Research article

Public and manager perceptions about prescribed fire in the Mid-Atlantic, United States

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ABSTRACT

Firescapes of the Mid-Atlantic are understudied compared to other ecosystems in the United States, and little is known about the acceptance of prescribed fire as a forest management tool. Yet, this region harbors high levels of wildland-urban interface (WUI), has a close intermingling of land ownerships, and reflects substantial regional heterogeneity in burning histories and fire hazards. As prescribed fire is increasingly applied in the Mid-Atlantic as a critical tool to meet various land management objectives, research is needed to help managers understand community perceptions of prescribed fire implementation. Through intercept surveys of forest recreationists and online surveys of fire managers, this study investigates perceptions about prescribed fire use in the Mid-Atlantic, in addition to the critical contributing factors of public support toward prescribed fires. Two states, Pennsylvania and New Jersey, were selected as case studies to explore regional differences in social perception due to their contrasts in fire history, policy, management objectives, and social exposure. Our results show moderate social awareness of local prescribed fires, moderate to high familiarity with prescribed burning, high agency trust, and strong community support toward prescribed fires. However, the perceived concerns and benefits differed between managers and forest recreationists and between recreationists from Pennsylvania and New Jersey. The factors influencing the support of prescribed burning practices included forest management beliefs, concern about prescribed fire effects, familiarity with prescribed fires as a forest management tool, and awareness of local prescribed fires. Collectively, these results highlighted needs in public outreach to strengthen education, build broader community awareness, engage critical stakeholder groups such as forest recreationists, and re-align public outreach messages based on community-level concerns and perceived benefits. Additionally, it will be vital for the scientific community to help monitor critical shifts in forest value orientations and fill in significant research gaps regarding prescribed fire benefits.

1. Introduction

Fire is a crucial disturbance process in forest ecosystems, regulating important ecosystem functions such as biodiversity, wildlife habitat, and nutrient cycling (Pausas and Keeley, 2019). Prescribed fires involve the controlled use of fire to accomplish various management goals. Due to multiple benefits such as fuel reduction and habitat regeneration, there have been increasing calls in the US to incorporate prescribed fires as a critical component of a comprehensive forest management approach (Hiers et al., 2020), especially in the Mid-Atlantic region, where many decades of fire suppression have altered forest composition and the majority of fire occurs via prescribed burning (Gallagher et al., 2022; Nowacki and Abrams, 2008). However, recent increases in wildfire intensity and extent, especially in the Western US, have led to increasingly

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expensive firefighting efforts (National Interagency Fire Center – NIFC, 2022; Pennick McIver et al., 2021) and reduced resources for prescribed burning, even in the Mid-Atlantic, where wildfires are less common. As a result, optimizing prescribed burning to meet multiple social and environmental objectives is critical (Bowman et al., 2018), and identifying community and manager perceptions of associated challenges and benefits is needed.

Prescribed fire implementation is highly variable spatially and temporally in the Mid-Atlantic (Dems et al., 2021; Zhao et al., 2021). This is partly attributed to the generally lower wildfire risk compared to other regions nationally, making fuel reduction a secondary objective in most areas. However, in some areas with high wildfire risk, such as the New Jersey Pine Barrens, there is a long tradition of prescribed burning, with an average of 7000 ha burned annually during the past decade (New Jersey Department of the Treasury, 2014; 2016, 2018, 2020, 2022). Additionally, the temporal and spatial heterogeneity in regulatory policies also contributes to the varied prescribed fire implementation. For example, Pennsylvania only recently passed the Prescribed Burning Practices Act in 2009. This reintroduced prescribed fires to areas excluded from fire for up to 80 years or more, primarily to restore habitat conditions and promote landscape-level biodiversity (Klimkos, 2017; PA Department of Conservation & Natural Resources – DCNR, 2022). In 2021, over 8863 ha of county, federal, private, and state lands were treated with prescribed fire in Pennsylvania (PA DCNR, 2022).

Overall, little is known about the social barriers and facilitators of prescribed fire implementation in the Mid-Atlantic compared to other US regions (Dupéy and Smith, 2018). In the western US, high wildfire concerns and the critical need to mitigate fire hazards have led to significant efforts to create social acceptance of prescribed fires (Monroe, 2005). Similarly, in the southeastern US, communities have a long history of living with and using prescribed fire in land management. In contrast, in places in the Mid-Atlantic (e.g., Pennsylvania) where prescribed fire recently emerged as a management tool, public perceptions remain largely unexplored. Limited previous studies were mostly conducted before 2010 in the fire-prone northeastern pitch pine forests (Blanchard and Ryan, 2007; Ryan and Wamsley, 2006, 2008; Ryan, 2012). However, even in these areas where prescribed fire has been historically more common, motivations for and extent of burning practices are shifting. For example, a 2018 policy in the Pine Barrens (NJAC 7:27–2.1, 2018) has diversified management objectives to include habitat restoration, meanwhile creating more flexibility in public-private partnerships to expand prescribed fire use on private lands. It is not clear how local communities perceive these changes yet.

Understanding the perceptions of prescribed burning in the Mid-Atlantic is important for several key reasons. First, as demonstrated in other regions nationally, public perceptions play an essential role in facilitating or limiting prescribed burning. For example, across the rangeland ecosystems where acceptance of prescribed burning is high, grass-roots efforts (e.g., prescribed burn associations) have been instrumental in educating the public and advocating for increased prescribed burning (Weir et al., 2016). Conversely, adverse public and manager perceptions, especially after escaped prescribed fires, have caused complete and long-term elimination of prescribed burning on certain landscapes and within specific agencies (Botti and Nichols, 2021). Such perceptions can also affect litigation outcomes and legislation that further limit prescribed burning (Yoder, 2008). Second, social perceptions of prescribed fire can be highly variable across regions, and the unique spatial and socio-ecological complexities in the Mid-Atlantic may lead to substantially different perceptions from those reported elsewhere. In particular, the pervasive wildland-urban interface (WUI) and tightly intertwined land ownerships here (Radeloff et al., 2018) mean fire operations and resultant smoke management are very important given their potential visibility and impact. Additionally, the complexity and heterogeneity of governance structures, land ownerships, and jurisdictional boundaries require balancing multiple burning objectives, from tick control to habitat management to climate change

mitigation (Gallagher et al., 2022; Quinn-Davidson and Varner, 2011; Sample et al., 2022; Zhao et al., 2021). Understanding people's preferred benefits will help optimize burn objectives for managers.

This paper investigates the social perceptions of prescribed fire use in the Mid-Atlantic by examining attitudes of the public and fire managers (Fig. 1). Additionally, we identify the critical contributing factors of public support toward prescribed fires. We focus on the aspects frequently shown by parallel studies elsewhere as significant factors of prescribed fire support (Dupéy and Smith, 2018; McCaffrey and Olsen, 2012; McCaffrey et al., 2013; Toman et al., 2013). They include experience, awareness of and familiarity with prescribed fire use, concerns over prescribed fire effects, perceived benefits of prescribed fires (Ascher et al., 2012), beliefs about forest management approaches (Bright et al., 2007), and agency trust (Shindler et al., 2009). Other important preferential characteristics such as recreationist type (Miller et al., 2020) and demographic variables (Gordon et al., 2020; McCaffrey, 2006) are also examined.

More specifically, we selected the two states of Pennsylvania (PA) and New Jersey (NJ) as case studies to explore how social perceptions may differ across regions due to the previously mentioned contrasts in fire history, policy, management objectives, and social exposure. Additionally, forest recreationists were selected as a focal stakeholder group due to the essential goal of managing forests for recreation. Their high exposure to natural areas management and frequent engagement with resource managers also mean potentially different attitudes towards fire management from non-recreationists (Vogt et al., 2006). Fire managers were included because their perspectives have been particularly understudied nationally (Dupéy and Smith, 2018), with no previous studies in the Mid-Atlantic. A comparison between the managers and recreationists will help understand how public attitudes are perceived by managers, with implications for decision-making.

With the above research gaps and study scope in mind, we address the following specific research questions:

RQ1 (Concerns and benefits): To what degree do forest recreationists from PA and NJ and managers differ in their views concerning the effects and importance of prescribed fire?

RQ2 (Beliefs and trust): To what degree do forest recreationists from PA and NJ differ in their beliefs and levels of trust regarding forest management?

RQ3 (Drivers of public support): To what extent do aspects of forest use characteristics, prescribed fire experience and perceptions, and demographic attributes contribute to public support of prescribed fire use?

2. Materials and methods

2.1. Research design and sampling protocols

We approached the research questions using intercept and online surveys of forest recreationists and fire managers in PA and NJ. The intercept recreationist surveys occurred in October–December 2017 in PA and May 2018 in NJ. Fourteen university-trained researchers administered different rounds of sampling at seven locations on public lands (Apx. A). Sampling was conducted on both weekdays and weekends to capture a wide range of forest recreationists. The researchers intercepted adult participants at each location to introduce the survey while obtaining verbal consent for participation. Electronic tablets were used to collect data via Qualtrics. The survey instrument (See Section A.1, Apx. A) was pilot-tested before distribution.

The recreationist survey instrument consisted of 25 questions about forest recreation preferences, general prescribed fire perceptions, concerns on prescribed fire effects, importance of prescribed fire benefits, forest management beliefs, agency trust, support toward burns, and demographic information. Specifically, recreation preferences were explored by asking about forest visit frequency, activities, and ranking of four factors affecting people's decisions to visit a forest, i.e., fire hazard, wildlife habitat quality, visibility, and travel time. General perceptions
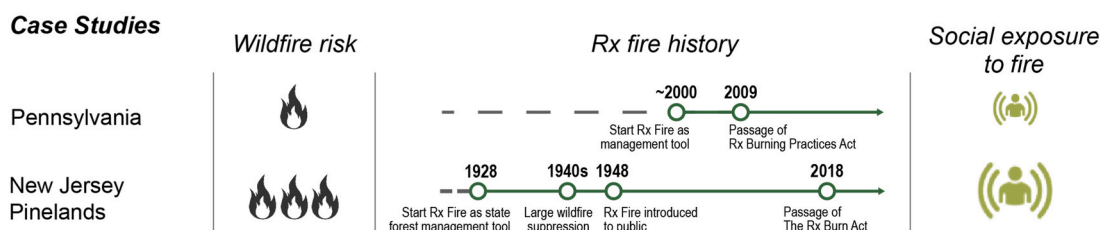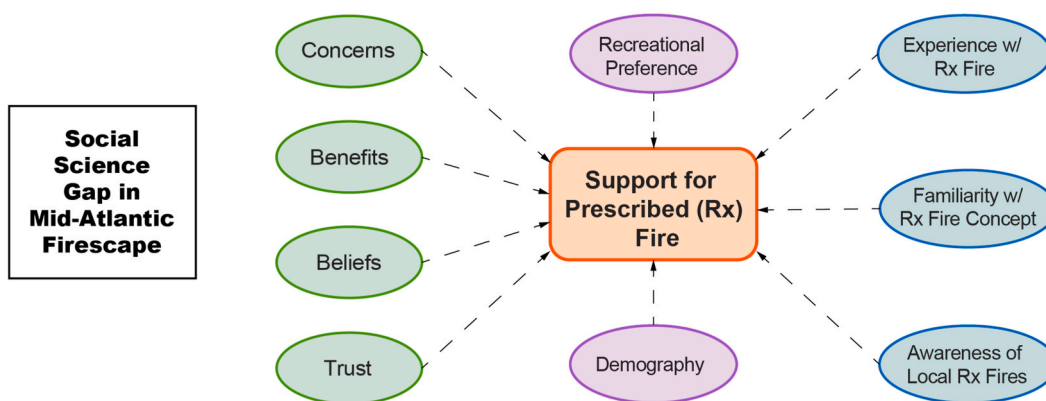
Fig. 1. Framework for exploring prescribed fire perceptions in the Mid-Atlantic.

were measured by awareness of local prescribed fires, experience, and self-reported familiarity with prescribed fires. Concerns and benefits of prescribed fire (RQ1) were measured, on a 5-point scale, by the degree of concern over six possible effects and importance of five potential benefits (Table 1). The lists of concerns and benefits were developed through four focus groups with 58 federal and state fire managers from the region. Forest management beliefs and agency trust (RQ2) were measured by the levels of agreement, on a 7-point scale, with six statements drawn from Bright et al. (2007) about the appropriateness of prescribed fire as a management tool and trust in agencies to effectively conduct burns. Finally, support toward burns (RQ2) was measured with a 7-point Likert-scale question.

Unlike the recreationist survey, the manager survey was distributed via an email listserv to fire managers in PA and NJ (e.g., PA DCNR, PA Prescribed Fire Council, PA Game Commission, Nature Conservancy, NJ

Forest Fire Service, National Park Service) in April 2018. Besides the above questions from the recreationist survey, managers were asked to provide input on their perceived top public concerns and benefits of prescribed fire through open-ended questions.

2.2. Data analysis

The entire dataset includes 350 responses from 304 recreationists (152 each from PA and NJ) and 46 managers. All the data were analyzed using SPSS and Amos version 27. First, descriptive statistics of participant profiles, forest recreation preferences, general prescribed fire perceptions, concerns, the importance of benefits, and forest management beliefs were generated. In particular, following the protocols in Section A.2, Apx. A, the two variables of forest recreation activities and prescribed fire experience were recoded to distinguish hunters vs. non-hunters and three levels (high, medium, and low) of prescribed fire experience, respectively.

Second, the samples were partitioned into three groups: PA and NJ forest recreationists, and managers. Independent t-tests were employed to explore how recreationists from PA vs. NJ differ in demographic characteristics, forest recreation preferences, awareness, experience, familiarity, trust, and support for prescribed fire.

Third, two-way Mixed ANOVA tests and subsequent simple main effects were conducted to determine whether a significant interaction exists between effect/benefit/belief type and group on perceptions of concerns, benefits, and beliefs, respectively.

Fourth, the structural equation modeling (SEM) technique (Kline, 2015) was employed to assess how forest use characteristics, prescribed fire experience and perceptions, and demographic attributes contribute to the support of prescribed fire. SEM is commonly applied in social and behavioral sciences to test complex, causal relations between multiple latent variables of interest through a convenient framework that contains multi-procedure statistical analysis (e.g., factor analysis, regression analysis) (Kline, 2015). We chose SEM not only because it allows complex human values, such as beliefs in our case, to be tested as constructs, but also can simultaneously verify the causality among multiple variables.

Prior to the SEM procedure, data for all recreationists (n = 304) were

Table 1
Measurement items for concerns, benefits, beliefs, and trust.

Factor		Measurement items
Concerns	1	Smoke and associated health concerns
	2	Wildlife mortality during burns
	3	Possible escape to private property
	4	Decreased forest aesthetics
	5	Limited recreational access
	6	Cost of conducting burns
Benefits	1	Lower wildfire risk
	2	Invasive species control
	3	Increase of game species carrying capacity
	4	Regeneration and preservation of endangered and iconic species
	5	Decline of tick population
Beliefs	1	*"We should just leave forests alone instead of setting prescribed burns."*
	2	*"Prescribed burns are not as appropriate as other measures for managing forests because of the associated risks."*
	3	*"It's acceptable for forest managers to use prescribed burns to decrease the chances of a large-scale fire."*
	4	*"It's acceptable for forest managers to use prescribed burns to improve wildlife and game habitat, and forest conditions."*
	5	*"The benefits of prescribed burns outweigh their risks, so it is appropriate to use prescribed burns for forest management."*
Trust	1	*"I trust that land management agencies know how to effectively plan and conduct prescribed burns."*

cleaned to account for missing data, outliers, skewness, and kurtosis, resulting in a subset with 213 complete responses (124 from PA and 89 from NJ; see subsample characteristics in Table S1, Apx. B). T-tests were run between the full and subsample and revealed no significant differences for any demographic variables.

Next, confirmatory factor analysis (CFA) was conducted to validate the measurements of the three latent variables of beliefs, concerns, and benefits. Factor loadings were reviewed to ensure that they exceeded 0.40. Composite Reliability (CR) and Cronbach's alpha were calculated to establish factor reliability, with thresholds set as 0.60 and 0.70, respectively (Hair et al., 2009). Bootstrapping (n = 2000) was applied to address multivariate normality concerns. Based on Ferraro et al. (2020), six goodness-of-fit statistics were used to evaluate how well the data fitted the hypothesized model constructs. They included the comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), standardized root mean square residual (SRMR), χ^2, and Bollen-Stine bootstrap (BS_{boot}) (Kline, 2015). In particular, CFI and TLI should be ≥ 0.90 (acceptable); RMSEA should be ≤ 0.10 (sufficient); SRMR should be ≤ 0.08 (acceptable) (Hu and Bentler, 1999; Kline, 2015). Moreover, it is acceptable for the χ^2 and BS_{boot} to be statistically significant ($p < 0.05$) due to the high likelihood for both indices to be rejected with larger samples (n $\geq$ 200) (Ferraro et al., 2020).

Lastly, building upon the CFA, a full SEM was established by incorporating seven other literature-informed variables, including hunting experience, experience and familiarity with prescribed fires, awareness of local prescribed fires, age, gender, and education. Because gender (p = 0.422) and education (p = 0.424) showed non-significant and minimal standardized regression weights (both < 0.05), they were removed from the model. Moreover, to investigate potential model differences between PA and NJ recreationists, we performed multigroup SEM Chi-square comparisons (Chin et al., 2016) (see Table S2, Apx. B) by constraining the measurement and structural weights to be invariant across the two groups. However, no significant changes in fit indices were produced compared to the unconstrained model. Therefore, the pooled sample SEM model is reported as the final model.

3. Results

3.1. Sample characteristics

The characteristics of the full sample with 304 recreationists and 46 managers are presented in Table 2. Among the recreationists, the majority were male (63%). The average age was ~45 years old. Over half of the respondents (57%) held a bachelor's or higher degree, likely due to some PA sampling sites close to a university and NJ sites attracting regional visitors during the Memorial Day weekend. About 36% had a 2016 household income of over $100,000. The managers were predominately male (89%), with an average age of ~49. About 38% held a bachelor's or higher degree, and 33% had their 2016 household income exceeding $100,000.

Among the recreationists, 42% visited forests more than once/week. The primary activities included hiking (68%), walking/dog walking (45%), and wildlife and plants observation (42%). People's visits were most importantly driven by habitat quality, followed by visibility, required travel time, and fire hazards (Fig. 2-a; see detailed statistics in Table S3, Apx. B). The PA and NJ recreationists differed by gender, recreationist type, and forest visit frequency. More PA visitors were male ($M = -0.27$, 95% CI [-0.39, -0.16], $t(292) = -4.775$, $p < 0.0001$, d = 0.491) and hunters ($M = 0.49$, 95% CI [0.41, 0.58], $t(299) = 11.307$, $p < 0.0001$, d = 0.378). They also visited forests more frequently (M = 1.43, 95% CI [1.02, 1.83], $t(301) = 6.928$, $p < 0.0001$, d = 1.794).

PA and NJ recreationists showed similar awareness of local prescribed fires (p = 0.764) and experience with prescribed fires (p = 0.468) (Fig. 2). About 46% of all recreationists were aware of local prescribed fire occurrences (Fig. 2-b). Twenty-two percent had deep experience,

Table 2
Participants' demographic profiles and forest use behavior.

	Groups			Total %	Total N
	PA recreationists	NJ recreationists	Managers		
Sample	152	152	46	100%	350
Gender					
Male	79%	51%	95%	69%	232
Female	19%	49%	5%	29%	98
Age					
18-35	29%	41%	14%	32%	105
36-65	56%	49%	78%	55%	179
$\geq$66	15%	11%	8%	12%	40
Education level					
High school/ GED or below	15%	17%	0%	14%	46
Technical/ vocational	5%	5%	5%	5%	16
Some college	19%	22%	54%	25%	82
Bachelor's	33%	34%	34%	33%	112
Master's & Ph.D.	29%	22%	7%	24%	79
Household income (2016)					
< $49,000	18%	25%	10%	20%	54
$50,000-$99,999	35%	38%	40%	37%	100
$100,000-$149,999	27%	24%	40%	27%	73
$\geq$ $150,000	20%	14%	10%	16%	44
Recreationist type					
Hunter	53%	3%	39%	30%	103
Non-hunter	47%	97%	61%	70%	244
Forest visit frequency					
< Monthly	18%	50%	18%	32%	111
1–3 times/ month	28%	25%	27%	27%	92
$\geq$ Weekly	54%	25%	56%	42%	145

working with prescribed burns at their jobs, or having their own or an acquaintance's work or livelihood affected by prescribed burns (Fig. 2-c). Another 46% had low experience, including having seen a recently burned forest, forest regrowth, or smoke, or heard about it in the news, on TV, or from family.

Conversely, PA and NJ recreationists showed significantly different familiarity with prescribed fire use (Fig. 2-d) and frequency following forest management (Fig. 2-e). The average self-reported familiarity was moderate to high (mean = 3.47), but NJ recreationists (mean = 3.77) showed significantly higher familiarity than PA (mean = 3.20) ($M = -0.57$, 95% CI [-0.87, -0.28], $t(285) = -3.856$, $p < 0.001$, d = 1.257). Additionally, most recreationists did not regularly follow their areas' management, with 62% checking management at intervals >1 month. PA recreationists followed management between monthly to a few times a year, significantly more frequently than NJ (~ a few times a year) ($M = -0.61$, 95% CI [-1.10, -0.11], $t(287) = -2.381$, p = 0.018, d = 1.794).

3.2. Concerns and benefits of prescribed fire

For all participants, the concern levels on all six prescribed fire effects were relatively low (means ranged from 1.88 to 2.60), with the aggregated mean (2.18) mildly above *slightly concerned*. The two-way Mixed ANOVA test revealed a significant two-way interaction between effect type and group, $F(9.155, 1423.53) = 15.535$, $p < 0.001$, $\varepsilon = 0.915$, partial $\eta^2 = 0.091$. The post-hoc pairwise comparisons with Bonferroni correction showed different orders and levels of concern for the three groups (Fig. 3-a; see all detailed statistics in Tables S4 and S5, Apx. B). Specifically, both PA and NJ recreationists ranked wildlife mortality as their top concern, whereas the managers rated possible
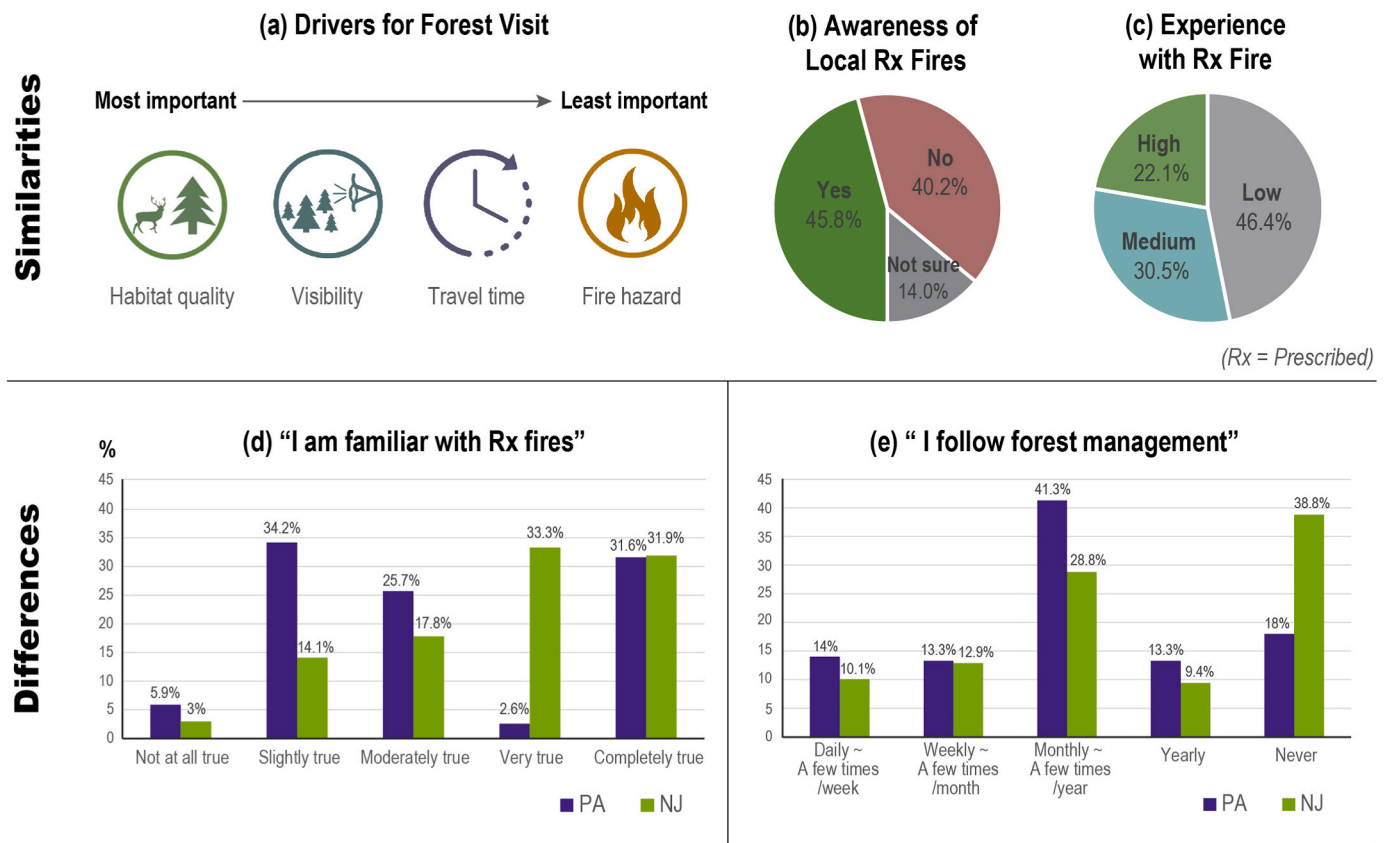
Fig. 2. Similarities and differences in forest recreationists' general prescribed fire perceptions in Pennsylvania and New Jersey.

escape as the highest. The managers' survey indicated that their perceived top public concern was smoke, which was not as crucial as recreationists thought, especially for the PA recreationists who ranked smoke the lowest.

For all participants, the average importance of all benefits was between moderately to very important (aggregated mean = 3.65, means ranged from 3.18 to 4.13). The two-way Mixed ANOVA test revealed a significant two-way interaction between benefit type and group, F (7.724, 1208.74) = 11.783, $p < 0.001$, $\varepsilon = 0.965$, partial $\eta^2 = 0.70$. The post-hoc pairwise comparisons with Bonferroni correction showed different orders and levels of benefit importance for the three groups (Fig. 3-b; Tables S6 and S7, Apx. B). Specifically, both PA and NJ recreationists ranked tick reduction as the most important, whereas the managers rated lower wildfire risk at the top and significantly more important than the recreationists. With that said, tick reduction remained highly important to managers. The managers' survey indicated that they perceived "lower wildfire risk" and "habitat improvement/healthier forest" as the top two most important public benefits, which differed from the above results, especially for the PA recreationists who ranked lower wildfire risk as the least important. Additionally, game species increase consistently ranked bottom for all three groups, and the NJ recreationists rated it significantly lower than the other two groups.

3.3. Beliefs, trust, and support

The two-way Mixed ANOVA test revealed no statistically significant two-way interaction between belief item and group ($p = 0.235$). Individual forest management beliefs were similar between PA and NJ recreationists with one exception: the former showed a significantly higher agreement with statement IV, i.e., prescribed burn as acceptable

tool to "improve wildlife and game habitat and forest conditions" (Table S8, Apx. B). Across the five belief items, recreationists showed lower agreement on the reversely coded beliefs I and II than III, IV, and V (Table S9, Apx. B).

The PA and NJ recreationists also showed similar agency trust ($p = 0.661$) and support for prescribed burns ($p = 0.384$). People indicated high trust in agencies' ability to plan and conduct burns (Fig. 4). Most recreationists (75%) had moderate, strong, or very strong support for prescribed burning. Very few (6%) answered "completely" or "strongly oppose."

3.4. Integrated drivers of public support

3.4.1. Measurement model analysis

The CFA examining the validity of the concerns, benefits, and beliefs measurements indicated a strong model fit (Fig. S1, Apx. B). Cronbach's alpha and CR passed the specified thresholds of 0.70 and 0.60, respectively (Table S10). Although the χ^2 ($\chi^2 = 194.33$, df = 100, $p < 0.001$) and BS$_{boot}$ ($p = 0.010$) were significant, all other fit statistics passed the rules of thumb (RMSEA = 0.067; SRMR = 0.0623; CFI = 0.929; TLI = 0.915). The factor loadings were all statistically significant ($p < 0.001$) and above the 0.30 cutoff, with most loadings > 0.60 (Fig. S1).

3.4.2. SEM

The fit statistics of the full SEM model (Fig. 5) also indicated a good model fit (RMSEA = 0.060, p-close = 0.068; SRMR = 0.0580; CFI = 0.919; TLI = 0.895), although the χ^2 ($\chi^2 = 313.707$, df = 178, $p < 0.000$) and BS$_{boot}$ ($p = 0.010$) were both significant. The model provided evidence for significant relationships between beliefs, concerns, awareness of local prescribed fires, familiarity with prescribed fires, and support toward prescribed burning (Table 3). Beliefs showed the strongest effect
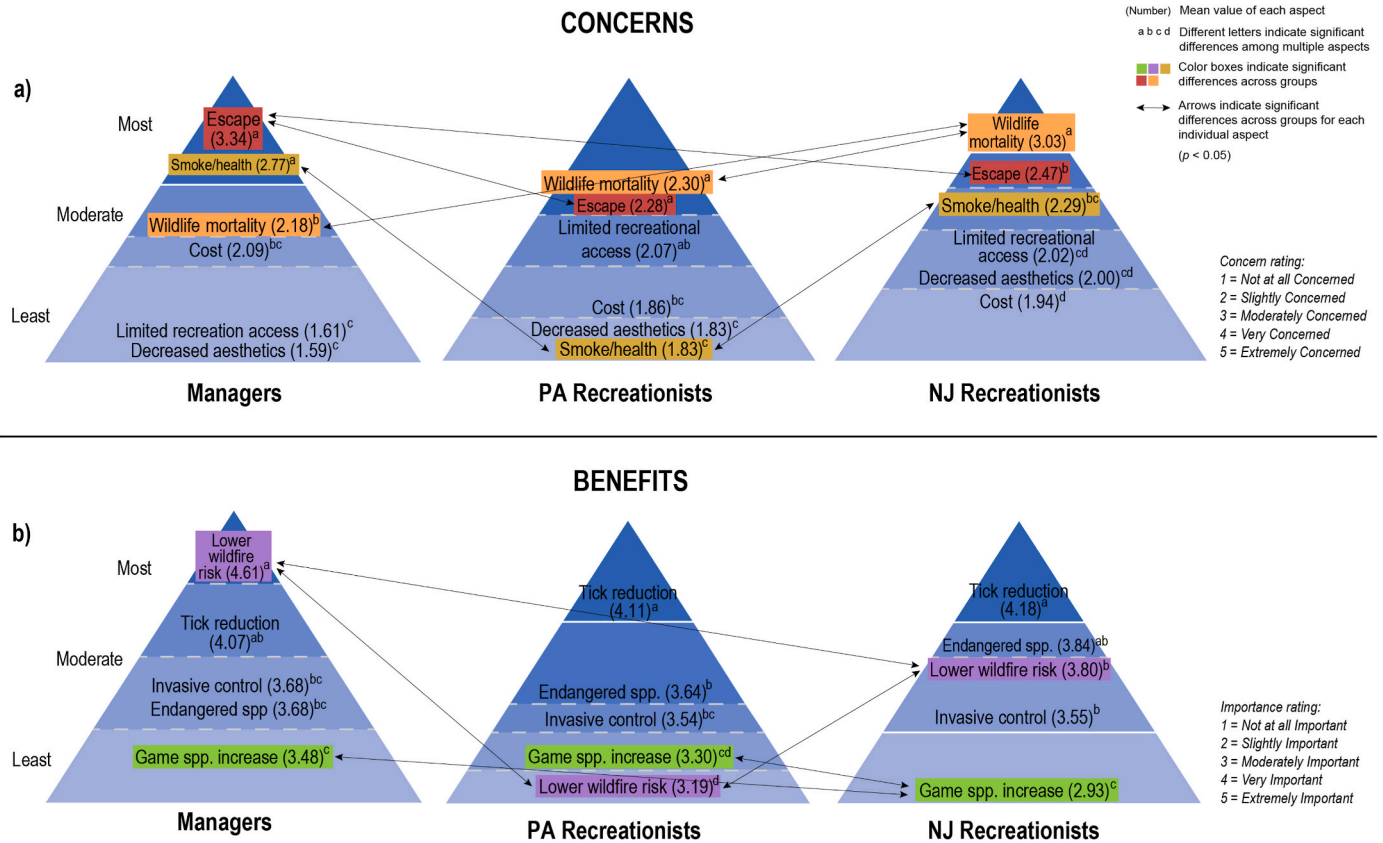
Fig. 3. Perspectives of forest recreationists and managers about concerns (a) and importance of benefits (b) of prescribed burning. See detailed statistics in Tables S4–S7 (Apx. B).

(0.421), whereas the other three showed similar lower effects (−0.220, 0.155, and 0.152, respectively).

To summarize the findings above, first, the recreationist survey captured a predominately male, mid-aged, high-income, and well-educated sample who frequently visited forests for recreation. Habitat quality was the top reason for people's visits, whereas fire hazards ranked at the bottom. Second, participants were moderately well aware of prescribed fire occurrences in their areas but lacked deep experience. They reported moderate to high familiarity with the prescribed fire concept, although most did not regularly follow local forest management. Most participants believed that prescribed fire was an appropriate management tool, although they appeared less sure about how it compared to other alternatives. Third, people generally showed low concerns over prescribed fire effects and recognized potential benefits, especially tick reduction and endangered species preservation. Fourth, agency trust and support for prescribed fires were stronger than perceived by managers. Lastly, forest management beliefs, concerns, familiarity with, and awareness of prescribed fire are significant predictors of support.

4. Discussion

The overall goal of this study was to elucidate community and manager perceptions of prescribed fire management in the Mid-Atlantic to support effective implementation. The results provide insights into the variability in concerns, benefits, and beliefs of prescribed fire between groups (recreationists and managers), and between locations where prescribed fire is relatively new (Pennsylvania) versus common (New Jersey). Overall, forest recreationists in the Mid-Atlantic support implementing prescribed fire as a forest management strategy. Moreover, commonalities and differences among locations and groups should be used to better coordinate communication and participatory

strategies.

This study fills essential gaps in prescribed fire-related social science literature in the Mid-Atlantic region. As previously noted, this region is generally underserved in wildfire and prescribed fire research, let alone their social aspects (Dupéy and Smith, 2018). Previous work in the northeastern pitch pine forests primarily explored how residents and landowners perceive wildfire risk, their support for fire-hazard mitigation strategies (Blanchard and Ryan, 2007; Ryan and Wamsley, 2006, 2008), and how landscape preference and environmental education influence attitudes (Ryan, 2012). Our study significantly enriches this literature by investigating perspectives of forest recreationists and managers in the contrasting ecosystems of Pennsylvania and New Jersey, measuring a comprehensive set of social factors. As states across the nation are being challenged by federal and state initiatives and legislation to increase the quantity and quality of prescribed burning for multiple land management objectives, our study is posed to provide essential information and management implications for this region.

Based on our findings, addressing community concerns will be important to gaining acceptance of prescribed fire, and messages could be tailored to particular groups. For example, the relative importance of concerns differed among recreationists and managers and between regions. While managers were concerned about possible escapes and smoke, recreationists were the most concerned about wildlife mortality. Although potential escape remained a moderate recreationist concern, smoke and health effects turned out one of the participants' least worries, especially for the PA recreationists. Knowing this, for example, management strategies in Pennsylvania that reduce the likelihood of deleterious wildlife impacts (e.g., appropriate burn timing and ignition techniques) and educational resources that inform communities about wildlife dynamics following a prescribed fire (e.g., Carter et al., 2002; Harper et al., 2016) could be helpful.

Similarly, the differing perceptions of prescribed fire benefits among
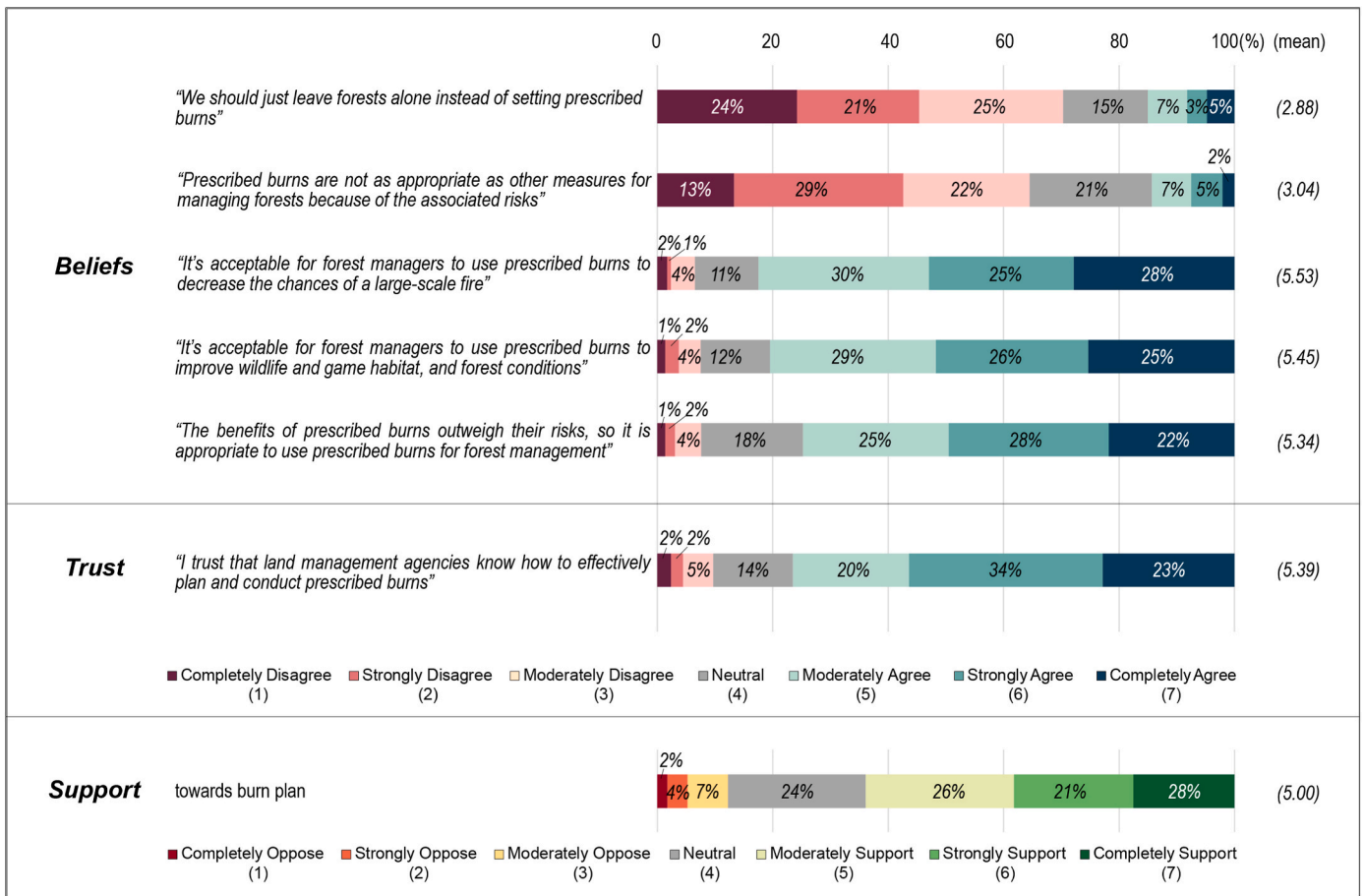
Fig. 4. Recreationists' forest management beliefs, agency trust, and support toward prescribed fire.
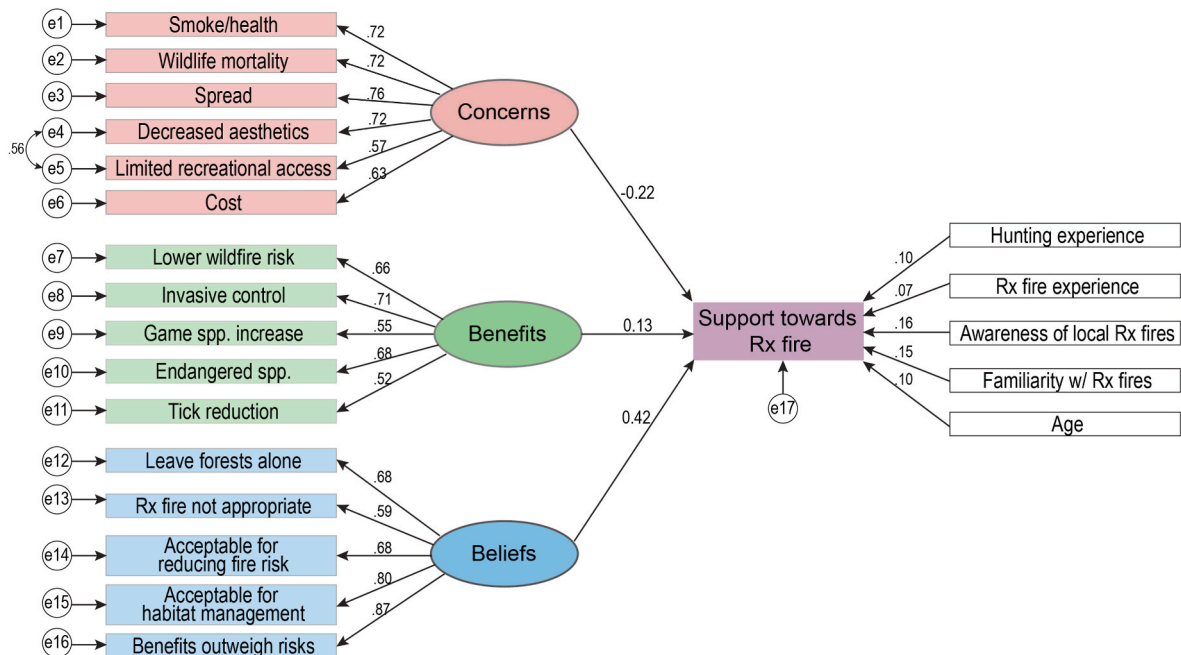

Fig. 5. Structural equation model for the relationship of concerns, benefits, beliefs, other variables, and support for prescribed burning. Fit statistics: $\chi^2 = 313.707$, df = 178, $p < 0.000$; BS_{boot}, $p = 0.010$; RMSEA = 0.060, p-close = 0.068; SRMR = 0.0580; CFI = 0.919; TLI = 0.895.

Table 3
Effects of predictors on support toward prescribed fires in SEM.

Predictors	Path coefficient	Effect size	CR	*p-value*
Concerns	−0.220	Small-Medium	−2.660	**0.050**
Benefits	0.133		1.792	0.162
Beliefs	0.421	Medium-Large	4.718	**0.016**
Hunting experience	0.097		1.718	0.227
Prescribed fire experience	0.073		1.278	0.408
Awareness of local prescribed fires	0.155	Small-Medium	2.492	**0.039**
Familiarity with prescribed fires	0.152	Small-Medium	2.528	**0.046**
Age	0.096		1.796	0.053

managers and recreationist groups can provide guidance for outreach strategies. Interestingly, tick reduction was uniformly considered the most important benefit by recreationists (and was even ranked second in importance by managers). This suggests that tick management may be an intriguing opportunity for aligning fire management goals with the public's most desired management outcome. However, despite some evidence supporting the post-burn decline of tick populations and tick-borne pathogens (e.g., Gallagher et al., 2022; Gleim et al., 2019; Parker-Fann, 2020; Tripp, 2017), burn effects on ticks remained poorly understood and understudied in the region. Aside from ticks, the NJ recreationists ranked wildfire risk reduction significantly higher, and game species increase significantly lower, than PA recreationists, again providing insights that could guide regionally specific communication and participatory strategies.

Perhaps the most intriguing outcome of our surveys was the strong level of trust and support of prescribed fire management by recreationists in both states, in contrast to the midlevel support by residents and homeowners near pitch pine forests reported in Ryan and Wamsley (2006). Our SEM approach provides nuanced understanding of the multiple factors driving that support, specifically the importance of beliefs around prescribed fire management. Results show that idea that 'benefits outweigh risk' and that fires can improve habitat management and reduce wildfire risk led to strong support for prescribed fire. These beliefs offered a greater contribution to overall support than either benefits or concerns alone. This points to the need to consider holistic approaches to working with communities in fire management coordination such that communities (at least forest recreationists, in this case) are aware of, and able to weigh, relative concerns and benefits.

Moreover, awareness of local prescribed fires and familiarity with this practice significantly contributed to management support. Although there were slight differences between recreationists in Pennsylvania (lower familiarity) and New Jersey (higher familiarity), results overall indicated that these factors were important for driving support. This aligns with previous studies, such as Blanchard and Ryan (2007), which showed a positive influence of prescribed fire knowledge on public support. These findings suggest effective communication strategies about regional and local burn plans and occurrences, developed and tested based on specific community context, could be influential in long-term support for fire management strategies.

A great deal of research has demonstrated how people's value orientation can critically influence their perceptions, attitudes, and behaviors toward forests (e.g., Bengston, 2020; Stern et al., 1995; Vaske et al., 2001). This body of research highlights several relevant implications based on our results. The most important of these is that it is vital for scholars and management agencies to monitor critical shifts in value orientations in their communities (McCaffrey et al., 2013; Smith et al., 2016). Such approaches can help identify appropriate adjustments to forest management policies and how socially acceptable practices can be employed to accomplish both ecological and social goals. Ultimately, this body of research also suggests that forest management beliefs are

unlikely to be driven solely by a particular communication strategy or outcome, but are rather a product of multiple influences, including values typically formed early in life (Chawla and Rivkin, 2014; Halstead and Taylor, 2000) and factors such as overall societal and cultural shifts relating to outdoor engagement and the rising influence of social media (Bengston, 2020). Thus, in addition to understanding the local context, fire management strategies that include community engagement should be situated in these broader societal and cultural contexts.

Finally, despite these important management implications for the Mid-Atlantic, we note several limitations of the study. First, as with other line-intercept approaches, and despite careful methodological considerations, the representativeness of the participants of the broader population cannot be assured. Because budget limitations precluded a more extensive sampling strategy across social, environmental, or management gradients and at different times throughout the year, we captured a relatively highly educated, older, and male population in late Spring or early Fall. Inferences to other forest user groups, geographies, or seasons should be conservative. Second, the study focused on forest recreationists and local land managers only. Perceptions of other stakeholder groups, such as homeowners adjacent to forest areas or policymakers, would be important to include in future work.

5. Conclusions

Through intercept and online surveys of forest recreationists and fire managers in Pennsylvania and New Jersey, we explored perceptions about prescribed fire use in the Mid-Atlantic by examining attitudes of the public and fire managers and identifying critical contributing factors of public support. Overall, we found strong support for prescribed burns, primarily influenced by forest beliefs about the relative importance of this management technique for reducing fire risk and enhancing habitat quality, and that the benefits outweighed the risks. The specific concerns and benefits of prescribed fire differed between managers and forest recreationists and between recreationists from Pennsylvania and New Jersey. In addition, familiarity with prescribed fires and awareness of their local occurrences influenced people's support.

Prescribed fire is an effective tool for managing wildfire risk and supporting habitat restoration. However, to be effective, its application must not only meet management goals but also have broad-scale public support. To broaden implementation where appropriate, future management and policy in the Mid-Atlantic can focus on strengthening education, building broader community awareness, engaging critical stakeholder groups such as forest recreationists, and re-aligning public outreach messages based on community-level concerns and perceived benefits. Meanwhile, the scientific community should contribute by monitoring critical shifts in forest value orientations and filling in significant research gaps regarding potential prescribed fire benefits.

Overall, our measurement of a comprehensive set of social factors, along with the investigation of critical contributing factors of public support, fills significant gaps in the social science literature about prescribed fires in the Mid-Atlantic region. Future research that expands to other stakeholder groups, such as homeowners and policymakers, and different areas of the region will be critical to gaining a comprehensive understanding of prescribed fire perceptions and informing better land management decision-making.

Conceptualization, Methodology, Writing – review & editing. **Margot W. Kaye**: Conceptualization, Methodology, Writing – review & editing. **Erica A.H. Smithwick**: Conceptualization, Methodology, Investigation, Resources, Writing – review & editing, Project administration, Funding acquisition.

Data availability

Data will be made available on request.

Appendices: Supplementary Materials.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2022.116100.

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