey items were tailored to the study context. To pilot test the instrument, we sent the questionnaire to 15 cattle producers in Nebraska, 8 of whom responded. We adjusted content and formatting based on all comments received.

We administered a mixed mode survey via a modified Dillman approach with multiple reminders for non-respondents to obtain the highest response rate possible (Dillman et al., 2014), with mailings occurring at two-week intervals beginning in February 2017. We chose this time frame to avoid corn and soy planting season and the peak of calving season. After an introductory postcard was sent to potential respondents, the survey was featured in two local newspapers. The second and fourth wave included the survey and a cover letter introducing the project and its relevance to landowners, with Iowa State University and University of Illinois at Urbana-Champaign named as sponsors. At every stage, we offered an online survey as an alternative mode (Qualtrics; Provo, UT). After the final reminder postcard, we called landowners with available phone numbers (n = 150) to remind them to turn in the questionnaire and to assess non-response bias.

2.3. Survey measures

We measured six constructs using multi-item scales that were drawn from previous literature (Harland et al., 1999; Prinbeck et al., 2011).

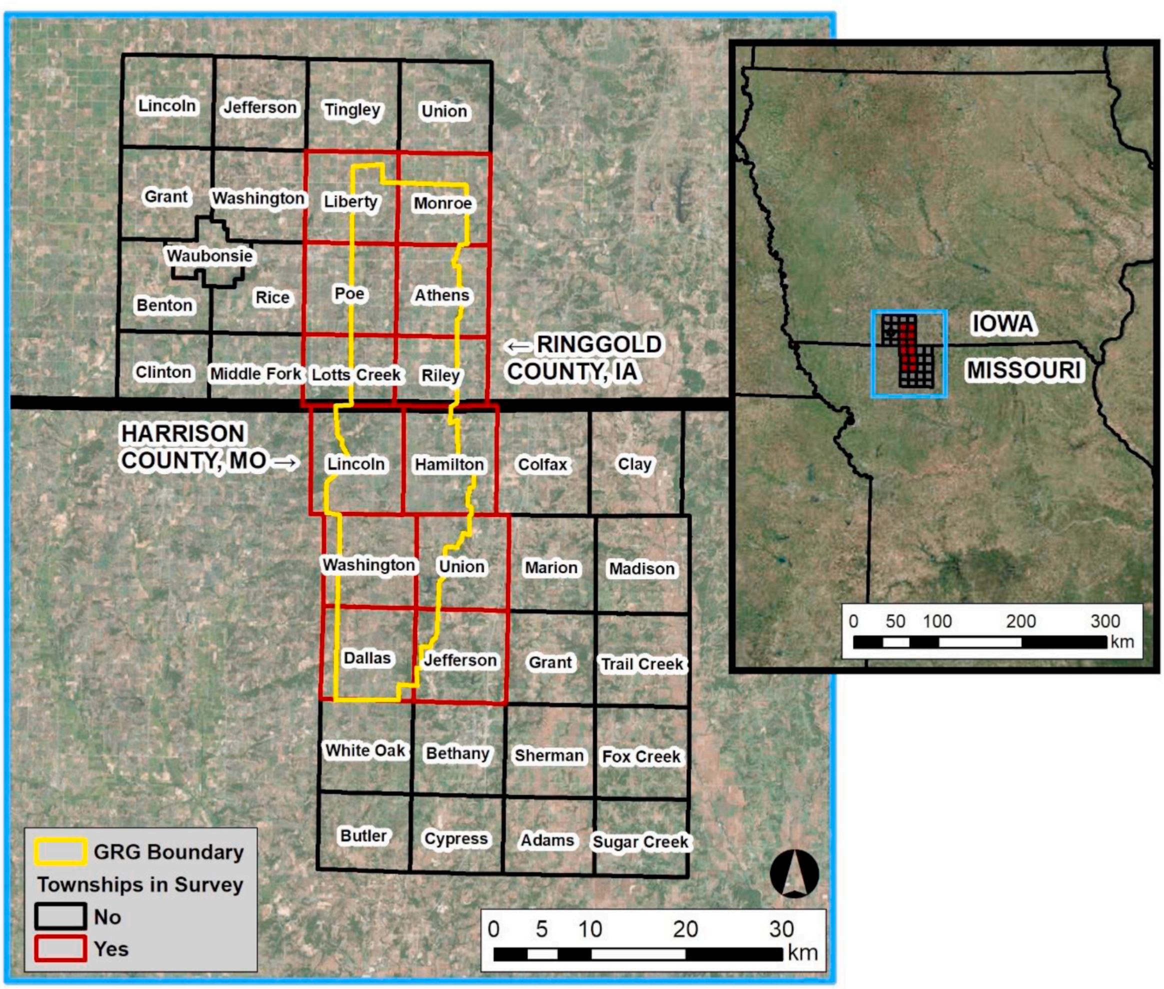

Fig. 3. The townships surveyed in the Grand River Grasslands conservation priority area in southern Iowa and northern Missouri.

The questionnaire is available online through Coon et al. (2018) and Supplementary Materials (Table A1). We measured *behavior* by asking how often five land management practices including herbicide, altered grazing regimes, prescribed fire, seeding native plants, and physical removal were employed previously, and *willingness* by asking how open respondents would be to use these practices in the future. Our indicators of *behavior* were formed in response to previous studies (Madison et al., 2001) and refined through consultation with natural resource professionals working in the study region. We measured *perceived ability* using four items related to barriers to implementing management (Harland et al., 1999). *Attitudes* were measured using four items that assessed how positively or negatively respondents viewed management of problematic non-native grasses on their land (Harland et al., 1999). *Personal norms* were assessed using statements about guilt, obligation, and willingness to put in extra effort to manage non-native grasses (Schwartz and Fleishman, 1978; Van Liere and Dunlap, 1978; Harland et al., 1999). *Social norms* were measured in two ways. First, by asking respondents to assess their perceptions of the actions and opinions of their neighbors (two items). Second, we asked respondents to assess how influential institutions viewed non-native grass management (three items). These institutions included university researchers, management agencies, and the Natural Resources Conservation Service, which were identified by the research team and by pilot-testers.

Also based on the recommendation of pilot-testers, we added a definition for non-native grasses at the beginning of the relevant section that identified common grasses in the region, including tall fescue (*Schedonorus arundinaceus*), brome (*Bromus* spp.), orchard grass (*Dactylis glomerata*), and Kentucky bluegrass (*Poa pretensis*).

2.4. Survey sample

After the first wave of the survey was sent to 514 addresses, 58 were ineligible because the mailing was undeliverable or the landowner was deceased. Of the 456 eligible households that received the survey, 149 (32.7%) responded (Coon et al., 2019). The mean ownership size was 180 ha. More men (80%) participated in the survey compared to women (16%) or those identifying as 'other gender' (4%). Nearly all (97%) respondents were White, and most (70%) grazed cattle on their land. The average age of respondents was 66 years ($SD = 11$; 36–90 years), and about 2% belonged to an Amish community. Half of the respondents had at least some college education, and most (64%) earned at least $50,000/year before taxes with an average of 41% derived from their land ($SD = 36\%$). Over 67% perceived themselves to be at least 'moderately knowledgeable' about non-native grasses, with only 13% selecting 'not knowledgeable.' Most landowners had not used herbicide (55%) or physical removal (60%) to control non-native grasses in the last ten years. Yet, about 60% selected that they were at least 'a little willing' to control non-native grasses on their land using herbicide, while 64% were at least 'a little willing' to use physical removal. Further details on sample demographics and land management can be found in Coon et al. (2018).

We assessed the sample for non-response bias on the basis of income derived from landowners' properties, size of properties, age, land use on individual properties mapped from aerial imagery, and attitudes toward grassland conservation. We did not detect differences between respondents and non-respondents ($n = 13$) who answered questions over the phone or early respondents (i.e., waves 1–3) with late respondents (i.e., waves 4–6; Coon et al., 2019). One possible source of bias was under-sampling of Amish landowners, although this could not be quantified. Respondents were similar in age and gender composition when compared to other private landowner samples drawn from the region (Morton et al., 2010; NASS, 2012).

To further assess representativeness, we examined missing data patterns. Of the 149 responses received, we omitted cases where two or fewer sections were completed out of the seven total sections in the survey. Although we still had high numbers of missing data in some variables ($M = 16\%$), our data were missing-completely-at-random as evaluated by the Little (1988) MCAR test (χ^2 [2191] = 2134.688, p = 0.802). However, older respondents were less likely to complete the entire survey (Coon et al., 2019). We accounted for this missing data using multiple imputation in SPSS (IBM®, 2015). After multiple imputation, we had 5 datasets each with 141 complete cases used in analysis. Finally, to prepare for analysis, we checked that the data met the assumption of multivariate normality using Q-Q and P–P plots in SPSS.

2.5. Analysis

We used structural equation modeling (SEM) to examine hypotheses derived from the combined TPB-NAM conceptual model. Due to concerns about model identification, we chose to use 'parceling,' or averaging across items within constructs. This form of aggregation has advantages when relationships between the constructs, and not between items, are of interest (Bandalos and Finney, 2001; Little et al., 2002). Although the two-step process outlined by Anderson and Gerbing (1988) is the standard practice, we added an initial exploratory phase using Principal Components Analysis (PCA) because parceling can mask model fit issues and because survey items were modified from past work for the specific study context. Specifically, we ran a PCA with varimax rotation to test if unmodeled factors were present or if items loaded on more than one factor (Cattell and Burdsal, 1975; Bandalos and Finney, 2001). During this step, the PCA identified one factor for each construct except *social norms*, which divided into two factors. One factor included items measuring *institutional norms* from natural resource agencies and universities, and the other reflected *social norms* from other landowners. We tested the validity and reliability of our scales using several methods (Table 1). Internal consistency of the scales met the reliability standards for Cronbach's alpha (Cronbach, 1951; acceptable values $\geq .6$) and Composite Reliability (CR; Raykov, 1997; acceptable values $\geq .7$). Five of the seven scales met the threshold for Average Variability Explained (AVE; Hair et al., 2011; acceptable values $\geq .50$). For the two scales that had lower AVE values, both cases met acceptable reliability standards according to Fornell and Larcker (1981) and Jayasinghe-Mudalige et al. (2012) (i.e., AVE>0.45 and CR > 0.6).

Next, we followed Little et al. (2013) and performed an item-level Confirmatory Factor Analysis on all constructs (Table 2). We dropped eight survey items to achieve acceptable reliability or due to low factor loading scores ($\Delta\chi^2 = 264.5$; Anderson and Gerbing, 1988). Three of these dropped survey items were management techniques that few study participants had engaged in, including disking, manipulations of grazing pressure, and seeding native grasses. Finally, we ran a manifest model using mean scores from each construct. SEM tests were estimated using TYPE = IMPUTATION in MPlus v8 (Muthén and Muthén, 1998–2020). During step 2, we used maximum likelihood estimation and evaluated fit using chi-square goodness of fit, root mean square error (RMSEA ≤ 0.07; Steiger, 2007); comparative fit index (CFI ≥ 0.90; Bentler, 1990), and standardized root mean square residual (SRMR ≤ 0.07; Hu and Bentler, 1999).

3. Model results

The final model was composed of seven mean scores, five of which included a minimum of three items, and two with only two items for *reported behavior* and *institutional norms* to achieve acceptable model fit (Table 1; Holahan and Moos, 1991; Little et al., 2002). In the structural model, nearly all of the regression coefficients were significant (Table 3; Fig. 4). *Willingness* and *perceived ability* explained 26% of the variance in *reported behavior*, supporting H_1 and H_2. *Attitudes* and *personal norms* together explained 28% of the variance in willingness to manage non-native grasses, supporting H_3 and H_4. The relationship between *perceived ability* and *willingness* was not supported (H_5; $\beta = -0.045$, SE = 0.079, p = 0.572). *Attitudes*, *social norms*, and *institutional norms* explained 42% of the variance in *personal norms*, supporting H_6 and H_7,

Table 1
Scaled items measuring factors that lead to controlling non-native grasses on private land, including factor loading scores (λ), means, and standard deviations (*SD*).

Construct, Items	Λ*	Mean (*SD*)
Attitudes[a] [α = 0.807 CR = 0.833 AVE = 0.633]		
AT_1 - Controlling non-native grasses on my land would be...	0.627	3.184 (1.102)
AT_2 - Reducing non-native grasses on my land would be...	0.966	2.906 (1.101)
AT_3 - Eradicating non-native grasses from my land would be...	0.699	2.699 (1.116)
Social Norms[b] [α = 0.744 CR = 0.752 AVE = 0.606]		
SN_1 - Most landowners who live near me would support control of non-native grasses on private land	0.871	2.165 (0.979)
SN_2 - Most landowners who live near me control non-native grasses on their own land	0.653	2.115 (1.142)
Institutional Norms[b] [α = 0.925 CR = 0.927 AVE = 0.809]		
IN_3 - Controlling non-native grasses is encouraged by: Natural Resources Conservation Service	0.867	2.604 (1.009)
IN_4 - Controlling non-native grasses is encouraged by: IA Dept. of Nat. Res. or MO Dept. of Cons.	0.948	2.582 (1.040)
IN_5 - Controlling non-native grasses is encouraged by: University researchers	0.803	2.682 (1.034)
Personal Norms[c] [α = 0.912 CR = 0.914 AVE = 0.781]		
PN_1 - I feel obligated to eradicate non-native grasses on my land	0.818	2.549 (0.985)
PN_2 - It is my responsibility to reduce non-native grass presence in my neighborhood	0.836	2.542 (0.927)
PN_3 - I am willing to put extra effort into controlling or removing non-native grasses on my land	0.923	2.733 (1.005)
Perceived Ability[c] [α = 0.823 CR = 0.830 AVE = 0.625]		
AB_1 - I have the skills or access to the skills required to control non-native grasses	0.787	2.848 (0.974)
AB_2 - I have the equipment or access to the equipment required to control non-native grasses	0.915	2.699 (1.056)
AB3 - If I wanted to, I could in most instances reduce or remove non-native grasses on my land	0.616	3.061 (1.005)
Willingness[d] [α = 0.753 CR = 0.825 AVE = 0.499]		
W_1 - How willing are you to control non-native grasses on your land with herbicide?	0.551	2.105 (1.137)
W_2 - How willing are you to control non-native grasses on your land with prescribed fire?	0.835	2.222 (1.199)
W_3 - How willing are you to control non-native grasses on your land with physical removal?	0.596	2.316 (1.231)
W_4 - How willing are you to control non-native grasses on your land by seeding native grasses?	0.498	2.489 (1.302)
Behavior[e] [α = 0.602; CR = 0.622; AVE = 0.459]		
B_1 - How often have you used herbicide to control non-native grasses on your land?	0.444	1.977 (1.227)
B_2 - How often have you used prescribed fire to control non-native grasses on your land?	0.690	1.882 (1.299)

*Factor loadings from confirmatory factor analysis.
[a] Mean scores on the following scale: 1 (Very Negative), 2 (A Little Negative), 3 (Neither Positive or Negative), 4 (A Little Positive), 5 (Very Positive).
[b] Mean scores on the following scale: 1 (Not Likely), 2, (A Little Likely), 3 (Moderately Likely), 4 (Very Likely), 5 (Extremely Likely).
[c] Mean scores on the following scale: 1 (Strongly Disagree), 2 (Slightly Disagree), 3 (Neither Agree or Disagree), 4 (Slightly Agree), 5 (Strongly Agree).
[d] Mean scores on the following scale: 1 (Not Willing), 2 (A Little Willing), 3 (Moderately Willing), 4 (Very Willing), 5 (Extremely Willing).
[e] Mean scores on the following scale: 1 (Not at all), 2 (Once in 10 Years), 3 (Once in 5 Years), 4 (Every Other Year),5 (Every Year).

with the strongest relationship between *attitudes* and *personal norms* (Fig. 4). H_8, the indirect relationship between *attitudes* and *willingness*, was also supported. We detected no indirect effect of *perceived ability* on *reported behavior* through *willingness* with a '0' effect size (H_9; $\beta = 0$, SE $= 0$, $p < 0.001$). Non-significant paths were removed from the final model.

4. Discussion

Human behavior has tended to be neglected in the study of environmental conservation and management, and this article aims to contribute to the growing body of literature on the factors that influence decisions in these contexts (Schultz, 2011; Manfredo et al., 2014; van Riper and Kyle, 2014; Arlinghaus et al., 2017). In our exploration of non-native grass management by landowners in the eastern Great Plains, we found that both internal (i.e., *attitudes, personal norms*) and external factors (i.e., *social norms, perceived ability*) influenced landowners' decisions. Landowners with positive *attitudes* toward management that felt social pressure also experienced a stronger moral obligation to control non-native grasses. These feelings of moral obligation and positive *attitudes* then increased *willingness* to implement management practices. Moreover, landowners who had access to relevant equipment and other resources reported to manage non-native grasses more often. This study is the first to fuse the TPB and NAM theoretical traditions to explore decisions surrounding non-native plants on private land, and is one of the few investigations of internal processes that influence non-native species management (but see Seekamp et al., 2016; van Riper et al., 2019).

Table 2
Summary of fit statistics for the Confirmatory Factor Analysis and manifest models that tested the hypothesized factor structures among variables predicting management of non-native grasses.

Fit indices	Confirmatory Factor Analysis model	Manifest model
X^2	Value = 127.363, df = 150, p = 0.90	Value = 11.486, df = 8, p = 0.176
RMSEA	0.000 (90% CI 0–0.016)	0.056 (90% CI 0–0.122)
CFI	1.000	0.971
SRMR	0.062	0.065

Table 3
Estimates of the final structural model merging the Theory of Planned Behavior and Norm Activation Model, including dependent variables, predictor variables, standardized regression coefficients (*β*), standard errors (SE), p-values, and R^2.

Dependent variables	Predictor variables	*β*	*SE*	p-value	R^2
Reported Behavior	Willingness	0.550	0.089	<0.001	0.259
Reported Behavior	Perceived Ability	0.175	0.090	0.052	–
Willingness	Personal Norms	0.365	0.095	<0.001	0.279
Willingness	Attitudes	0.224	0.083	0.007	–
Personal Norms	Social Norms	0.272	0.079	<0.001	0.419
Personal Norms	Institutional Norms	0.127	0.059	0.032	–
Personal Norms	Attitudes	0.421	0.068	<0.001	–
Willingness	Attitudes (indirect)	0.154	0.049	0.002	–

4.1. Internal drivers of non-native grass management

Our finding that *attitudes* and *personal norms* were predictors of non-native grass management challenges the assumption that such decisions are simple, utilitarian considerations. Of these two variables, the influence of attitudes on behavior has been considered more often (Heberlein, 2012; Shackleton et al., 2019c). In many cases, when the public reports positive attitudes toward a control initiative, projects aiming to reduce or eradicate non-native species are more successful (Polonsky et al., 2004; García-Llorente et al., 2008; Sharp et al., 2011). In addition, negative attitudes toward the non-native species have previously corresponded to stronger support for control initiatives (Fischer et al., 2014).

Previous research has suggested that attitudes alone do not predict willingness or behavior (Heberlein, 2012). In line with this assertion, we found that another internal variable, *personal norms*, was a strong predictor of *willingness* to manage non-native grasses. In a practical sense, this means that landowners who felt a heightened sense of moral responsibility to reduce the prevalence of non-native grasses in their community were more willing to manage them. This finding adds to a

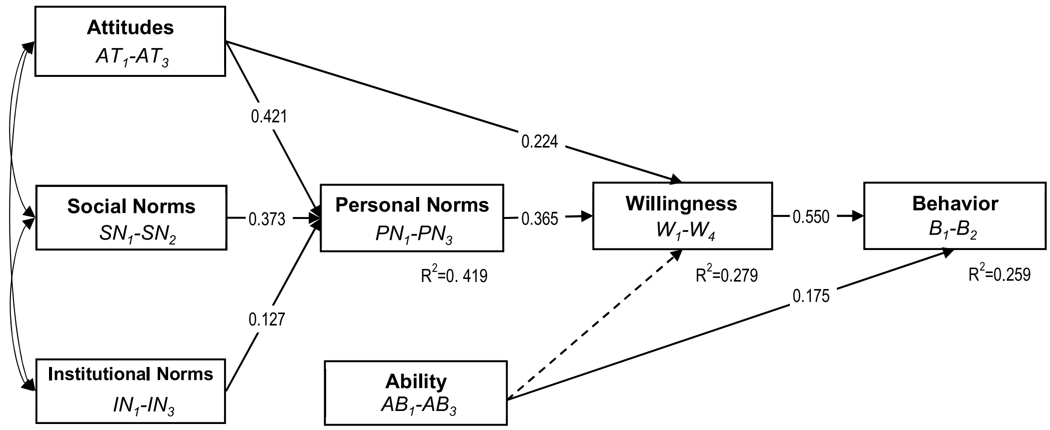

Fig. 4. Results from a path analysis of hypothesized relationships in a combined Theory of Planned Behavior-Norm Activation model. Coefficients (**β**) are shown on the arrows indicating hypothesized relationships. Dotted lines indicate non-significant relationships.

body of work that advocates for leveraging morality to influence environmental behavior (Harland et al., 1999; López-Mosquera and Sánchez, 2012; Chen and Tung, 2014). We believe that a sense of moral responsibility is particularly relevant when considering non-native grasses—a problem that impacts the well-being of human communities (Epanchin-Niell and Wilen, 2015). Thus, our results indicate that researchers evaluating willingness to manage non-native species should consider personal norms in their studies.

4.2. External drivers of non-native grass management

Similar to other work, we found that *perceived ability*, in addition to *willingness*, influenced whether landowners controlled non-native grasses. In contrast to other work, *perceived ability* did not predict *willingness*, indicating that landowners were (or were not) willing to undertake control activities regardless of their abilities. This suggests that increasing access to resources may increase control practices, but only for already-willing landowners. Therefore, future research should differentiate between *willingness* ('I am willing to manage') and *intention* ('I intend to manage'). Although these two concepts are sometimes considered to be alternative measures of the same construct in the TPB (Ajzen and Fishbein, 2005), evidence from the literature on risky adolescent behaviors shows that *willingness* requires less consideration of consequences or effort compared to *intention* or the related concept *behavioral expectation* (Gibbons et al., 2000; Pomery et al., 2009). In our case, it is possible that respondents did not consider the effort or consequences associated with managing non-native grasses when asked about their *willingness* to the extent that the relationship between *perceived ability* and *willingness* was not supported. Notably, other studies that have supported the relationship between *perceived ability* and *willingness* have examined relatively lower-effort behaviors, such as paying for conservation of an urban park (López-Mosquera et al., 2014) and stocking fish (von Lindern and Mosler, 2014). In comparison, non-native grass management is a years-long effort that involves ongoing changes to daily activities. Our approach, using *willingness*, may not be preferred in all management contexts. Given differences between constructs, we suggest researchers carefully consider the measure of intention that is most appropriate for the study.

While access to monetary or other resources is frequently examined, *social norms* are not often considered as predictors of non-native species management (but see Niemiec et al., 2016; Lubeck et al., 2019). In our merged TPB-NAM model, *social norms* predicted *personal norms*. This indicates that a sense of moral obligation to reduce non-native grasses increases when landowners perceive that other people support that reduction. While few studies on non-native species examine both *personal norms* and *social norms*, individuals in several studies have expressed concern about how peers and institutions view management of non-native species (Polonsky et al., 2004; Prinbeck et al., 2011). These studies and our results support theoretical propositions (Schwartz, 1977; Bamberg and Möser, 2007) and empirical evidence (Klöckner, 2013; Hynes and Wilson, 2016; Olsson et al., 2018) asserting that *social norms* should be antecedents to *personal norms*.

We found that landowners responded differently to normative pressures from institutions (i.e., *institutional norms)* versus peers (i.e., *social norms*). Our findings, while not common in the literature, align with two studies that found *social norms* organize around social groups (Steg, 2005; Wall et al., 2007). Our observations may indicate that individuals are more impacted by their own social group than the institutions explored in this study (Terry et al., 1999). It could be that residents experienced less pronounced effects from institutions due to skepticism of government intervention in rural areas, especially for interventions related to the environment (Shoreman-Ouimet, 2010). Although agency personnel in our study region have a very visible role in managing public lands that are scattered throughout the region (Miller et al., 2012), it is still likely that landowners are more likely to see management efforts by their neighbors versus institutions. Given our finding that social norms were distinguishable from institutional norms, future research should test for emergent properties in survey data using exploratory analyses when parceling constructs that have a less developed theoretical basis.

4.3. Limitations and future work

Although *attitudes*, *personal norms, social norms*, and *perceived ability* explained a sizeable amount of the variation in non-native grass management practices performed by survey respondents, there are other factors at work in these decisions. For example, ecological or climatic context should be considered. In rain-fed systems like the eastern Great Plains, high grazing pressure is possible and the stress-tolerance of non-native grasses makes them highly valuable to cattle producers who use high stocking rates (Raynor et al., 2019). In addition, the stress-resistant traits of some grasses may make them useful in the drought-prone western Great Plains. Variability in precipitation due to climate change may further complicate landowners' willingness to control these grasses in both regions. A regional comparison of non-native grass management, stocking rates, and climate could provide useful insight into how biophysical factors affect decisions.

In this study, we explored willingness to manage non-native grasses common to our study region without differentiating between individual species. Yet, the unique social-ecological context of non-native grass management suggests that further exploration of landowner views of potentially contentious grass species is needed (Grice et al., 2012). In contrast to forage grasses, we expect that views are less heterogenous for non-native plants without economic purpose that are almost universally perceived to be harmful, like palmer amaranth (*Amaranthus palmeri*; Bagavathiannan et al., 2019). In contrast, even non-native grasses that cause both ecological and agronomic harm, like tall fescue, are still valued and used by some landowners (Coon et al., 2018; Raynor et al., 2019). Although there is little information on landowner perceptions of particular non-native grass species, less is known about how landowners view other grasses when ecological or agronomic priorities conflict or at early phases of degradation. The complexity surrounding these species means that regional context and landowner priorities are essential considerations for researchers working on management of potentially contentious non-native grasses.

4.4. Implications for management

A growing body of research (Michie et al., 2008; Steg and Vlek, 2009; McKenzie-Mohr and Schultz, 2014) draws from behavioral drivers to formulate management options and provide insight into behavior change interventions. Here, we draw from our study findings to review and apply these strategies to the management of problematic non-native grasses on private land based on our results. We suggest that several external factors could be leveraged to change behavior. For instance, higher *perceived ability* to control non-native grasses increased the frequency of management by landowners but had no influence on *willingness*. These results show that a lack of resources (e.g., equipment, skills) could be a barrier for people wishing to manage non-native grasses. Thus, providing access to equipment, information on best practices, or training through field days where landowners can practice and observe may contribute to increased management in already-willing individuals (Kilpatrick, 2000; Van den Berg and Jiggins, 2007).

Simply providing equipment or information is unlikely to change behavior without motivation (Stern, 2000; Cole et al., 2016). One motivational element that could be used to influence behavior is social norms. In our study, landowners felt more personally responsible to manage non-native grasses if management was socially acceptable, aligning with other studies that found collective factors predicted invasive plant control (Niemiec et al., 2016; Lubeck et al., 2019). In practice, there have been several cases where social norms facilitated behavior change in landowners, including in the southwestern U.S. where group identities were activated to encourage environmentally-friendly behavior (Clayton and Brook, 2005), and in the western Great Plains where private citizens formed cooperative burning associations to deal with the problem of invasive woody plants (Taylor, 2005; Twidwell et al., 2013). Creating cooperative networks working to reduce non-native grasses, along the same lines as cooperative burning associations, may simultaneously activate social norms and provide access to skills and resources.

Cooperative efforts require cultivating trust between stakeholders and conservation groups or agencies (Davenport et al., 2007; Wagner and Fernandez-Gimenez, 2009). Although we found that *institutional norms* influenced landowners' feelings of moral responsibility to manage non-native grasses, this effect was much weaker than the influence of *social norms* from peers. In combination with strong, negative views toward institutions working in the region (Coon et al., 2019), our results indicate that conservation groups need to deliberately work to rebuild trust in rural American communities (Shoreman-Ouimet, 2010), potentially through increased personal interactions between biologists and landowners (Lutter et al., 2018). When possible, conservation initiatives should work within existing landowner social networks to disseminate information, foster social learning, and draw from local knowledge to ensure desired management outcomes are achieved (Morton, 2008; Kueper et al., 2013).

Personal norms were another driver of *willingness* to manage non-native grasses in our study. As such, messaging that activates landowners' sense of moral responsibility is a motivational tactic that may be successful in increasing management. Because *personal norms* are rooted in feelings of responsibility for environmental problems (Stern et al., 1999; van Riper and Kyle, 2014), they can be linked to the concept of environmental stewardship. Stewardship, which frames ecological function as a 'public good,' connects conservation on individual private lands to well-being at the landscape scale (Cooke and Moon, 2015). Non-native grasses potentially threaten this function through negative impacts on ecosystem services (Godfree et al., 2017). Although stewardship is likely a dominant factor in the decisions of rural landowners, it is sometimes overlooked in the study of environmental behavior (Larson et al., 2015; Thompson et al., 2015; Prokopy et al., 2019). Given the potential of personal norms and environmental stewardship to influence invasive species management (Selge et al., 2011; Seekamp et al., 2016), managers and researchers could use messaging that reinforces landowners' existing sense of moral responsibility, reminding them that controlling non-native grasses can reduce environmental degradation and positively impact wildlife, cattle production, and scenic values, both on their land and in their communities. Importantly, multiple different message frames are likely needed to appeal to the heterogeneous views of landowners, and we recommend that stewardship be considered alongside production-focused messaging (Kusmanoff et al., 2016).

5. Conclusions

In our exploration of non-native grass management in the Great Plains, we found that fusing theoretical traditions from the Norm Activation Model (Schwartz, 1977) and Theory of Planned Behavior (Ajzen, 1991) provided a strong foundation for understanding factors influencing willingness to implement control procedures, including both practical external factors and internal moral drivers of behavior. We recommend that other researchers adopt a combined internal-external approach when exploring drivers of management on private lands, especially considering behaviors that have moral implications like non-native species management.

Because of complex social-ecological tradeoffs, successful management of non-native grasses at regional scales has proven elusive (Pellant, 1996; Kitchen, 2014). Yet, managing non-native grasses in private-land dominated landscapes is by no means a lost cause. In our sample, over 60% of landowners were at least 'a little willing' to reduce non-native grasses on their land, indicating a level of openness that is notable in an area where livestock is a major industry reliant on non-native grasses. This willingness can be transformed into action if management initiatives work to activate the internal processes and external factors that influence behavior. Although complete eradication of economically-valuable non-native grasses is not something that many landowners are interested in pursuing (Coon et al., 2018), working to reduce the prevalence of these exotic grasses has the potential to both increase habitat quality for grassland biodiversity (Barnes et al., 2013) and the resilience of private grazing lands that support rural livelihoods (Steinfeld et al., 2013).

CRediT authorship contribution statement

Jaime J. Coon: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Visualization, Writing - original draft, Writing - review & editing. **Carena J. van Riper:** Conceptualization, Methodology, Resources, Supervision, Writing - review & editing. **Lois Wright Morton:** Conceptualization, Methodology, Funding acquisition, Writing - review & editing. **James R. Miller:** Conceptualization, Methodology, Funding acquisition, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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