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Factors Influencing Family Forest Owners' Interest in Community-led Collective Invasive Plant Management

Mysha Clarke[1] · Zhao Ma[2] · Stephanie A. Snyder[3] · Kristin Floress[4]

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Abstract

Effective invasive plant management requires collective action. However, little is known about what motivates individuals to work collectively. We conducted a mail survey of 2,600 randomly selected family forest owners in Indiana, USA to examine factors associated with community-led collective action. Specifically, we examined the role of perceived self-efficacy, perceived collective efficacy, concerns about invasive plants, and social norms associated with invasive plant management in shaping family forest owners' self-reported likelihood to work with their neighbors to remove invasive plants. We found that past experience talking to others or working with neighbors to remove invasive plants were important predictors of landowners' intention to work collectively, as were perceived self-efficacy in their own ability to manage invasive plants, perceived need for collective action, social norms, and concerns about invasive plants on neighboring or nearby properties. However, most socio-demographic characteristics (e.g., age, gender, education level, income) and land ownership characteristics (e.g., residence status, having a written forest management plan) were not statisically significant predictors of family forest owners' likelihood to work with their neighbors. Our findings suggest that building individual sense of competence, facilitating neighbor interactions, and strengthening shared concerns may facilitate community-led collective action to manage invasive plants.

Keywords Collective action · Self-efficacy · Collective efficacy · Social norm · Non-industrial private forest · Private landowner

Introduction

Non-native invasive species are intentionally or unintentionally introduced to a new place or new type of habitat where they were not previously found, posing a serious threat to ecosystems globally (Simberloff 2013). Non-native invasive species can modify ecosystems, impact public health, and increase economic costs of land management (Early et al. 2016; Simberloff 2013). Most research on non-native species invasion has focused on the ecological dimensions of invasive species including their distribution and patterns over time, ecological impacts, and current or potential management approaches (Estévez et al. 2015). Increasingly, researchers have argued that the social aspects of invasive species management should also be prioritized (Ma et al. 2018; Clarke et al. 2019; Bagavathiannan et al. 2019; Estévez et al. 2015; Head 2017) because humans are key to introducing, distributing, and controlling them (Erwin et al. 2019; Head 2017; Perrings et al. 2002).

Invasive plants are generally undermanaged among individual landowners because they often consider the private costs and benefits of management, rather than societal costs and benefits (Epanchin-Niell and Wilen 2015). Researchers have described invasive plants as a threat to public goods like biodiversity or public safety (Niemiec et al. 2016) because the costs and benefits of management can be non-excludable (Bagavathiannan et al. 2019; Epanchin-Niell et al. 2010; Graham and Rogers 2017;

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✉ Mysha Clarke
mysha.clarke@ufl.edu

[1] School of Forest, Fisheries and Geomatics Sciences, University of Florida, Gainesville, FL, USA

[2] Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, USA

[3] USDA Forest Service, Northern Research Station, St. Paul, MN 55108, USA

[4] USDA Forest Service, Northern Research Station, Evanston, IL 60201, USA

Graham et al. 2019; Perrings et al. 2002). This means that individual landowners who do not manage invasive plants on their properties can inadvertently increase the invasion risk and management costs of their neighbors. Likewise, when individual landowners manage invasive plants on their properties, their neighbors may also indirectly benefit via reduced invasion risk and potential reduced management costs (Ma et al. 2018; Erwin et al. 2019; Epanchin-Niell et al. 2010; Graham et al. 2019; Hershdorfer et al. 2007; Yung et al. 2015). Therefore, invasive species are also sometimes classified as a "weakest link" public goods problem because the benefits of invasive species management often depend on how much the least willing actors (i.e., "weakest links") would be willing to engage in management actions (Graham et al. 2019; Niemiec et al. 2020; Perrings et al. 2002).

Most research on the human dimensions of invasive plant management has focused on individual landowners' efforts (e.g., Niemiec et al. 2017a). However, collective action among landowners can be more effective than individual efforts by reducing overall invasion risk and management costs and increasing treatment effectiveness (Bagavathiannan et al. 2019; Epanchin-Niell and Wilen 2015; Graham 2013, 2019; Hershdorfer et al. 2007; McKiernan 2017; Niemiec et al. 2017b; Yung et al. 2015). A review of empirical research found that collective action to manage invasive species could be classified as externally led, community-led, co-managed, or managed by organizational coalitions (Graham et al. 2019). In this paper, we focus on community-led collective action, which refers to collaborative efforts by private landowners to manage invasive species across ownership boundaries (Graham et al. 2019). These community-led efforts may involve public officials and generally do not involve external agencies, organizations, or government mandates, but primarily are based on an internal system of social pressure and shared concern that motivates landowners to collaborate to address invasive species (Graham et al. 2019).

There is a small but growing literature on community-led collective action to manage invasive species (Graham et al. 2019; Marshall et al. 2016; Niemiec et al. 2016). So far there is no consensus about how many or what types of landowners need to be working together to constitute collective action. In fact, many studies simply use the term "neighbors" to describe participating landowners in their studies of collective management of invasive plants. Other studies have associated community-led collective action to manage invasive plants with farmers' cooperative efforts for integrated pest management with neighbors or other local farmers (Stallman and James 2015), herbicide-resistant weed management among farmers (Erwin et al. 2019), neighbors cooperating to control non-native invasive plants (Yung et al. 2015), private landowners teaching their neighbors about invasive plants (Niemiec et al. 2016), and communities sharing information and applying social pressure to other landowners (Graham 2013; Graham and Rogers 2017). In this study, we define community-led collective action as landowners working with one or more of their neighbors to remove invasive plants from their properties. This type of collective action involves landowners supporting and coordinating with each other to remove invasive plants without external leadership, as highlighted in the previous literature (Graham et al. 2019). The purpose of this study is to assess the factors that influence forest landowners' likelihood to participate in community-led collective action to manage invasive plants.

Background and Literature Review

A key subset of private landowners is family forest owners (FFOs)—unincorporated groups of individuals and families who collectively own 290 million acres (36%) of forest in the United States (Butler et al. 2016). To date, research on FFOs' interests in collective action have mostly focused on cross-boundary cooperation in the contexts of timber harvesting (Fischer et al. 2019; Kittredge 2005), wildfire management (Canadas et al. 2016; Fischer et al. 2019), and ecosystem management (Fischer et al. 2019; Floress et at. 2018; Kittredge 2005; Rickenbach et al. 2011; Schulte et al. 2008). Fischer and Charnley (2012) and other researchers have suggested the importance of understanding FFOs' coordination and cooperation in their invasive species management actions.

Landowners' decisions to participate in collective actions are influenced by their perceived self-efficacy (Niemiec et al. 2017b), or an individual's belief that they can perform an action effectively (Bandura 1997). In this study, perceived self-efficacy refers to the landowners' beliefs in their own abilities to control invasive plants on their properties. The collective action literature emphasizes that higher perceived self-efficacy may result in higher perceived collective efficacy (i.e., beliefs that people can work together to achieve collective benefits), thereby increasing the likelihood that individuals will contribute to collective actions (Bagavathiannan et al. 2019; Bandura 2000). However, we also note that in some cases higher perceived self-efficacy may not translate into higher perceived collective efficacy (Bandura 2000). A small number of studies have examined the role of collective efficacy on people's decisions to participate in community-led collective action to manage invasive plants (Bagavathiannan et al. 2019; Lubeck et al. 2019; Niemiec et al. 2016, 2017b). In this literature, perceived collective efficacy has been measured by aggregating

individuals' perceptions of their own ability to act (i.e., self-efficacy) or by aggregating individuals' perceptions of their group's ability to act (Bandura 2000). In this study, we used the latter measure of perceived collective efficacy.

We also included various socio-demographic factors (i.e., age, income, education, gender) and land characteristics (i.e., forest property size) because they are often included as control variables in models of FFO behaviors (e.g., Floress et al. 2018) and previous studies have sometimes found them to be related to invasive species management. In some cases, the effect of these factors on invasive species management depends on the size, mobility, reproductive rates, and management methods of the invasive species (Niemiec et al. 2017a, b). For example, it was difficult for landowners with smaller properties in the Puna District of Hawai'i to effectively manage the invasive Albizia tree (*Falcataria moluccana*) on their properties without their neighbors also taking management actions (Niemiec et al. 2016). However, property size may not be as important for managing mobile predator invasive species (Glen et al. 2017). Previous studies have also found that female landowners are more likely to control invasive plants than their male counterparts (Yung et al. 2015), and landowners with lower income are more likely to engage in collective invasive species management than landowners with higher income (Niemiec et al. 2018). Additionally, landowners with higher levels of education are also more likely to talk to their neighbors and organize efforts to address their collective needs for invasive species management than those with lower levels of education (Niemiec et al. 2018).

Landowners' collective action is also influenced by social norms which provide social expectations about certain behavior, especially from significant others, family, friends, or neighbors (Lubeck et al. 2019; McKiernan 2017; Niemiec et al. 2016, 2017b; Prinbeck et al. 2011; Sullivan et al. 2017). Social norms can be descriptive (i.e., perceptions of what others are doing and how they usually address an issue) or injunctive (i.e., perceptions about what is acceptable or unacceptable, which may be accompanied with informal rewards or sanctions) (Cialdini et al. 2006). In the case of invasive plant management, descriptive norms may motivate some landowners to undertake management actions or participate in programs if they perceive their neighbors are also actively managing (Ma et al. 2018; Clarke et al. 2019; Epanchin-Neill and Wilen 2015; McKiernan 2017; Niemiec et al. 2017a; Yung et al. 2015). At the same time, some landowners may be reluctant to reach out to their neighbors to discuss invasive plant management because of social norms related to privacy and independence (Ma et al. 2018; Ervin et al. 2019; Graham 2013; Jussaume et al. 2019; Niemiec et al. 2017b; Ravnborg and Westermann 2002). In brief, some social norms may motivate landowners to collectively manage invasive plants while other social norms may stifle collective action (Niemiec et al. 2016; McKiernan 2017).

The literature has also shown that FFOs' participation in collective invasive species management in general is related to their shared concern and prior experience (Sullivan et al. 2017; Lubeck et al. 2019; McKiernan 2017; Fischer et al. 2019). Shared concern is important because it presents invasive species as a collective threat (Estévez et al. 2015; Fischer et al. 2019; Niemiec et al. 2017b; Prinbeck et al. 2011). Experience with invasive species management can either motivate landowners to continue managing (Clarke et al. 2019; Kalnicky et al. 2019; Niemiec et al. 2017b) or discourage them if they were unsuccessful before (Sullivan et al. 2017). As such, shared concern and prior experience can motivate landowners to manage invasive plants independently and to engage others and work together (Sullivan et al. 2017; Niemiec et al. 2017b).

Despite a growing body of literature about collective action to manage invasive species among private landowners, much remains unknown. For example, studies about community-led collective action to manage invasive plants are primarily qualitative (Graham 2019; Ravnborg and Westermann 2002), or focused on the role of cooperatives, community programs, or group activities (Fischer et al. 2019; Hershdorfer et al. 2007, Marshall et al. 2016, Graham and Rogers 2017, McKieran 2017). There are several quantitative studies addressing the role of social norms on an individual's invasive plant management efforts or collective action (Erwin et al. 2019; Niemiec et al. 2016, Lubeck et al. 2019), but research that comprehensively examines factors that motivate FFOs to participate in community-led collective invasive plant management remains scant. The purpose of this study is to determine the importance of various social-psychological factors like social norms, shared concern, perceived self-efficacy, and perceived collective efficacy, as well as FFOs' socio-demographic characteristics and prior management experience, on their likelihood to work with their neighbors to remove invasive plants through the lens of community-led collective action.

Methods

Data Collection

We first conducted in-person interviews with 11 forestry professionals and 12 FFOs in Indiana. The interviews investigated landowners' knowledge and perceptions of invasive plants, prevention and removal activities, perceived responsibilities for invasive plant management, and their needs and concerns with respect to invasive plant

management (see Ma et al. 2018). We then used the results from our interviews to inform the development of a survey questionnaire. The data used in this study were collected using this survey questionnaire from a random sample of FFOs in Indiana, USA. Specifically, the survey addressed FFOs' familiarity with invasive plants on their land, past invasive plant management activities, future plans for managing invasive plants, concerns about invasive plants, socio-demographic characteristic, and land ownership characteristics. We provided the following definition of invasive plants on the front cover of the survey to create a shared understanding among study participants: "Invasive plant species are introduced deliberately or unintentionally outside their natural habitats where they have the ability to establish, spread, sometimes crowd out native vegetation and the wildlife that feeds on it, and even change ecosystem processes. Invasive plants may have economic or environmental impacts on your wooded land."

We created a sampling frame of FFOs in Indiana in two stages. First, we identified forest in the state using statewide forest parcel data available through the IndianaMap initiatives and property ownership information from the Indiana Department of Local Government Finance. After reviewing the forest ownership database, we deleted industrial and organizational owners and other erroneous entries and created a final list of 163,666 FFOs who owned at least one acre of land categorized as woodland or classified forest in the state of Indiana as of 2014. We then selected a random sample of 2,600 FFOs and used the Tailored Design Method (Dillman et al. 2014) to implement the survey.

We sent five mailings to each FFO: a prenotification postcard; the first survey packet (including a questionnaire, a cover letter, and a prestamped return envelope) and a $2 bill as a token of appreciation to enhance response rates (Simmons and Wilmot 2004); a reminder postcard; the second survey packet; and the final survey packet. Our study was approved by Purdue University's Institutional Review Board and administered from November through December 2015. Of the 2,600 surveys sent, 1,422 usable surveys were returned, whereas 112 had inaccurate or unreachable addresses and 64 were sent to landowners who were deceased or no longer owned woodland. Therefore, our adjusted response rate was 58.7%. We analyzed the survey data using STATA 12.0. We tested nonresponse bias by comparing the first 10% of survey responses (early respondents) with the last 10% (late respondents) because "persons responding later are assumed to be more similar to nonrespondents" (Armstrong and Overton 1977, p. 397). We examined differences between respondents' socio-demographic characteristics, land ownership characteristics, knowledge and attitude about invasive plants, and whether they managed invasive plants in the past. We did not find any statistically significant differences at the 0.05 level.

Statistical Analyses

We constructed an empirical model to evaluate factors associated with FFOs' intentions to engage in community-led collective invasive plant management. The response variable for the model is "collective_action", measured as respondents' self-reported likelihood to work with their neighbors to remove invasive plants on their woodlands during the next five years, using a five-point Likert scale (from 5 = very likely to 1 = very unlikely). Overall, 28.3% of respondents indicated they were very unlikely to work with their neighbors, 36.1% were unlikely, 22.2% were undecided, 10.7% were likely, and 2.8% were very likely. We were primarily interested in understanding what factors would lead FFOs to be likely to engage in collective invasive plant management (vs. not), and the finer-grained understanding of likelihood was not of substantive interest for this study. Therefore, we recoded this variable to 1 if respondents indicated that they were likely or very likely to work with their neighbors during the next five years and 0 if they indicated otherwise, following similar practices outlined in Vaske (2008).

Our independent variables included respondents' level of concern about invasive plants, perceived self-efficacy, perceived collective efficacy, social norms regarding invasive plant management, past experience managing invasive plants, past experience talking to others about invasive plants, land ownership characteristics, and socio-demographic characteristics (Table 1). Perceived self-efficacy was measured by asking respondents to indicate their level of confidence in their own ability to remove invasive plants from their woodland in Indiana if needed (confidence_removal). Perceived collective efficacy was measured by asking respondents to indicate how much they agreed with the statement, "Woodland owners know how to self-organize and cooperate with one another to control/remove invasive plants" (know_how_cooperate).

Composite scores were created for the variables that describe FFOs' experience talking to family, neighbors, or other woodland owners about invasive plants (past_talk) and social norms (social_norm) because responses to several survey items that measured the same construct were highly correlated. Specifically, to measure FFOs' experience talking to others about invasive plants (past_talk), we asked respondents to indicate yes or no to three statements (Table 1). We then calculated the Cronbach's (1951) alpha for the three statement to assess their reliability or internal consistency. A Cronbach's alpha larger than 0.8 is considered internally consistent (Acock 2016), a value between 0.6 and 0.8 is considered adequate, and a value lower than 0.6 should be interpreted with caution (Nunnally 1978; Burnham and Ma 2017). In this case, the Cronbach's alpha for the three statements about talking to others was 0.61,

Table 1 Variables used in the empirical model for estimating respondents' likelihood to work with their neighbors to remove invasive plants from their woodlands during the next five years

Variable name	Description (type of variable, levels of variable)	Percentage of respondents associated with each variable level	Mean (SD) in the case of continuous, ordinal, or binary variable
collective_action	Binary—likelihood of working with their neighbors to remove invasive plants on all of their woodlands in the next five years. 1 if likely or very likely; 0 if otherwise	13%	0.13 (0.34)
concern_nearbyland	Ordinal—level of concern about invasive plants on neighboring or nearby wooded land (treated as continuous in the model)		3.08 (1.12)
	1 = no concern	7%	
	2 = little concern	25%	
	3 = moderate concern	33%	
	4 = concern	22%	
	5 = great concern	14%	
confidence_removal	Ordinal—level of confidence in one's own ability to remove invasive plants from their woodlands in Indiana, if needed (a measure of perceived self-efficacy; treated as continuous in the model)		2.57 (1.12)
	1 = not confident	20%	
	2 = low confidence	29%	
	3 = moderately confident	32%	
	4 = confident	14%	
	5 = very confident	6%	
past_talk	Continuous—composite score calculated by averaging responses to three statements about past experience talking to others about invasive plants		0.11 (0.23)
	Binary—response to statement "I talked to my family about invasive plants." 1 if yes; 0 if otherwise	14%	0.14 (0.35)
	Binary—response to statement "I talked to my neighboring woodland owner about invasive plants." 1 if yes; 0 if otherwise	8%	0.08 (0.27)
	Binary—response to statement "I talked to other woodland owners who is not my neighbor about invasive plants." 1 if yes; 0 if otherwise	10%	0.10 (0.30)
past_work_together	Binary—1 if worked with neighbors to remove invasive plants from all of their wooded lands	2%	0.02 (0.14)
past_management	Binary—1 if reduced or eliminated invasive plants on their property in the past five years	28%	0.28 (0.45)
know_how_cooperate	Ordinal—Level of agreement with the statement "Woodland owners know how to self-organize and cooperate with one another to control/remove invasive plants." (a measure of perceived collective efficacy; treated as continuous in the model)		2.67 (0.86)
	1 = strongly disagree	10%	
	2 = disagree	28%	
	3 = undecided/do not know	49%	
	4 = agree	11%	
	5 = strongly agree	2%	

Table 1 (continued)

Variable name	Description (type of variable, levels of variable)	Percentage of respondents associated with each variable level	Mean (SD) in the case of continuous, ordinal, or binary variable
need_work_together	Ordinal—level of agreement with the statement "Effective control and removal of invasive plants require woodland owners to work together." (treated as continuous in the model)		3.73 (0.80)
	1 = strongly disagree	2%	
	2 = disagree	4%	
	3 = undecided/do not know	28%	
	4 = agree	53%	
	5 = strongly agree	14%	
social_norm	Continuous—composite score calculated by averaging responses to three statements about FFOs being subject to the influence of others		3.67 (0.81)
	Ordinal—response to statement "If my neighbors are controlling/removing invasive plants from their wooded lands, I will feel the need to do the same." 1 = strongly disagree, 2 = disagree, 3 = undecided/do not know, 4 = agree, 5 = strongly agree		3.77 (0.85)
	Ordinal—response to statement "If other woodland owners (not necessarily my neighbors) are controlling/removing invasive plants from their property, I will feel the need to do the same." 1 = strongly disagree, 2 = disagree, 3 = undecided/do not know, 4 = agree, 5 = strongly agree		3.57 (0.87)
	Ordinal—response to statement "If my family and friends are controlling/removing invasive plants from their wooded lands, I will feel the need to do the same." 1 = strongly disagree, 2 = disagree, 3 = undecided/do not know, 4 = agree, 5 = strongly agree		3.66 (0.88)
acreage	Continuous–size of forestland owned (acres)		81.6 (135.44)
residence	Binary—1 if home (primary) residence is within one mile of their wooded land in Indiana; 0 otherwise	70%	0.70 (0.46)
farm_history	Binary—1 if currently or previously farmed; 0 otherwise	73%	0.73 (0.44)
management_plan	Binary—1 if have a written forest management or stewardship plan; 0 otherwise	21%	0.21 (0.41)
org_membership	Binary—1 if member of an environmental, conservation, or woodland owner organization; 0 if otherwise	13%	0.13 (0.33)
age	Continuous—age of respondent (years)	n/a	63.29 (12.70)
gender	Binary—1 if male, 0 if otherwise	79%	0.79 (0.41)
education	Ordinal—education level of the respondent (treated as continuous in the model)		3.60 (1.59)
	1 = less than high school/General Education Diploma (GED)	3%	
	2 = high school/GED	33%	
	3 = some college	20%	
	4 = associate degree	8%	
	5 = bachelor's	18%	
	6 = graduate degree	18%	

Table 1 (continued)

Variable name	Description (type of variable, levels of variable)	Percentage of respondents associated with each variable level	Mean (SD) in the case of continuous, ordinal, or binary variable
hh_income	Ordinal—annual household income (treated as continuous in the model)		3.11 (1.34)
	1 = <$25,000	9%	
	2 = $25,000–$49,999	26%	
	3 = $50,000–$99,999	35%	
	4 = $100,000–$149,999	16%	
	5 = $150,000–$199,999	6%	
	6 = $200,000 or more	9%	

so we calculated the composite score of past_talk by averaging the responses to the three statements. Similarly, we measured social_norm as the extent to which respondents were subject to normative social influence. Specifically, we averaged scores measuring respondents' agreement with the three statements about conforming to descriptive norms associated with invasive plant management on a five-point Likert scale (from 5 = strongly agree to 1 = strongly disagree; Cronbach's alpha = 0.93; Table 1).

To estimate the probability that FFOs will engage in collective invasive plant management, we developed a binary logistic regression model. Before running the model with all the variables, two strong correlations were found between concern about invasive plants on one's own woodland and concern about invasive plants on neighboring or nearby woodland ($r_s = 0.807$; $p < 0.001$), and between age and retirement status ($r_s = 0.7129$; $p < 0.001$). Generally, a correlation of 0.1 indicates a weak relationship, 0.3 indicates a moderate relationship, and 0.5 or larger indicates a strong relationship (Acock 2016). Consequently, we removed variables measuring concern about invasive plants on own woodland and retirement status. After removing these two variables, we ran a variance inflation factor (VIF) test to check for multicollinearity. The average VIF score for the variables in the final model was 1.24, well below 4, a common rule of thumb for detecting multicollinearity (Vaske 2008; Warne 2018).

Results

The average age of respondents was 63 years old (SD = 12.7) and a majority (79%) of respondents were male. The average forest parcel size owned by respondents was 82 acres, and 70% of respondents had their primary residence on or within a mile of their forestland. Twenty-one percent of respondents had a written forest management or stewardship plan, whereas 13% were members of an environmental, conservation, or woodland owner organization. The socio-demographic characteristics of our FFO respondents were comparable to the average FFO in Indiana and the USA (detailed comparisons can be found in Table 2 in Clarke et al. 2019). For example, nationally the average age of FFOs is 64.8 years old (SE = 0.2, median = 65 years) and 79% of FFOs in the U.S. were self-identified as male (Butler et al. 2016). The most notable difference between our FFO respondents and FFOs nationally is that a larger percentage of our respondents owned land as part of a farm (57% of respondents) compared to 38% nationally, 21% of our respondents had a written forest management plan compared to 13% nationally, and 50% of our respondents had plans to remove invasive plants from their own woodland in the next five years compared to 29% of FFOs

Table 2 Logistic model estimating family forest owners' likelihood to work together with neighbors to remove invasive plants on both of their woodlands in the next five years

Independent variable	Odds ratio	Standard error
concern_nearbyland	1.3587**	0.1604
confidence_removal	1.4478**	0.1627
past_talk	2.7478*	1.2146
past_work_together	33.3208**	28.9650
past_management	0.6784	0.1903
know_how_cooperate	1.0936	0.1402
need_work together	1.4441*	0.2511
social_norm	1.9254**	0.3655
acreage	1.0005	0.0007
residence	1.0752	0.2751
farm_history	0.7929	0.1989
management_plan	0.5832	0.1867
org_membership	1.0632	0.3567
age	1.0001	0.0096
gender	1.0389	0.3095
education	0.9738	0.0776
hh_income	0.8842	0.0876
number of observations	845	
LR chi-squared	138.48	
Pseudo R^2	0.2027	

*$p < 0.05$; **$p < 0.01$

with similar plans nationally (Butler et al. 2016). As such, our survey results should be interpreted with these differences in mind.

Two percent of respondents had worked with their neighbor to remove invasive plants from their forestlands in the past five years. In addition, most respondents had not talked to or shared information about invasive plants with their family and friends (86%), neighbors (92%), or other woodland owners (90%). However, 28% of respondents had undertaken invasive plant management activities on their own land in the past five years. Thirty-two percent had little to no concern, 33% were moderately concerned, and 35% were concerned or had great concern about invasive plants on neighboring or nearby forestlands.

Thirteen percent of respondents agreed or strongly agreed that "woodland owners know how to self-organize and cooperate with one another to control or remove invasive plants," suggesting low perceived collective efficacy. Despite these perceptions, 67% of respondents agreed or strongly agreed that "effective control and removal of invasive plants require woodland owners to work together."

Thirteen percent of respondents indicated that they were likely or very likely to work with their neighbors to remove invasive plants on all of their forestlands during the next five years, whereas 22% were undecided, and 65% were unlikely or very unlikely to do so. The logistic regression model for estimating FFOs' likelihood to engage in collective invasive plant management in the next five years was statistically significant ($X^2 = 138.81$; $p < 0.001$; Table 2).

At the 1% significance level ($p < 0.01$), five variables were significant predictors of FFOs' likelihood to engage in collective invasive plant management: concern about invasive plants on nearby or neighboring lands (concern_nearbyland, +), perceived self-efficacy (confidence_removal, +), past experience talking to others about invasive plants (past_talk, +), past experiences working with others to manage invasive plants (past_work_together, +), and social norms (social_norm, +) (see Table 2 for a full description of each variable). Respondents who were concerned about invasive plants on neighboring or nearby lands were more likely to be interested in collective invasive plant management. Landowners who expressed confidence in their own abilities to remove invasive plants from their own property indicated a higher likelihood of engaging in collective action. If landowners had worked with their neighbors to manage invasive plants or had talked to family and friends, neighboring landowners, or other non-neighboring landowners about invasive plants in the past five years, they were also more likely to indicate a higher likelihood of engaging in collective action. Those who perceived social norms associated with invasive plant management in reference to their family and friends, neighbors, and other landowners were also more likely to engage in collective action. At the 5% significance level ($p < 0.05$), two additional variables were statistically significant: need_work_together (+) and acreage (+) (Table 2). This means that respondents who agreed or strongly agreed that effective control and removal of invasive plants requires landowners to work together were more likely to be interested in collective action in the next five years, and that respondents who had larger woodland holdings also were more likely to be interested in collective action.

Discussion

We examined the importance of various social-psychological factors on FFOs' likelihood to work with their neighbors to remove invasive plants through the lens of community-led collective action. Our results show that landowners were significantly more likely to engage in collective invasive plant management if they were concerned about invasive plants on nearby or neighboring properties, had prior experience talking to others about invasive plants, had experience working with their neighbor to remove invasive plants from both of their lands, were perceiving descriptive social norms, and had higher levels of perceived self-efficacy.

As shown here, perceived self-efficacy was statistically significant in our model, but perceived collective efficacy

was not. This result is unexpected because collective efficacy beliefs have encouraged people to engage in other forms of invasive species management, such as working with extension professionals (Erwin et al. 2019; Lubeck et al. 2019). It is also unexpected because collective efficacy beliefs have been found in some studies to be a more significant predictor of other types of pro-environmental behavior than perceived self-efficacy (Jugert et al. 2016). Therefore, further research is needed to clarify the role of collective efficacy including the conditions under which collective efficacy triggers collective action and when its effect may be muted by other factors. Furthermore, previous research has documented the role of model landowners in recruiting and motivating other landowners to engage in natural resource management (Niemiec et al. 2019). Studies have also shown that landowners may be motivated to engage in collective action for natural resource management when there are various micro interventions such as neighbor discussion and collective goal setting organized locally by trusted peers or community leaders (Niemiec et al. 2019). Therefore, further research may help understand the potential for model FFOs to enhance collective efficacy beliefs among peer landowners, through demonstrating effective management, sharing information, providing encouragement, or other approaches.

We also found that most FFOs in our study had low levels of perceived self-efficacy and collective efficacy in terms of managing invasive plants. Furthermore, most FFOs had little to no past experience working with others to manage invasive plants. Given previous studies suggesting that higher perceived self-efficacy is associated with higher perceived collective efficacy (Bandura 2000; Jugert et al. 2016), enhancing FFOs' perceived self-efficacy about invasive plant management may be an effective way to motivate collective action. Landowners' perceived self-efficacy may be boosted by not only their own successful invasive plant management experiences in the past but also observing other landowners managing invasive plants successfully, coupled by encouragement and positive affirmation from others (Bandura 1997). In other words, facilitating FFOs in gaining perceived self-efficacy may result in them being more inclined to collectively manage invasive plants as well.

Social norms were positively associated with FFOs' likelihood to work together, as were positive attitudes toward the need for FFOs to work together to effectively manage invasive plants. Our results are consistent with previous research on social norms and invasive species management, which suggested that landowners are less likely to manage invasive species if their neighbors are not also managing them (Marshall et al. 2016; Epanchin-Neill et al. 2010; McKiernan 2017). In addition to the power of social norms, it is possible that landowners who are knowledgeable about invasive plants may think it is futile to manage invasive plants themselves if their neighbors' properties are still a source of propagation (Ma et al. 2018). Although social norms regarding expected management behavior can be a powerful motivator (McKiernan 2017), many FFOs own their properties for a sense of independence and privacy (Clarke et al. 2019). Such a culture of independence and privacy may be a barrier to FFOs sharing information regarding invasive plant management or collaborating on control efforts (Erwin et al. 2019; Graham 2013; Ma et al. 2018; Ravnborg and Westermann 2002). Accordingly, we suggest that nonintrusive, creative forms of information sharing, and strategies for amplifying social norms associated with invasive plant management would be important. For example, placing signs on the properties of FFOs who have been controlling invasive plants to make their actions visible to others may be a nonintrusive but effective way to facilitate a sense of social norm about invasive plant management in a local community, which could motivate other landowners to do the same. Finally, it is important to note that we incorporated one dimension of social norm in our study by measuring the extent to which our survey respondents were subject to normative social influence. Additional insights may be gained by incorporate measures of various dimensions of social norm in future research on invasive plant management.

We found that concern about invasive plants on neighboring woodlands was a strong predictor of likelihood to work with neighbors to manage invasive plants, which may indicate recognition among FFOs of invasive plants as a landscape-level problem or even a public goods problem. Prior research has suggested that if landowners do not collectively perceive invasive plants as a threat, collective action might be difficult (McKiernan 2017; Fischer et al. 2019; Lubeck et al. 2019). In our study, 43% of FFOs agreed or strongly agreed that Indiana needs a coordinated effort to control or remove invasive plants on privately owned woodlands. Opportunities may exist for landowners to work with organizations such as the Cooperative Extension programs that can help recruit unwilling landowners and provide financial support to control invasive plants (Graham and Rogers 2017). For example, farmers who have worked with Extension agents to manage weeds on their properties are more likely to communicate with their neighbors about herbicide-resistant weeds and perceive a greater need for cooperative management than farmers who have not yet worked with Extension agents (Erwin et al. 2019). Further work is needed to better understand if there are specific impediments for public and private organizations to act on landowners' shared concern about invasive plants on neighboring woodlands and how to capitalize on FFOs' shared concern to mobilize them to communicate with neighbors about invasive plants.

We found that FFOs were more likely to indicate a likelihood to work with their neighbors if they had prior experience collaborating with others to manage invasive plants or if they had at least talked to others about invasive plants. However, mechanisms for facilitating communication among FFOs regarding invasive plant management are not well understood. One would assume if a landowner is a member of an environmental, conservation, or woodland owner organization, they may be more likely to be interested in working with others. However, membership was not a statistically significant predictor in our model. Previous research has shown that participation in community organizations provides opportunities for residents to build trust, which may lead to an increase in perceived collective efficacy (Collins et al. 2014; Flint and Luloff 2007). Therefore, our result could mean that invasive plant management is not a major or frequent topic of discussion among these environmental, conservation, or woodland owner organizations, or that membership in environmental, conservation, or woodland owner organizations may not facilitate a sense of collective efficacy among FFOs. It is also possible that FFOs in our study are members of national or state-level conservation organizations (e.g., Indiana Audubon Society, Indiana Native Plant Society, Indiana Forestry & Woodland Owners Association) that may not afford opportunities to facilitate networking, trust, or information sharing at the local level, which is important for promoting collective action. As suggested by Graham and Rogers (2017), landowner groups are more likely to experience increased collective efficacy when they organize events to address common challenges associated with invasive plant management locally.

When FFOs share information about invasive plant management, it creates an opportunity to establish greater social networks and trust. Trust and reciprocity among neighbors have been found to facilitate collective invasive plant management (Marshall et al. 2016; Niemiec et al. 2016). Reciprocity can be cultivated and enhanced through repeated social interactions to build trust among landowners by providing opportunities for them to socialize, share information and resources, or plan activities together (Ostrom 2010; Ma et al. 2012). However, this can also be challenging because FFOs might not know their neighbors and, in some cases, FFOs' properties may be geographically isolated. Furthermore, high property turnover is an impediment to collective invasive plant management (McKiernan 2017). Examination of the ways in which FFOs interact and communicate about landscape-level threats such as invasive species, may inform how to target information sharing and assistance among FFOs to facilitate community-led collective action.

In our study, residence status (absentee versus resident) was not associated with an FFO's likelihood to work with their neighbors to manage invasive plants. Previous studies suggest that absentee landowners are less likely than resident landowners to participate in various forms of forest management such as removing invasive plants (Snyder et al. 2020; Niemiec et al. 2018; Sagor and Becker 2014) or harvesting timber (Hendee and Flint 2013). A study of absentee landowners in Montana reported that absentee landowners do not manage invasive plants because of the time commitment (Yung et al. 2015). However, absentee landowners who are members of a conservation organization are more likely to engage in wildlife habitat management and removing invasive plants than other absentee landowners who are not members of a conservation organization (Snyder et al. 2020). So far, studies of the effect of residence status on forest management have been inconclusive and have mostly focused on individual management behaviors. Our result suggests a need to further understand the role of residence status in shaping collective actions. In fact, invasive plant management can be time consuming, labor intensive, and costly for both absentee and resident landowners (Ma et al. 2018; Clarke et al. 2019; Yung et al. 2015). For absentee landowners, these challenges can be further compounded by the fact that they may not be up to date with the invasive plant problems on their property since they do not reside there on a regular basis. For resident landowners, these challenges can be compounded by absentee neighbors not managing invasive plants in a timely manner. This presents a need and an opportunity to create dialogue among neighbors, both resident and absentee landowners, to address the landscape-level nature of invasive plant management through tailored messaging and facilitated conversations.

Previous studies also suggested that having a written management plan is a significant predictor of collective action (Kittredge 2005; Schulte et al. 2008; McKiernan 2017). However, a written management plan was not a significant predictor in our model. Currently, most forest management plans in Indiana provide landowners with species inventory and management recommendations for the next five to ten years on the basis of landowners' visions for their properties. It is unclear the extent to which invasive species information is included in these forest management plans and whether landowners use these forest management plans to guide their actions on the ground. There is limited understanding of how landscape-level and collective resource management issues such as invasive species management and fire management, are or could be incorporated into forest management plans.

Conclusion

Community-led collective action can increase the success of invasive plant management at both the individual and

landscape levels (Bagavathiannan et al. 2019). Previous studies evaluated the effectiveness of invasive species management programs or cooperatives (Graham 2013; Graham and Rogers 2017; Hershdorfer et al. 2007; Niemiec et al. 2017b); however, understanding of the complex relationships among perceived self-efficacy, collective efficacy, social norms, and community-led collective action relative to invasive plant management remains incomplete. Our study identified factors associated with neighboring landowners working together to manage invasive plants without a formal mechanism or program. Specifically, our study contributes to knowledge of invasive plant management and collective action by examining the association between FFOs' perceived self-efficacy and collective efficacy and their interest in undertaking invasive plant removal activities in coordination with their neighbors.

Although we recognize that individual FFOs' activities relative to invasive plant management are necessary, the ultimate success of such efforts will likely be shaped by the collective action of FFOs in areas where invasive plants have established. As such, more insights on how best to measure perceived self-efficacy and collective efficacy about invasive plant management could further enhance understanding of the strengths of these factors in facilitating community-led collective action and identify opportunities for leveraging these factors to encourage community-led collective action. Successful invasive plant management usually requires sustained efforts over multiple years. Therefore, it is worthwhile to identify not only factors that motivate the initiation of community-led collective action among neighboring landowners, but also factors that contribute to the longevity of effective community-led collective action.

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Compliance with Ethical Standards

Conflict of Interest The authors declare no competing interests.

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