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Public Acceptance of Wildland Fire and Fuel Management: Panel Responses in Seven Locations

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Abstract Wildland fire affects both public and private resources throughout the United States. A century of fire suppression has contributed to changing ecological conditions and accumulated fuel loads. Managers have used a variety of approaches to address these conditions and reduce the likelihood of wildland fires that may result in adverse ecological impacts and threaten communities. Public acceptance is a critical component of developing and implementing successful management programs. This study examines the factors that influence citizen support for agency fuel reduction treatments over time—particularly prescribed fire and mechanical vegetation removal. This paper presents findings from a longitudinal study examining resident beliefs and attitudes regarding fire management and fuels treatments in seven states: Arizona, Colorado, Oregon, Utah, Michigan, Minnesota, and Wisconsin. The study was implemented in two phases over a 6-year period using mail surveys to residents of communities adjacent to federal lands in each location. Questions replicated measures from the original project as well as some new items to allow a more in-depth analysis of key concepts. The study design enables comparisons over time as well as between locations. We also assess the factors that influence acceptance of both prescribed fire and mechanical vegetation removal. Findings demonstrate a relative stability of attitudes toward fuels management approaches over time and suggest that this acceptance is strongly influenced by confidence in resource managers and beliefs that the treatments would result in positive outcomes.

Keywords Fuels reduction · Public acceptance · Wildland fire management

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Introduction

Throughout much of the previous century, federal fire policy was directed at excluding fire from the landscape. In many locations, fire exclusion along with other resource management practices has resulted in ecological changes, including shifts in species composition, increased vegetative density, and reduced ecological health (e.g., Agee 1997). These changes have altered fire regimes and contributed to changes in the likelihood and intensity of wildland fires (Dombeck et al. 2004). At the same time, the human population living in or near natural areas has increased substantially in recent decades (Radeloff et al. 2005; Hammer et al. 2009) resulting in a greater numbers of people and private property at risk of damage from wildfire events. Residents in these areas, known as the wildland-urban interface (WUI), play an important role in these landscapes related to wildland fire both on private as well as public (by influencing the types of management interventions that can be undertaken) lands.

The interactive effects between humans and wildland fire dynamics highlight the importance of understanding

human aspects of wildfire management. The first study examining social issues was completed by Stankey among wilderness users in a 1971 study in Montana's Selway-Bitterroot Wilderness. Published in 1976, Stankey found that participants generally overestimated the negative impacts of fire while underestimating fire's beneficial effects. Not surprisingly, a majority preferred complete fire suppression. In the 1980's, a series of studies were completed by Cortner, Taylor, and colleagues (e.g., Cortner et al. 1984; Taylor and Daniel 1984; Gardner et al. 1985; Carpenter et al. 1986; Taylor and Mutch 1986). These projects examined beliefs and attitudes among the general public including residents of fire-prone landscapes and found increased understanding of treatment outcomes and acceptance of alternatives to fire suppression including the use of management-ignited prescribed burns.

Beginning in the early 2000's, the number of social science research projects examining wildland fire increased substantially. A recent review identified more than 200 publications in the peer- or editor-reviewed literature published or in in-press status between January 1, 2000 and December 31, 2010 (McCaffrey et al. 2012). Findings from this research provide evidence of increasing support for the use of fuel treatments in many regions of the US over time (e.g., Manfredo et al. 1990; Winter et al. 2002; Brunson and Shindler 2004; Blanchard and Ryan 2007). However, most of these studies consist of data collected at a single point in time and, typically, in one location. While such cross-sectional approaches enable examination of current beliefs, attitudes toward fire and fuels management approaches, and contributory factors, they provide limited ability to understand potential changes in the variables of interest over time (Babbie 1995). Although variables such as beliefs and attitudes have some degree of stability, they exist within a dynamic social and ecological environment. Multiple factors (e.g., new information, an escaped prescribed burn, an increase of beetle-killed trees, etc.) may cause individuals to re-consider their beliefs over time. Longitudinal research designs provide a means to directly examine potential change.

The few wildfire social science projects completed to date that have included a longitudinal research design provide interesting insights. Following-up on Stankey's original 1976 study, McCool and Stankey (1986) completed a trend analysis (comparing different samples of the same population over time) of visitors to the Selway-Bitterroot Wilderness Area. Results demonstrated increased awareness of the effects of wildland fire on forest ecosystems as well as increased support for the use of fire in management activities. More recently, Shindler and Toman (2003) completed a panel study (comparing responses from the same participants at two or more points in time) of residents in northeast Oregon and southeast Washington. While findings showed that citizen acceptance of both prescribed fire and mechanized thinning treatments had remained relatively stable across the study period (with nearly 90 % supporting some use of each treatment), they also revealed a declining relationship between participants and local resource managers. This finding was particularly critical given the strong correlation between positive citizen–agency relationships and acceptance of fuels management activities. These studies demonstrate the value of longitudinal methodologies to better understand the dynamic nature of beliefs and attitudes over time as well as the factors that influence such change. On the practical side of things, these types of studies can provide an important opportunity to identify areas that may need attention by managers to develop and or maintain agreement regarding management goals and approaches.

In addition to the relatively limited number of longitudinal studies, questions also remain about variation in public beliefs and attitudes toward wildland fuels management between locations. While the body of research on this topic has grown substantially, many of the studies rely on different methodologies resulting in a limited ability to directly assess similarity and differences in responses between locations.

This paper helps contribute to addressing these existing research gaps by (1) examining the stability of treatment acceptance over time (comparing responses within locations at two different points in time), (2) assessing variance in treatment acceptance and influencing factors between locations, and (3) assessing the relative influence of commonly measured independent variables on treatment acceptance. The study replicated research across a 6-year time period in Arizona, Colorado, Oregon, Utah, Michigan, Minnesota, and Wisconsin. The follow-up study contacted the same individuals who participated in the first round of data collection and replicated measures to enable comparisons in responses over time. Several new questions were also added in the second phase of research to explore additional items of interest (further explained below).

Review of Related Literature

Substantial research has examined public beliefs and attitudes toward wildland fire management. In the following sections, we review findings relevant to this study.

Treatment Acceptance

A number of studies have examined acceptance of the use of fuels treatments, particularly prescribed fire and mechanized thinning, on public lands in several regions of the United States. Findings demonstrate increasing acceptance over time with consistently high levels of support in more

recent studies (e.g., Carpenter et al. 1986; Vogt et al. 2005; Toman et al. 2013). Some studies have suggested differences in treatment acceptance between locations (e.g., Loomis et al. 2001); however, it is unclear whether these findings reflect meaningful differences between locations or result from the different methodological or measurement approaches used to collect data in each location.

A few studies do enable direct comparisons between locations by using consistent measures in multiple locations. Vogt et al. (2005) found attitudes toward prescribed fire and thinning treatments differed statistically between California, Florida, and Michigan. Although attitudes were positive toward both treatments in each location, California residents expressed greater acceptance of thinning treatments, while Florida residents preferred prescribed fire. Michigan residents expressed less positive attitudes about both treatments. Similarly, Brunson and Shindler (2004) found high levels of acceptance, with more than three-fourths of all participants in Arizona, Colorado, Oregon, and Utah supporting at least some use of both prescribed fire and thinning treatments. However, they also found that acceptance differed statistically between states. Similar results were found by Shindler et al. (2009) in Michigan, Minnesota, and Wisconsin.

Variables Influencing Treatment Acceptance

Several studies have examined the variables that contribute to treatment acceptance. Across these studies, the most common predictor of acceptance across studies is familiarity with or knowledge of a particular practice (e.g., Absher and Vaske 2006; McCaffrey and Olsen 2012; Toman et al. 2011). This finding has been robust over time (e.g., Stankey 1976; Shindler and Toman 2003) and in different locations (e.g., Blanchard and Ryan 2007; Toman et al. 2011). Increased knowledge of treatments may contribute to reduced concerns with their use and more positive beliefs about treatment outcomes. Blanchard and Ryan (2007) found that participants who indicated a greater knowledge of prescribed fire were less concerned about potential negative impacts to esthetics and wildlife. Similarly, McCaffrey (2004) found that those who had more experience with educational materials regarding prescribed fire were more likely to expect positive outcomes from its use, such as improved wildlife habitat and diversity, and less likely to express concern regarding esthetics or smoke emissions. This influence of knowledge about treatments is particularly important as both concerns and beliefs about treatment outcomes have also been found to influence treatment acceptance (e.g., Loomis et al. 2001; Brunson and Shindler 2004).

Several studies have also found that citizen trust and/or confidence in management agencies significantly influences treatment acceptance (e.g., Winter et al. 2002; Shindler and Toman 2003; Vogt et al. 2005). Trust has been conceptualized differently in these studies resulting in some difficulty drawing more general conclusions from the range of studies. Across this body of research, measure of trust primarily emphasizes (1) *relational trust* based on relationships between people (or between people and an organization), (2) *calculative trust* often referred to as confidence and is based on perceived abilities and past performance, or (3) a combined approach that includes both relational and calculative items (Earle 2010). Recently, Toman et al. (2011) found confidence (based on perceived ability to effectively implement treatments) in agency managers to effectively implement specific treatments significantly influenced acceptance of both prescribed fire and thinning treatments, while accounting for other variables (e.g., residency status, ratings of agency management) including a more general measure of trust in agency managers.

Some studies have also identified associations between treatment acceptance and citizen involvement in development of treatment plans, perceptions of risk, and situationally specific variables (e.g., size of treatment, proximity to homes, weather conditions, etc.) (Winter et al. 2002; Blanchard and Ryan 2007). Demographic variables (e.g., gender, education, income) have been less consistent with significant associations with treatment support in some cases but not in others (e.g., Shindler and Toman 2003; Weible et al. 2005; Toman et al. 2011).

Research Design

Data for this project were collected in two phases. In the first phase (referred to throughout the paper as Phase I), a mail survey was sent to a random sample of residents in seven states, four in the western US (Arizona, Colorado, and Oregon), and three in the upper Midwest or Lake States (Minnesota, Michigan, and Wisconsin). Samples from western states were drawn from counties with a high concentration of public land. Samples from the Lake States sample (MI, MN, WI) were selected from all counties adjacent to National Forest land. The second phase of data collection (Phase II) occurred 6 years following the initial survey. Participants from Phase I data collection were identified, and mail surveys were sent to all of those still living in the study areas.

Surveys were mailed following a modified version of the "total design method" (Dillman 1978). Mailings were sent in three waves consisting of (1) a complete mail packet (cover letter, questionnaire, and stamped return envelope), (2) a reminder postcard sent to non-respondents, and (3) a second mailing of complete packets to all who had not yet

Table 1 Sample size and response rate

Location	Completed surveys (Phase I)	Adjusted sample[a] (Phase II)	Completed surveys (Phase II)	Adjusted response rate (Phase II) (%)
Arizona				
Yavapai County	151	111	60	54
Colorado				
Boulder and Larimer Counties	149	121	71	59
Oregon				
Deschutes and Jefferson Counties	161	122	71	58
Utah				
Salt Lake City and Tooele Counties	147	134	68	51
Michigan				
Communities adjacent to the Huron Manistee, Ottawa, and Hiawatha National Forests	168	151	81	54
Minnesota				
Communities adjacent to the Chippewa and Superior National Forests	191	179	99	55
Wisconsin				
Communities adjacent to the Chequamegon–Nicolet National Forests	192	181	96	53
Total	1,159	1,000	546	55

[a] Adjusted for participants from Phase I who had moved or were deceased

returned a survey. After accounting for participants who had moved from the study regions or were unable to complete the follow-up survey (they were deceased or incapacitated), a combined total of 1,000 individuals remained in the sample for the second phase of research. Of these, 546 completed the survey for a 55 % overall response rate. Sample sizes and response rates for each location are presented in Table 1. Only participants who completed surveys in both Phase I and Phase II of this project are included in this analysis.

To enable comparisons across the study period, the follow-up survey replicated several measures from the Phase I questionnaire. In addition, several new items were also included in the Phase II survey to examine emerging issues at each location. These new questions were developed based on interviews with resource managers in each location to identify significant activities or management efforts that had occurred in each area during the study period as well as key findings from relevant literature following the Phase I survey. Questions included Likert-type scales and closed-choice question sets as well as semantic differential scales requiring respondents to choose between two opposing statements associated with fire and fuels management decisions.

Data analysis was completed in multiple steps. The data were first summarized using descriptive statistics. Next, replicated items responses were paired across pre-test and post-test measures and compared using paired-*T* tests to assess potential change in individual responses across the study period. Change in responses over time was calculated within each of the seven study locations. Using a Chi square or one-way analysis of variance (ANOVA) and post-hoc comparisons, we also compare Phase II responses between study locations to examine variance in beliefs and attitudes toward treatments and forest management agencies. Significant differences in responses between Phase I and Phase II and between locations are noted in the Findings section below. Finally, we use correlation analysis and logistic regression to model the influence of multiple independent variables (suggested by findings from prior literature) on treatment acceptance.

Findings

This section begins with a general summary of study participants. We then move on to examine findings to several specific items. Measures of treatment acceptance and confidence in agency managers were asked in both study phases (Phase I and II); for these items, we present findings from each phase and provide an analysis of differences over time. For each question, we also examined differences between locations in Phase II responses. Questions examining perceived treatment outcomes and citizen–agency interactions were added for the second phase of the project. For these items, only differences between locations were assessed. This section concludes by examining the variables that influence participant acceptance of prescribed fire and mechanized thinning treatments in Phase II responses.

Table 2 Summary of participant characteristics from Phase II responses

	Responses							
	AZ	CO	OR	UT	MI	MN	WI	Overall
Gender (% male)	74	68	77	82	76	82	84	78
Median Age (years)[a]	69	56	62	56	63	60	65	62
Percent with BS/BA degree[a]	51	63	48	37	38	36	42	44
Wildfire occurred in area during study period (% yes)[b]	76	66	78	93	40	38	28	56
Estimated distance from home to where wildfire may burn (mean miles)	3.31	2.90	2.37	5.7	4.75	2.44	2.28	3.3

AZ Arizona, *CO* Colorado, *OR* Oregon, *UT* Utah, *MI* Michigan, *MN* Minnesota, *WI* Wisconsin

[a] Responses significantly different between locations (based on ANOVA, $P \leq .05$)

[b] Responses significantly different between locations (based on Chi square test, $P \leq .05$)

Summary of Participants

Study participants were primarily males with a median age of 62 (Table 2). Overall, fewer than half had completed a bachelor's degree although this differed significantly between locations. A majority of participants in all western states reported fire activity in their area during the study period with a high of 93 % in Utah. While experience with fire during the study period differed significantly across locations, more than one-fourth in every state indicated a wildfire had occurred in their area in the previous 6 years. As for impacts from these fires, several respondents experienced some discomfort from smoke, but few were evacuated (9 % in AZ, 4 % in CO, 7 % in OR, 5 % in MN, and none in UT, MI, and WI), and none incurred property damage.

Participants estimated the distance from their home to a natural area where a wildfire might burn. Although the western United States receives greater attention in terms of fire activity, responses were quite similar between locations. Overall, the average perceived distance across sites was just 3.3 miles and ranged from 2.3 miles in Wisconsin to 5.7 miles in Utah. Moreover, nearly three-fourths of participants from Minnesota and Wisconsin indicated that they lived directly adjacent to a natural area that might burn. Even in Utah, which had the highest average distance, 70 % of participants indicated that they were within 5 miles of where a wildfire might burn.

Treatment Acceptance

Respondents were asked to indicate their acceptance of the use of prescribed fire and mechanized thinning to reduce fuels in public forests and rangelands. To ensure a common reference, the following definitions were provided on the questionnaire:

- Prescribed fire—also called controlled burning, this practice can involve (1) letting a naturally caused fire burn under close and careful watch; or (2) intentionally setting fires in ways that can be controlled to produce desired conditions.
- Mechanical vegetation removal—Managers can use chainsaws, mowers, or other specialized machines to reduce the number of shrubs and small trees where they are so numerous that they increase the risk and size of wildfires.

Participants selected one of four options to indicate their level of acceptance for each treatment (ranging from "an unnecessary practice" to "a legitimate tool that resource managers should be able to use whenever they see fit") (Tables 3, 4).

Acceptance of prescribed fire and mechanical treatments was high in most locations with 85 % of participants in Phase II indicating some level of support for prescribed fire use; 44 % believed the local forest agency should have full discretion for prescribed fire treatments, while an additional 41 % said the agency should use prescribed fire only in carefully selected areas. Participants also indicated strong acceptance of mechanical vegetation removal with a majority of respondents willing to give managers full discretion to use mechanical treatments. In each location, participants expressed greater acceptance for use of mechanical treatments than for the use of prescribed fire.

Participant acceptance of these treatments was stable over time (Table 5). Within locations, acceptance of prescribed fire changed (decrease) significantly in only one location, Colorado. Although there was a slight increase over time in acceptance of mechanized thinning in aggregate ratings, none of the individual study locations experienced a significant change.

To further examine change in treatment acceptance, we calculated the differences in responses for each participant by subtracting acceptance ratings in Phase I from those in Phase II. This provided a measure of change for each individual that could range from negative three (if a participant indicated the practice was a "legitimate tool" in

Table 3 Acceptance of prescribed fire use

In my opinion, using prescribed fires on public forests and rangelands is…	Percentage of responses															
	AZ		CO		OR		UT		MI		MN		WI		Overall	
	PI	PII	PI	PII	PI	PII	PI	PII	PI	PII	PI	PII	PI	PII	PI	PII
A legitimate tool that resource managers should be able to use whenever they see fit	50	61	52	34	55	60	40	41	35	31	53	45	34	38	45	44
Something that should be done only infrequently, in carefully selected areas	47	25	42	56	37	30	52	50	38	42	44	45	53	35	45	41
A practice that should not be considered because it creates too many negative impacts	0	7	3	3	7	7	3	3	9	6	0	3	1	7	3	5
An unnecessary practice	2	0	1	1	1	0	0	0	1	1	1	3	5	4	2	2
I know too little to make a judgment	2	7	1	6	0	3	6	6	17	19	2	4	7	15	5	9

AZ Arizona, *CO* Colorado, *OR* Oregon, *UT* Utah, *MI* Michigan, *MN* Minnesota, *WI* Wisconsin, *PI* Phase one responses, *PII* Phase two responses

Table 4 Acceptance of mechanical vegetation removal

In my opinion, using mechanical vegetation removal on public forests and rangelands is…	Percentage of responses															
	AZ		CO		OR		UT		MI		MN		WI		Overall	
	PI	PII	PI	PII	PI	PII	PI	PII	PI	PII	PI	PII	PI	PII	PI	PII
A legitimate tool that resource managers should be able to use whenever they see fit	76	75	63	70	67	68	56	57	47	50	60	67	50	52	59	62
Something that should be done only infrequently, in carefully selected areas	16	10	24	20	21	22	34	31	31	32	28	21	26	27	26	24
A practice that should not be considered because it creates too many negative impacts	3	3	3	4	6	1	0	2	4	3	1	1	4	2	3	2
An unnecessary practice	2	0	3	0	1	1	0	2	4	4	3	3	5	1	3	2
I know too little to make a judgment	3	12	7	6	4	7	10	9	15	12	8	8	15	17	9	10

AZ Arizona, *CO* Colorado, *OR* Oregon, *UT* Utah, *MI* Michigan, *MN* Minnesota, *WI* Wisconsin, *PI* Phase one responses, *PII* Phase two responses

phase one and that it was "unnecessary" in phase two) to positive three (for the opposite change in response). The distribution of change across the study period resembled a normal distribution with most participants indicating no change (61 % for prescribed fire and 67 % for mechanical vegetation removal). Aggregate responses are displayed in Fig. 1; the distribution was similar in each location.

We also assessed differences in acceptance between locations for Phase II responses (Table 5). Acceptance was high for both treatments in each location. For prescribed fire, treatment acceptance differed significantly between study locations, ranging from three-fourths of participants in Arizona finding it acceptable at some level to just over half in Wisconsin. We calculated post-hoc comparisons

Table 5 Mean acceptance of fuels treatments

	Mean responses[a]															
	AZ		CO		OR		UT		MI		MN		WI		Overall	
	PI	PII	PI	PII	PI	PII	PI	PII	PI	PII	PI	PII	PI	PII	PI	PII
Prescribed fire[b]	3.47	3.58	3.47[c]	3.30[c]	3.45	3.54	3.39	3.40	3.28	3.26	3.51	3.36	3.23	3.24	3.40	3.38
Mechanical vegetation removal	3.71	3.81	3.59	3.69	3.61	3.68	3.62	3.58	3.42	3.44	3.57	3.64	3.40	3.57	3.55[c]	3.62[c]

AZ Arizona, *CO* Colorado, *OR* Oregon, *UT* Utah, *MI* Michigan, *MN* Minnesota, *WI* Wisconsin, *PI* Phase one responses, *PII* Phase two responses

[a] Based on responses from 1 (an unnecessary practice) to 4 (legitimate tool) with a "don't know" option; "don't know" option excluded from calculation of mean

[b] Responses significantly different between locations (based on ANOVA, $P \leq .05$)

[c] Phase I and Phase II responses significantly different (based on paired-*T* test, $P \leq .05$)

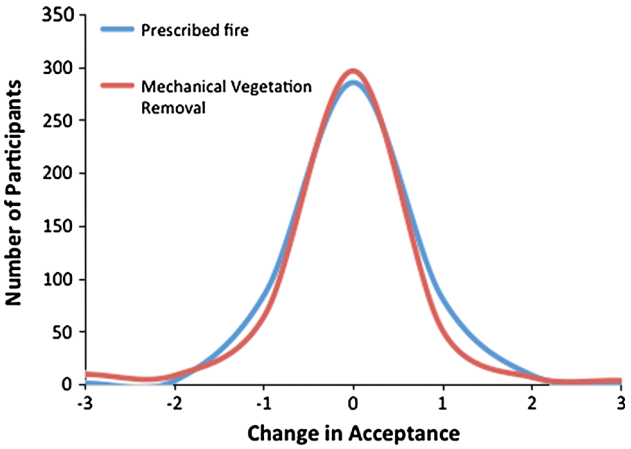

Fig. 1 Distribution of change in treatment acceptance across the study period

between mean ratings for each state; findings suggest that this geographic difference is primarily driven by higher mean ratings in Arizona (the Arizona ratings were significantly different from all but Oregon and Utah using a least significant difference post-hoc comparison; $P \leq .05$). However, as these contrasts are based on a pair-wise comparison of mean response between locations, it is important to note that the large number of "don't know" responses from Michigan is excluded from this analysis. With these responses excluded, the mean rating in Michigan is statistically similar to those of the other locations. For mechanical treatments, responses were similar across study locations.

Confidence in Agency Managers

Participants were also asked to indicate their level of confidence in agency managers to use both treatments as part of a fuels management program in both Phase I and II (Table 6). Responses indicate that participants have a moderate amount of confidence in managers to use each treatment. Moreover, most participants were able to express an opinion about this item; "no opinion" responses were 7 % or less except in Michigan (19 % indicated "no opinion" for prescribed fire and 14 % for mechanical vegetation removal) and Wisconsin (10 and 12 %, respectively).

Confidence ratings did not change over time except in Utah where more participants expressed confidence in managers to use prescribed fire in Phase II. We found no significant differences between locations in our analysis of Phase II responses between locations.

Treatment Outcomes (Phase II Only)

Participants were asked to indicate the likelihood of several potential outcomes with prescribed fire and mechanical treatments using a 5-point scale and a "don't know" option (Table 7). Five of the items addressed general possible outcomes and were similar between treatments, while other items addressed outcomes specific to a given treatment (e.g., smoke in the case of prescribed fire and harvested timber products in the case of mechanical treatments).

In general, participants expected both treatments to result in positive outcomes. For prescribed fire, the mean response for four potential treatment outcomes (reduce fire risk, save suppression costs, restore forest conditions, and improve wildlife habitat) indicated a belief that such outcomes are "somewhat" or "very" likely. A high number of participants also agreed that while prescribed fire will result in smoke in the short term, it will reduce long-term emissions. The mean response for the final item (reduced scenic quality) was just above the scale's midpoint. Participants expressed similar expectations for outcomes of mechanical treatments. In addition, there was high agreement that mechanical treatments would provide economically valuable products. Two potential mechanical outcomes were rated as less likely: participants did not believe that mechanical treatments would result in overharvesting or reduce scenic quality. Most participants felt

Table 6 Confidence in agency managers to use treatment as part of effective fuels management program

	Mean responses[a]															
	AZ		CO		OR		UT		MI		MN		WI		Overall	
	PI	PII	PI	PII	PI	PII	PI	PII	PI	PII	PI	PII	PI	PII	PI	PII
Prescribed fire	2.98	3.03	2.72	2.65	2.83	2.88	2.69[b]	3.03[b]	2.64	2.79	2.88	2.86	2.68	2.74	2.78	2.85
Mechanical vegetation removal	3.02	3.05	2.92	2.80	3.05	2.97	2.95	3.05	2.90	2.81	3.03	2.86	2.77	2.75	2.95	2.89

AZ Arizona, *CO* Colorado, *OR* Oregon, *UT* Utah, *MI* Michigan, *MN* Minnesota, *WI* Wisconsin, *PI* Phase one responses, *PII* Phase two responses

[a] Based on a scale of 1 (none)–4 (full confidence) with a "no opinion" option; "no opinion" responses excluded from calculation of means

[b] Phase I and Phase II responses significantly different (based on paired-*T* test, $P \leq .05$)

Table 7 Perceived likelihood of treatment outcomes (question only asked in Phase II of the study)

	Mean response[a]							
	AZ	CO	OR	UT	MI	MN	WI	Overall
Prescribed fire								
Effectively reduce fire risk[b]	3.92	3.80	4.15	3.61	3.31	3.98	3.42	3.74
Save money by reducing the cost of fighting a wildfire[b]	3.81	3.78	4.06	3.75	3.12	3.82	3.28	3.66
Restore forests to a more natural condition[b]	3.77	3.83	3.87	3.45	3.09	3.83	3.22	3.58
Improve conditions for wildlife[b]	3.67	3.51	3.80	3.57	3.19	3.85	3.26	3.55
Reduce scenic quality	2.59	2.93	2.55	2.84	2.90	2.77	2.80	2.77
Create more smoke in short term, but less smoke over time[b]	3.49	3.59	3.70	3.35	2.91	3.58	3.37	3.43
Mechanical thinning								
Effectively reduce fire risk[b]	4.16	3.78	4.12	3.67	3.21	3.87	3.30	3.71
Save money by reducing the cost of fighting a wildfire[b]	4.05	3.77	4.20	3.78	3.20	3.87	3.30	3.72
Restore forests to a more natural condition[b]	3.87	3.77	4.00	3.28	2.93	3.54	3.13	3.48
Improve conditions for wildlife[b]	3.80	3.55	3.81	3.45	2.94	3.79	3.31	3.51
Reduce scenic quality	2.32	2.24	1.93	2.35	2.28	2.18	2.39	2.24
Extract useful wood products	3.65	3.78	3.90	3.76	3.74	3.95	3.94	3.83
Result in more harvesting than necessary	2.54	2.24	2.05	2.33	2.59	2.16	2.41	2.32

AZ Arizona, *CO* Colorado, *OR* Oregon, *UT* Utah, *MI* Michigan, *MN* Minnesota, *WI* Wisconsin

[a] Based on a scale of 1 (not at all likely)–5 (extremely likely) with a "don't know" option; "don't know" option excluded from calculation of mean

[b] Responses significantly different between locations (based on ANOVA, $P \leq .05$)

they knew enough to express an opinion about potential outcomes, although "don't know" responses were slightly higher in Utah, Michigan, and Wisconsin.

There were several differences between locations. In nearly every case where differences arose, participants in Michigan and Wisconsin expressed more negative views of treatment outcomes (post-hoc comparisons indicated Michigan and Wisconsin were most likely to differ significantly from other states). Participants in these states were less likely to agree that either treatment would reduce fire risk, reduce the cost of fighting future wildland fires, restore natural conditions, or improve conditions for wildlife.

Citizen–Agency Interactions (Phase II Only)

The Phase II survey also included several items designed to examine citizen experiences with resource management agencies in each location (Table 8). Responses provide a rather tepid assessment of citizen–agency interactions. Perhaps most striking is the high number of participants who selected "don't know" for each item; this option was commonly selected by a fifth or more of participants in every location and rose to more than 40 % for some items indicating participants had limited exposure to management agencies in each of our study locations.

This high number of "don't know" responses resulted in a substantially reduced sample size to provide a rating for each item. The means and ANOVA results reported here should therefore be viewed with some caution regarding how well they represent agreement on these ratings. Most mean responses fell near the middle of the scale between Disagree and Agree for each of these items. Responses differed significantly between locations for four of the five items although the mean responses are relatively similar. Post-hoc comparisons did not provide evidence of a recognizable trend differences between locations.

Table 8 Participant experiences with resource management agencies

	Mean response[a] (don't know responses)							
	AZ	CO	OR	UT	MI	MN	WI	Overall
The agency is open to public input and uses it to shape management decisions	2.98 (30 %)	2.78 (40 %)	2.84 (38 %)	2.64 (40 %)	2.59 (40 %)	2.70 (35 %)	2.70 (19 %)	2.74 (34 %)
Managers do a good job of providing information about management activities[b]	2.93 (21 %)	2.71 (34 %)	2.85 (34 %)	2.59 (31 %)	2.47 (41 %)	2.77 (31 %)	2.73 (26 %)	2.73 (31 %)
Agency managers build trust and cooperation with local citizens[b]	3.00 (29 %)	2.73 (35 %)	2.86 (38 %)	2.65 (34 %)	2.67 (37 %)	2.70 (33 %)	2.52 (26 %)	2.72 (33 %)
There are adequate opportunities for citizens to participate in the local agency planning process[b]	2.78 (36 %)	2.83 (41 %)	2.76 (41 %)	2.40 (46 %)	2.46 (45 %)	2.64 (44 %)	2.52 (30 %)	2.62 (40 %)
I am skeptical of information from the forest agency in my area[b]	1.77 (16 %)	2.02 (18 %)	1.98 (16 %)	2.16 (20 %)	2.31 (33 %)	2.33 (23 %)	2.29 (21 %)	2.14 (21 %)

AZ Arizona, *CO* Colorado, *OR* Oregon, *UT* Utah, *MI* Michigan, *MN* Minnesota, *WI* Wisconsin

[a] Based on a scale of 1 (strongly disagree)–4 (strongly agree) with a "don't know" option; "don't know" responses excluded from calculation of means

[b] Responses significantly different between locations (based on ANOVA, $P \leq .05$)

Influences on Treatment Acceptance

In this final section, we examine the influence of the variables described above on participant acceptance of prescribed fire and mechanical fuels treatments in Phase II responses. We first conducted a correlation analysis to identify independent variables that have a significant association with treatment acceptance. We then developed two logistic regression models to examine the relative influence of those variables that demonstrated a significant association with acceptance for either treatment.

Three variables used in this analysis merit additional explanation. First, we included a dichotomous variable to test differences between "regions" with the western states grouped together and the Lake States grouped separately. Second, a summated scale was developed to provide a measure of "treatment outcomes" by combining responses to the items presented in Table 7. Separate variables were created for each treatment and could vary from 6 to 30 for prescribed fire or 7–35 for mechanical vegetation removal as one additional outcome item was included for mechanical treatments (see Table 7). Three total items were reverse coded to match the direction of the other items ("reduce scenic quality" was reverse coded for both prescribed and thinning, and "result in more harvesting than necessary was also reverse coded for thinning). The reliability analysis indicated that the items in the scale had an acceptable level of internal consistency (Cronbach's alpha = .821 for prescribed fire outcomes and .783 for thinning outcomes). Third, using a similar approach, we developed the "citizen–agency interactions" variable by combining responses to the questions presented in Table 8 above regarding previous experiences and interactions with agency managers. Scores could range from 5 (if participants 'strongly disagreed' with each question) to 20 (if participants 'strongly agreed'). One item (I am skeptical of information from forest agencies) was reverse coded to match the direction of the other items. Internal consistency was also adequate for this scale (Cronbach's alpha = .845).

Correlation Analysis

Results from the correlation analysis are displayed in Table 9. Demographic variables provided mixed results; age was not significantly associated with acceptance of either treatment; males were more likely to accept prescribed fire use, while years of formal education were negatively associated with acceptance of mechanical treatments. The variable designed to assess geographic differences (Region) was significantly associated with acceptance of prescribed fire, with those in western states more likely to express acceptance. Perceived likelihood of fire and the distance from participant's home to where a wildfire might burn were not significantly associated with either treatment. For both treatments, more positive ratings of citizen–agency interactions, increased confidence in managers to use treatments, and greater expectations of positive treatment outcomes were all positively associated with acceptance. Each variable that indicated a significant association with one or both treatments was included in the logistic regression models described below. One additional finding of note, participant ratings of "citizen–agency interactions" were strongly correlated with "confidence" in managers to use both prescribed fire ($R = .409$, $P < .001$) and mechanical vegetation removal ($R = .376$,

$P < .001$); participants with positive interactions with agency managers were more likely to express confidence in the ability of local managers to use fuels treatments.

Logistic Regression

To explore the relative influence of the variables presented here on treatment acceptance, we dichotomized responses to the acceptability questions presented in Tables 3 and 4 (with 1 representing responses indicating the treatment is "a legitimate tool and should be used whenever managers see fit" or "something that should be used in carefully selected areas" and 0 representing all other responses—"a practice that should not be considered because it creates too many negative impacts," "an unnecessary practice," and "know too little to make a judgment"). We then used logistic regression to examine the influence of the seven independent variables that were significantly correlated with acceptance of prescribed fire and mechanized thinning. The resulting logistic regression models are presented in Table 10.

The Chi square statistics for both models are statistically significant, indicating that the combination of independent variables in the model significantly influences treatment acceptability. Each model correctly classified at least 95 % of cases. The Nagelkerke R^2, which provides an estimate of the variance predicted by each model (Vaske 2008), indicates the prescribed fire model explained 59.2 % of the variance, while 31.4 % of the variance was explained in acceptance of mechanical vegetation removal.

Despite exhibiting significant correlations in the initial analysis, four variables—"sex," "education," "region," and "citizen–agency interactions"—did not significantly influence acceptance of prescribed fire or mechanized thinning treatments when accounting for the influence of the other independent variables. Two variables were significantly associated with treatment acceptance in both models, confidence in agency managers to effectively implement the particular treatment, and beliefs in positive treatment outcomes. For each treatment, as confidence in agency managers or belief that each treatment would result in positive outcomes increased, so did acceptance of treatment use.

The coefficients provide evidence of the relative influence of these variables; however, as logistic regression coefficients provide log-odds ratios, these require some additional interpretation. To estimate the influence of a 1-unit change in the independent variable on treatment acceptance, one must calculate the exponential value of the coefficients provided in Table 10. Doing this indicates that, holding everything else constant, the odds of a participant accepting the use of prescribed fire increase by a factor of 4.2 for a 1-unit increase in confidence (e.g., from moderate to high confidence) and 1.5 for a-1 unit increase in the perceived positive treatment outcome index. For mechanical vegetation removal, the odds of participant acceptance increased by a factor of 5.0 for a 1-unit increase in confidence and 1.3 for a 1 unit increase in perceived positive outcomes.

Table 9 Bivariate correlations between independent variables and treatment acceptance (Pearson's R calculated unless otherwise noted)

Independent variables	Prescribed fire R (significance)	Mechanical vegetation removal R (significance)
Age	−.005 (.917)	−.015 (.746)
Sex[a]	**−.134 (.036)**	−.095 (.239)
Education[b]	−.124 (.107)	**−.143 (.016)**
Region[a,c]	**−.129 (.043)**	−.120 (.075)
Perceived likelihood of fire	.009 (.852)	.001 (.982)
Distance from home to where a fire might burn	.003 (.942)	.044 (.341)
Treatment-specific confidence	**.524 (<.001)**	**.291 (<.001)**
Treatment outcomes[d]	**.541 (<.001)**	**.389 (<.001)**
Citizen–agency interactions[e]	**.273 (<.001)**	**.097 (.133)**

Variables in bold exhibit significance at the .05 level or greater with acceptance of at least one of the treatments

[a] Point-biserial correlation calculated due to dichotomous nature of independent variable

[b] Cramer's V correlation calculated due to categorical nature of independent variable

[c] Independent variable created to examine differences between western (AZ, CO, OR, and UT coded as 0) and lake states (MI, MN, and WI coded as 1)

[d] Scale created by combining responses reported in Table 7. Some items were reverse coded so increasing numbers reflect agreement with positive experiences with agency interactions

[e] Scale variable created by combining responses reported in Table 8. Separate indices were created for prescribed fire and thinning treatments. One item was reverse coded so increasing numbers reflect perceived likelihood of positive outcomes

Discussion

This study adds to the existing literature on public beliefs, attitudes, and acceptance of wildland fuels management by using a longitudinal approach to examine citizen acceptance of agency fuels treatments over time across seven study sites. Several key points emerge from this analysis.

First, responses demonstrate a remarkable stability over time in each of our locations. This is particularly true for treatment acceptance, where almost no change occurred across the study period. While several prior studies has also found high levels of support for agency treatments (e.g.,

Table 10 Logistic regression estimates predicting influence of independent variables on treatment acceptance

Independent variables	Prescribed fire β (significance)	Mechanical vegetation removal β (significance)
Sex	.245 (.845)	−.612 (.536)
Education	.532 (.052)	−.061 (.830)
Region	−1.482 (.111)	1.036 (.224)
Treatment-specific confidence	**1.428 (.004)**	**1.616 (.003)**
Treatment outcomes[a]	**.376 (<.001)**	**.226 (.007)**
Citizen–agency interactions[b]	.087 (.523)	−.118 (.374)
Chi square	55.237 (<.001)	20.213 (.003)
Percentage calculated correctly	95.8	96.0
Nagelkerke R^2	.592	.314

Variables in bold exhibit significance at the .05 level or greater with treatment acceptance in both models

[a] Scale created by combining responses reported in Table 7. Some items were reverse coded so increasing numbers reflect agreement with positive experiences with agency interactions

[b] Scale variable created by combining responses reported in Table 8. Separate indices were created for prescribed fire and thinning treatments. One item was reverse coded so increasing numbers reflect perceived likelihood of positive outcomes

Brunson and Shindler 2004; Vogt et al. 2005; Lim et al. 2009), results here add to this body of research by demonstrating not only a supportive constituency but also a stability of attitudes over time toward fuel treatments. Interestingly, this held true even among participants from the three Lake States where fuels programs have a shorter history of implementation. While acceptance of prescribed fire did vary across locations, a strong majority, just under three-fourths, in each location accepted at least some level of prescribed fire use. Overall, acceptance was even greater for mechanical vegetation removal as approximately 80 % or more accepted some use of mechanical treatments and expressed greater discretion to use mechanical treatments.

The stability in acceptance here should not be interpreted to mean that these ratings are unchangeable, as the decreasing acceptance of prescribed fire use in Colorado demonstrates. Rather, citizens in each location will continue to make judgments regarding the acceptability of these treatments based on their confidence in local managers and the outcomes of their use. When these are perceived positively, citizens are likely to continue to express positive acceptance toward the treatments. Moreover, a sizeable portion of our participants in Michigan and Wisconsin expressed uncertainty about both treatments. As fuels treatment programs continue to progress in these states, these residents will likely have additional exposure to treatments and draw judgments about their use. Engaging these residents as they develop attitudes toward treatments will likely be important for continued support of fuels management programs in these states.

Despite the strong acceptance scores, findings also highlight potential trouble spots. First, participants had limited prior experience with resource management agencies, and those with previous interactions generally did not rate their experiences very highly. While these ratings varied between locations, participants in each study site provided a poor assessment of the current state of citizen–agency interactions. Many expressed frustration with currently available opportunities for citizen involvement in agency planning and decision-making processes. Research into a variety of natural resource management issues has found that citizens want an expanded role beyond what is typically available through standard planning approaches and traditional scoping meetings (e.g., Blahna and Yonts-Shepard 1989; Lawrence et al. 1997; Toman et al. 2006). This desire for increased involvement seems particularly relevant for fuels treatments. Ultimately, residents in forest communities are directly affected by agency fire and fuel management efforts.

Lastly, one objective of this study was to examine the factors that influence treatment acceptance. Using a correlation analysis, we first assessed the association between numbers of independent variables identified from prior research as potentially influencing acceptance. Interestingly, two variables that may be expected to be associated with the perceived threat of fire impacts (perceived likelihood of fire and the distance to an area where a fire might burn) were not significantly associated with treatment acceptance. Three demographic variables were significantly associated with acceptance although not for both treatments: sex and region of residency were correlated with prescribed fire acceptance, while education was correlated with mechanical vegetation removal. Lastly, three variables were correlated with acceptance of both treatments: confidence in agency managers to effectively implement treatments, citizen–agency interactions, and treatment outcomes.

The logistic regression models enabled further analysis of these variables by assessing the influence of each potential predictor variable while holding the other variables constant. In the resulting models, only two variables significantly influenced treatment acceptance after accounting for the influence of the other independent variables. As has been found in previous research, the demographic variables did not significantly predict treatment acceptance (e.g., Toman et al. 2011; McCaffrey and Olsen 2012). Somewhat more surprising given findings elsewhere (e.g., Winter et al. 2002; Shindler and Toman 2003), the index of citizen–agency interactions also did not have a significant influence on acceptance (we consider

some potential explanations for this below). Ultimately, two variables, confidence in agency managers and perceived treatment outcomes, significantly influenced acceptance of both treatments. Both of these variables were positively associated with treatment acceptance; participants with greater confidence in agency managers and who believed treatments would result in positive outcomes, they were more likely to support treatment use. It is also worth noting that these models explained a sizable amount of variance in treatment acceptance (nearly 60 % for acceptance of prescribed fire and just under a third of the variance in acceptance of mechanical vegetation removal).

While substantial prior research has suggested the importance of confidence in agency managers (e.g., Winter et al. 2002; Brunson and Evans 2005; Toman et al. 2011), these findings illustrate how influential confidence is in predicting treatment acceptance. Even after accounting for the potential influence of the other variables, confidence strongly influenced acceptance of both treatments. Confidence is considered one dimension of the broader concept of trust (Earle 2010). By demonstrating the influence of treatment-specific confidence even when accounting for a variety of other potential influencing factors, the findings here add support to the substantial prior research that has identified the importance of trust to treatment support (e.g., Winter et al. 2002; Shindler and Toman 2003; Vogt et al. 2005; Winter et al. 2006).

Beliefs about treatment outcomes have been shown to influence acceptance in some prior literature, though their influence has been inconsistent across study sites and treatments (Winter et al. 2006). Notably, participants believed both treatments would likely result in a number of positive outcomes while fewer believed potential negative outcomes were equally likely. Although the potential for overharvesting has been cited as an issue for thinning treatments (e.g., Winter et al. 2002; Shindler and Toman 2003; Blanchard and Ryan 2007), our participants felt that while mechanical treatments would likely provide forest products, they were not concerned it would lead to overharvesting. While the index of expected outcomes was positively associated with treatment acceptance, it is important to note that this approach may mask some important variability between perceived outcomes. Essentially, by creating an index, we assumed each potential outcome has equal weight in influencing judgments. However, it is quite feasible to expect some potential outcomes (e.g., the potential for an escaped prescribed burn) to have greater weight than others (e.g., reduce scenic quality). These potential distinctions could be further explored in future research to provide a more complete picture of how beliefs about outcomes influence acceptance of treatment use.

We conclude this section by further considering the influence of citizen–agency interactions. While ratings of prior interactions with agency personnel did not significantly influence treatment acceptance, a couple of explanatory points seems noteworthy here. First, our ability to assess this variable was likely reduced by the limited experience with federal agencies among our study participants indicated by the large number of participants (in some cases up to nearly half) who selected "don't know" for these items. Moreover, these items were only included in Phase II of our study, so we were unable to assess potential change in responses over time. Having said that, it is worth noting that ratings of prior interactions were highly correlated with confidence in agency managers; these findings suggest that such interactions could be influential in ratings of treatment acceptance if not directly, then through their effect on confidence. Thus, confidence may serve as a mediating variable between citizen–agency interactions and treatment acceptance. Meaningful citizen–agency interactions can contribute to improved confidence in agency managers to implement fuels treatments (e.g., Toman et al. 2006) and understanding of treatment outcomes (e.g., Parkinson et al. 2003; McCaffrey 2004) both of which were shown to have a direct and strong influence on treatment acceptance. Accordingly, we expect that public engagement is still likely to significantly influence acceptance of fuels treatments.

Conclusion

By enabling comparison of responses at two points in time and between locations, this paper contributes to addressing an existing gap in the literature on public perceptions of wildland fuels management. While there were some significant differences, findings here are most notable for their lack of change across the study period. This stability may indicate a maturity of citizen beliefs and attitudes regarding fuels management in general (albeit findings do suggest less familiarity in Michigan and Wisconsin). Moreover, when viewed within the context of the broader body of research, these findings provide additional evidence of high levels of citizen understanding regarding the rationale for fuels treatments and support for treatment use to reduce the potential for wildland fires. Findings here also demonstrate how far citizen understanding and acceptance of treatments have advanced, since the earliest research found limited support for anything other than traditional fire suppression activities (e.g., Stankey 1976; Manfredo et al. 1990).

To date, resource agencies have had much success in their efforts to build effective fuels management programs. As managers have demonstrated their ability to effectively implement treatments over time, residents have grown more familiar with fuels management practices and gained confidence in resource managers. Maintaining this acceptance into the future will depend on managers' ability to

build on this existing support. Effectively engaging stakeholders including WUI residents will be an important component of such efforts as such engagement can influence resident understanding of fuels treatments and confidence in agency managers (e.g., Parkinson et al. 2003; Toman et al. 2006). Even in WUI communities, many residents still have had limited experience with agency managers. Through effective outreach and communication programs, agency managers can build understanding of expected treatment outcomes and contribute to the development of confidence in agency managers (e.g., Toman et al. 2006; McCaffrey and Olsen 2012).

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