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Safety climate in the US federal wildland fire management community: influences of organisational, environmental, group and individual characteristics

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Abstract. This study examined the effects of organisational, environmental, group and individual characteristics on five components of safety climate (High Reliability Organising Practices, Leadership, Group Culture, Learning Orientation and Mission Clarity) in the US federal wildland fire management community. Of particular interest were differences between perceptions based on respondents' Incident Position. Those in supervisory positions at the ground level (Type 1 Firefighters) and those at the top (Incident Commanders and operational leads) scored significantly higher than did mid-level supervisors (Single Resource, Division Supervisors, Task Force and Strike Team Leads). This was particularly the case for High Reliability Organising Practices, which measure the degree of communication among and between units, and Group Culture, which measures the tightness of a group and the degree of psychological safety felt by members. Both components directly affect the amount and type of information flowing within and between incident units. That the critical middle links in incident organisation perceive these essential safety-related functions to be significantly lower than do individuals at other levels provides a startling empirical insight into, and powerful leverage for further improving, incident operations and resulting safety outcomes.

Additional keywords: high reliability organisation (HRO), incident, operations, safety culture.

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Introduction

Wildland fire activity in the western United States increased markedly in the mid-1980s, with higher frequency of Class E fires (>121 ha), longer incident durations and longer fire seasons driven by both land use history and climate change (e.g. Westerling *et al.* 2006). These changes compound risk in an inherently risky operating environment; operations can quickly devolve to result in economic, ecologic and socio-political disasters, and loss of life. Safety has become a priority issue within the wildland fire management community (Wildland Fire Lessons Learned Center 2006) and with this has come a focus on the human dimensions of wildland fire management, particularly decision making, leadership, crew dynamics and organisational learning (Putnam 1996; Useem *et al.* 2005; Lewis 2008; Lewis *et al.* 2011).

To understand and continue improving performance in wildland fire management researchers and practitioners have turned to the extensive body of knowledge on organisational culture, and safety culture more specifically. 'Organisational culture' describes shared values that affect and influence members' attitudes and behaviours; 'safety culture' (a subset of organisational culture) is thought to affect members' attitudes and behaviours in relation to an organisation's ongoing safety performance (Cooper 2000). 'Safety climate' is commonly understood as the surface expression of safety culture (Guldenmund 2000), which can be directly measured through members' perceptions, attitudes and beliefs regarding safety issues in their organisation. Following a thorough review of the organisational safety literature, Wu *et al.* (2007, p. 92) concisely define safety climate as 'employees' perceptions of safety culture in the organisation … perceptions which are influenced by organisational factors and individual factors [and] eventually affect employees' safety behaviours'. Successful efforts to improve safety performance must then begin with a solid understanding of existing perceptions of an organisations' safety climate. Only then can an organisation and its members take concrete improvement actions with confidence. Here, we seek to characterise influences on the current safety climate in US federal wildland fire operations.

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Table 1. Description, explanatory value and sample items for each component of safety climate

Component (*n* of items; Crohnbach's α)	Eigenvalue (percentage explained variance)	General description The extent to which…	Sample items (examples of survey questions)
HRO practices (18 items; α = 0.911)	7.397 (13.86)	…information, knowledge and awareness flowed freely within and across all hierarchical levels of the organisation during the incident.	We constantly kept one another in the loop about our activities. People were rewarded or thanked for spotting potential trouble spots. People were familiar with what was going on beyond their own part of the fire.
Leadership (10 items; α = 0.886)	5.513 (10.4)	…leaders exhibited openness by seeking input from the crew and responding accordingly, and explicitly recognised the value of teamwork during the incident.	My boss actively listened when different views were presented. My boss told us that our task required us to work well together.
Group culture (9 items; α = 0.858)	5.222 (9.85)	…group members experienced group cohesiveness and capitalised on their knowledge of each other to address situations during the incident.	People showed a great deal of respect for each other. We took advantage of the unique skills of our colleagues when attempting to solve a problem.
Learning orientation (10 items; α = 0.803)	3.917 (7.39)	…group members reflected upon problems that arose during the incident, and attempted to predict and prevent problems that might arise in the future.	After the fire, we discussed whether there were ways we could have predicted or prevented problems that arose. We discussed alternatives as to how to go about our work activities.
Mission clarity (6 items; α = 0.774)	3.320 (6.27)	…group members were clear about their purpose, objectives and tasks during the incident.	Our mission and objectives for each day were clear throughout the day. We knew what actions were required to achieve the outcomes we wanted.
	(total variance = 47.78)		

High reliability organising[A] (HRO), one domain of organisational safety research, emerged in the late 1980s as part of an effort to identify commonalities among organisations that function under hazardous conditions yet experience few adverse events. Theoretical development derived from observing operations on aircraft carriers, air traffic control towers and nuclear power plants, and has been more recently extended to wildland fire (Weick and Sutcliffe 2007, 2008; Sutcliffe 2011). This work indicates that highly reliable organisations engage in practices that create a rich, nuanced, ever evolving, tentative and shared understanding of operations. This requires a social dynamic that accesses, communicates and uses all information and expertise, regardless of where in the hierarchy it resides. Members constantly seek evidence disconfirming their expectations, which enables them and the organisation to detect and address problems when small, before they have an opportunity to evolve into a major issue. Such groups find ways to constantly reflect upon actions and outcomes and integrate insights into ongoing and future operations.

Understanding how these attributes appear in operations – wildland fire operations specifically – is one avenue for identifying ways to improve performance. Yet to date, the bulk of empirical work has focussed on hospital staffs (e.g. Wilson *et al.* 2005; Vogus and Sutcliffe 2007). Several recent studies have examined the relevance of the HRO paradigm for wildland fire management (e.g. Dether and Black 2006; Knotek and Watson 2006; Thomas *et al.* 2007; Weick and Sutcliffe 2008) but these were limited to qualitative examinations.

In 2007, the first author initiated an effort to create an empirical benchmark of safety climate in the federal wildland fire community (Black *et al*. 2008). A quantitative survey was developed drawing on an initial suite of interviews and the organisational safety and HRO literature. The survey included demographic questions about the respondent, organisational and environmental questions about his or her most recent involvement in a fire event and a series of Likert-scale items designed to measure aspects of safety climate with respect to that last event (see Sample Items, Table 1). The majority of these were adapted from previously published survey scales and items (e.g. Vogus and Sutcliffe 2007). Brief results from part of this study (Barton and Sutcliffe 2008) found evidence for a connection between *a priori* groupings of HRO practices and perception of group performance, an increasing need for these practices when uncertainty is high, and a direct connection between goal clarity and perception of performance. Further exploratory analysis (A. E. Black and B. Baldauf McBride, unpubl. data) revealed five distinct, and somewhat different, components of safety climate: HROPractices, Leadership, GroupCulture, LearningOrientation and MissionClarity (Table 1). As opposed to the *a priori* groupings used by Barton and Sutcliffe (2008), the components used here provide starker distinctions between practices of information flow

[A]We use HRO to refer to both organisations (high reliability organisations) and the practices in which these organisations engage to promote high performance (high reliability organising).

Table 2. Characteristics of sample ($n = 574$)

Abbreviations are as follows: USFS, US Forest Service; BLM, Bureau of Land Management; NPS, National Park Service; Rx, prescribed fire; WFU, wildland fire use; FFT1, firefighter type 1, FFT2, firefighter type 2, DIVS/TSK/STK, division supervisor, task force and strike team leaders; Command-LG, type 1, 2 and 3 incident command positions; Command-SM, type 4, 5 qualified incident commanders, burn bosses. See Table 3 for more complete descriptions

Characteristic Variable name	Classes	Frequency	%	Valid %
Organisational				
Agency	USFS	231	40.2	40.2
	BLM	131	22.8	22.8
	NPS	212	36.9	36.9
	(Total)	(574)	(100.0)	(100.0)
Environmental				
FireType	Rx/WFU	129	22.5	22.5
	Suppression	445	77.5	77.5
	(Total)	(574)	(100.0)	(100.0)
FireSize/Complexity	HomeUnit/Extended Attack	294	51.2	51.4
	InitialAttack	95	16.6	16.6
	Team/Project	183	31.9	32.0
	(Total)	(572)	(99.7)	(100.0)
Group				
ProportionOfGroupKnown	None	75	13.1	13.2
	Less Than Half	108	18.8	19.0
	Approximately Half	66	11.5	11.6
	More Than Half	56	9.8	9.9
	Almost All	263	45.8	46.3
	(Total)	(568)	(99.0)	(100.0)
KnowledgeOfGroup's SkillsAbilities	Not At All	49	8.5	8.6
	A Little	35	6.1	6.1
	Somewhat	79	13.8	13.8
	Fairly Well	156	27.2	27.3
	Very Well	252	43.9	44.1
	(Total)	(571)	(99.5)	(100.0)
Individual				
IncidentPosition	Agency	32	5.6	5.6
	Command-LG	65	11.3	11.3
	Command-SM	47	8.2	8.2
	Dispatch	53	9.2	9.2
	DIVS/TSK/STK	77	13.4	13.4
	SingleResource	138	24.0	24.0
	FFT1	72	12.5	12.5
	FFT2	27	4.7	4.7
	Support	63	11.0	11.0
	(Total)	(574)	(100.0)	(100.0)
Gender	Male	449	78.2	78.2
	Female	125	21.8	21.8
	(Total)	(574)	(100)	(100)
		Mean	s.d.	
YearsInFireMgmt		15.9	9.2	($n = 572$)
YearsSuppression		7.5	7.0	($n = 570$)
YearsRx		3.7	4.0	($n = 571$)
YearsWFU		1.5	2.4	($n = 570$)
Age		41.1	9.6	($n = 565$)

(HROPractices), behaviours to surface the diverse perspectives and disconfirming evidence necessary to create a rich situational awareness (embedded in Leadership), internal dynamics that enable group sense-making (GroupCulture) and group learning practices (LearningOrientation). Both studies reveal a fairly robust safety climate in the federal fire management community as a whole.

Our primary interest here is to explore influences on perceptions of safety climate overall and on each of these components. We explore influences of four suites of characteristics (environmental, organisational, group and individual, following Hoy and Miskel (1982), Isla Díaz and Cabrera (1997) and Wu *et al.* (2007)) seeking to build a rich and detailed understanding of existing conditions.

Materials and methods

Survey instrument

The survey measured a variety of potentially influential characteristics (Table 2). Our effort was exploratory; we began with no *a priori* hypotheses other than the null. Here we describe each of the variable characteristics (with variable names in parentheses).

Organisational (Agency)

Federal agencies with responsibility for managing wildland fire in their jurisdictions in the US are subject to different land management missions and internal hierarchies.

Environmental (FireType, FireSize/Complexity)

Federal policy in 2007 identified three types of wildland fire. Where and when fire plays its natural and beneficial role on the landscape land agencies may use fire to achieve land management objectives. When management ignites such a fire intentionally it is called prescribed fire (Rx); when nature is responsible for ignition it was called wildland fire use (WFU). We combined these two into a single Rx/WFU category. When fire threatens property or natural resources, managers may select to suppress an ignition (Suppression).

Fires are also classified by their size and complexity. As fire size increases, the management organisation and issues often increase in size and complexity as well. Smaller incidents are usually managed by a small number of people from the local unit who know well each other, the local unit objectives and the landscape. Larger incidents draw in more people. Initial attack, referring to the initial response, is accomplished by local unit personnel. InitialAttack is either successful (i.e. the fire is extinguished) or it transitions to a larger management structure. The first level above initial attack for a suppression event is extended attack, which is often still managed by the local unit but draws in additional crews. For our analysis, we include 'home unit' fires (which capture all fire use events in our dataset) in this category, because the number and type of incident positions required are similar. Fires that exceed the capacity of the HomeUnit/ExtendedAttack organisation are called Team/Project fires. For these, an external team is called upon to manage the incident and to free the local unit to focus on strategic direction, local expertise and oversight. These incident management teams (IMT) comprised 7–68 highly qualified and experienced individuals who provide the structure and functional expertise to manage large incidents (finance, logistics, information, operations, command, plans, safety). Team rosters are often stable from year to year and can be drawn from a single agency or from a variety of federal, state, local agencies, retirees and contractors. Each area of the country has several teams, though in busy seasons the IMT for an incident may be from a distant geographic area. Total number of personnel on an incident may exceed 1000 and include crews and people from all over the country.

Group (ProportionOfGroupKnown, KnowledgeOfGroup'sSkillsAbilities)

Although there may be some year-to-year change in IMT personnel, the bulk of the team will have worked together on many incidents for several years. At the other end of the experience and qualification scale are the seasonal crews for which the only consistent member may be the permanent crew leader. Although there is an intuitive link between time spent together and knowledge of each other, high performing teams figure out ways to quickly assess and share knowledge and skills with each other so as to enable them to access critical skills and expertise when needed. These two continuous variables sought to capture measures of both previous time spent together and knowledge of each other's skills and abilities.

Individual (IncidentPosition, YearsInFireMgmt, YearsRx, YearsWFU, YearsSuppression, Gender, Age)

As with any industry, wildland fire has a fully developed set of position descriptions, qualifications and training. Uniquely, the role a person plays on an incident may be quite different from their permanent job. They may work in a different content area on an incident or at a higher or lower level of responsibility than in their day job. We grouped respondents into one of nine IncidentPositions identified by the type of role they played on their last incident and the level of qualification needed for that role (Table 3).

Similarly, the amount of time a respondent has spent in fire management may affect their perceptions of safety climate but perceptions might also differ depending upon whether those years were spent in Rx, WFU or suppression; thus we measured each of these separately. Finally, perceptions may vary by age cohort or gender.

Survey population and sample

The survey population included permanent seasonal and full-time employees filling fire, fuels, dispatch and fire aviation positions in the three largest federal fire management agencies: US Forest Service (USFS), Bureau of Land Management (BLM) and National Park Service (NPS).

We drew a stratified random sample from complete lists of National Forests, BLM State Offices and National Parks with fire programs to reflect the relative proportions of fire personnel within each agency. The target number of surveys was 700: 400 USFS, 200 BLM and 100 NPS (57, 29 and 14% of sample)[B]. We then randomly sampled local districts and personnel within each major unit, seeking to reflect the relative proportions of fire personnel at each administrative level (57% ground, 29% middle and 14% upper-level positions in each agency) making the initial assumption that permanent position would approximate incident position. Although we sampled people based on their permanent position, we addressed, coded and analysed the survey based on the self-reported response for most recent incident position.

[B]For all five federal wildland fire agencies (of which the three included here comprise the bulk of fire employees), internal agency calculations put the population of employees who bill at least 51% of their time to fire at nearly 10 000, with ~7000 in primary fire positions (Huelster, pers. comm., 2 July 2012). Based on this, we estimate we have surveyed ~10% of the population.

Table 3. Description of incident positions

Incident position	Incident qualification or position description	Description
Agency	Fire Management Officer, Duty Officer, Resource Advisor, Agency Administrator	Tasks associated with the local management unit. May or may not have incident qualifications.
Command-LG	Type 1, 2 or 3 Incident Commander, Type 1, 2 Operations/ Air Section Chief, Fire Use Manager	Experience, classroom and field training and qualifications beyond Command. Manages larger, more complex incidents.
Command-SM	Initial Attack Incident Commander, Type 4 Incident Commander, Burn Boss, Trainee, Assistant Engine Captain	Commanders of smaller, less complex incidents have more experience than Single Resource; depending upon level most have at least Division Supervisor, Task Force or Strike Team Leader qualification.
Dispatch	Dispatch	Associated with organisation that oversees ordering of supplies and resources. May not have other qualifications.
DIVS/TSK/STK	Division Supervisor, Group Supervisor, Task Force Leader, Strike Team Leader	Mid-level field supervisors on larger incidents. More experience and qualification than Single Resource. Leads multiple sets of engines, or mixed ground resources.
Single Resource	Helicopter Manager, Helibase Manager, Hotshot Squad Boss, Dozer Boss, Engine Module Leader	Overseas single ground resource unit. Has more experience and classroom training than Fire Fighter Type 1.
FFT1	Fire Fighter Type 1, Hotshot, Crew Foreman, Engine Boss, Helitack crew	Has acquired more experience and both field and classroom qualifications than Fire Fighter Type 2.
FFT2	Fire Fighter Type 2	Initial entry-level fire position.
Support	Finance, Information, GIS, Cache, Rehabilitation, Regional Support	Provides staffing for a variety of non-operational tasks. May/may not have advanced fire qualifications.

Survey administration and data preparation

In October and November of 2007, 668 telephone surveys were completed by a professional polling organisation at the University of Montana. Individuals were asked to think back on their most recent fire event, which ranged from the day of the interview to 6 months earlier, with the majority occurring within 3 months of the interview (see Table 1 for example questions). All surveys for which the respondent gave 'no response' for more than two items were excluded from the dataset, yielding 574 surveys for analysis. Scores for fewer than two 'no response' items were interpolated for each respondent. The demographics and scores of the 94 excluded cases were compared with the remaining 574 cases to check for non-response bias. None was detected. Sample and population distributions were similar with respect to Agency and IncidentPosition, though the USFS was somewhat under-sampled (Table 2).

Statistical procedures

The dependent variables used here are the five components of safety climate developed and described by A. E. Black and B. Baldauf McBride (unpubl. data). To assess the effects of categorical characteristics on safety component scores, we conducted a series of one-way MANOVAs using each characteristic as the independent variable and the components of safety climate as the dependent variables. Pillai's trace statistic (recommended when sample sizes differ; Field 2009) was employed to test the overall effect of each characteristic on the complete set of dependent variables (safety culture 'as a whole'). If a significant overall effect was detected ($P < 0.05$) we used separate one-way ANOVAs to assess the characteristic's influence on each component of safety climate. We explored the nature of each significant effect using the Games–Howell *post hoc* procedure (recommended when the assumption of equal variances is not met; Field 2009).

We used a similar approach to assess the effects of the continuous characteristics: a series of multiple regression analyses were followed by separate linear regressions where the overall effect was significant ($P < 0.05$).

Finally, to gain a better understanding of the relationships between respondents' characteristics, we conducted Pearson's Chi-square analyses for all combinations of categorical variables, and separate one-way ANOVAs for combinations of categorical and continuous variables. We assessed significance among the categorical characteristics by examining standardised residuals using a z-score greater than $|1.96|$ to indicate significance at $P < 0.05$ (Field 2009). All statistical analyses were performed using SPSS Statistics Gradpack 17.0 (SPSS Inc., Chicago, IL).

Results and discussion

Safety climate in the US federal wildland fire management community

The fairly high overall mean and low standard error indicate a positive perception of safety climate in the federal wildland fire management community as a whole (Fig. 1). On average the represented crews and teams frequently engage in practices that build situational awareness (GroupCulture), maintain connections across hierarchical levels (HROPractices) and engage in learning behaviours (Learning); the leaders of these units create moderately open group dynamics (Leadership) and the crews and teams are clear about their objectives and how to achieve them (MissionClarity).

However, there were significant differences in safety climate ratings. Respondents' ratings of GroupCulture and MissionClarity were significantly higher than, and ratings of HROPractices, Leadership and LearningOrientation significantly lower than, the overall mean ($P < 0.05$; Fig. 1). Readily plausible reasons for the first two exist but cannot be tested with this

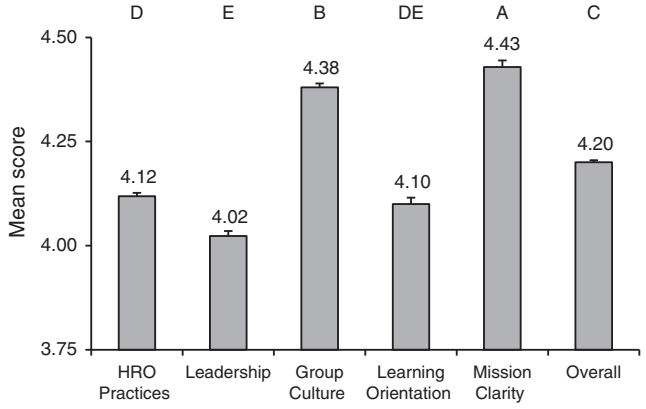

Fig. 1. Comparison of mean scores for components of safety climate ($n = 574$). Error bars are +1 standard error of the mean. Letters indicate statistically homogenous groups (Bonferonni *post hoc* procedure, $P < 0.05$). Note: items rated using a five-point Likert scale: either 1 = almost never, 2 = infrequently, 3 = sometimes, 4 = frequently, 5 = almost always or 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree. HROPractices refers to high reliability organising practices, which include a suite of group interaction and cross-scale communication practices theorised to assist in improving awareness, safety and performance.

dataset; namely, higher GroupCulture scores may be reflective of the high, ongoing priority placed on group cohesiveness during early leadership and annual refresher trainings. Higher scores on MissionClarity may be driven by a combination of factors, such as the daily briefings on work objectives that are delivered to fire personnel on suppression events and the specificity of strategy and tactics on smaller fires and fire use (Rx/WFU) events. Developing interpretations of variations in HROPractices, LearningOrientation and Leadership are less intuitive and averages are not very useful for revealing the specifics of when, where, who and how to improve safety and performance. Parsing the analysis by each of the components and influences separately provides additional clarity, particularly by directing manager and research focus towards the more powerful areas for further discussion and investigation.

Influences on safety climate

Safety climate was significantly influenced by all categorical measures of organisational, environmental, group and individual characteristics, but only by YearsInFireMgmt among the continuously measured characteristics (Table 4). The following sections present results and interpretation in greater detail.

Organisational influences

NPS respondents differed significantly from other agency respondents in perception of safety climate on all components except MissionClarity. Notably, the NPS respondents were significantly different with respect to the FireType, FireSize/Complexity and IncidentPosition filled by them (top row of Table 5). NPS respondents had fewer total years of experience in fire, fewer respondents in high-scoring positions (e.g. FFT1), more in lower-scoring positions (e.g. SingleResource and Command-SM) and more respondents from Rx/WFU events.

Environmental influences

The significant effects of both environmental characteristics (FireType and FireSize/Complexity) on the overall safety climate were driven by significantly different patterns of response to MissionClarity (Table 4). Respondents on Rx/WFU incidents were significantly clearer about their mission, objectives and comfort level with how to achieve those goals than were respondents on suppression fires (Table 5). Similarly, respondents on the more focussed, short-duration InitialAttack incidents indicated significantly higher perceptions of MissionClarity than did those on the more complex, longer-duration Team/Project fires.

The higher MissionClarity score for Rx/WFU incidents is plausibly because of more advance planning than what occurs before suppression incidents, with more up-front discussion and analysis of desired outcomes, tactics and potentialities. Rx/WFU crews often cooperatively develop and clarify their mission and objectives well before the fire, in addition to discussing how their mission might change if certain trigger points (fire location, timing, fire behaviour) are reached. Crews can be told exactly what to expect and what they should accomplish, projections which are less likely to change given the generally more moderate fire weather and behaviour conditions required to meet burn objectives. Rx/WFU incidents also tend to involve fewer people, who are familiar with the terrain and each other. In contrast, suppression fires, particularly large ones, tend to involve more people, more complexity and more moving parts. Suppression crews are generally given site- and time-specific tactical missions and objectives, which may or may not have an accompanying description of overall objectives and desired outcomes, or how their segment fits into the bigger picture. Strategies and tactics may need to quickly change because of dynamic fire behaviour, and these changes may not be easily communicated throughout the chain of command.

That MissionClarity is higher on smaller fires is also intuitive. FireSize/Complexity captures the management complexity and organisational size of an incident. InitialAttack fires are almost always small, local and have a single objective, whereas Team/Project fires draw the majority of their crews from elsewhere and have greater size and complexity.

The interaction effect – Rx/WFU fires were mostly HomeUnit/ExtendedAttack, whereas Suppression fires tended to be InitialAttack or Team/Project – further suggests that the degree of complexity influences perceptions of MissionClarity. That is, keeping clear on daily mission is more difficult on suppression fires that have exceeded initial attack than on other types of incidents.

Group influences

Group members' knowledge of each other, particularly of each other's skills and abilities, positively influenced perceptions of safety climate (Table 4). KnowledgeOfGroup'sSkillsAbilities had a significant, direct effect on all components of safety climate except Leadership. ProportionOfGroupKnown had a significant, direct effect on all but Leadership and LearningOrientation. However, despite the fact that previous experience with one's group relates directly to knowledge of group members' skills and

Table 4. Effects of organisational, environmental and individual characteristics on perceptions of safety climate

Probabilities are significant at *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$; ns, not significant. Agency categories are: USFS, US Forest Service; BLM, Bureau of Land Management; NPS, National Park Service. HROPractices are High Reliability Organising Practices. IncidentPositions are based on reported National Wildfire Coordinating Group qualifications, such as: FFT1, firefighter type 1; FFT2, firefighter type 2, DIVS/TSK/STK, division supervisor, task force and strike team leaders; Command-LG, type 1, 2 and 3 incident command positions; Command-SM, type 4, 5 qualified incident commanders, burn bosses. Note: although the 1-way ANOVA for HROPractices was significant overall ($P < 0.05$), *post hoc* comparisons were not significant

Predictor	MANOVA			1-way ANOVA	
Indices	Pillai's Trace	η^2	Power	F	*Post hoc* comparison (P set at <0.05)
Agency					
(All)	$F = 2.930$**	0.025	0.98		
HROPractices				5.424**	USFS, BLM > NPS
Leadership				5.362**	USFS, BLM > NPS
GroupCulture				8.288***	USFS, BLM > NPS
LearningOrientation				5.459**	USFS > NPS
MissionClarity				0.106	
FireType					
(All)	$F = 2.247$*	0.019	0.731		
HROPractices				0.861	
Leadership				0.003	
GroupCulture				0.036	
LearningOrientation				0.913	
MissionClarity				7.346**	Rx/WFU > Suppression
FireSize/Complexity					
(All)	$F = 3.029$**	0.026	0.984		
HROPractices				1.315	
Leadership				0.993	
GroupCulture				1.706	
LearningOrientation				2.511	
MissionClarity				4.703**	InitialAttack > Team/Project
ProportionOfGroupKnown					
(All)	$F = 1.956$**	0.017	0.987		
HROPractices				2.497*	ns (see note)
Leadership				1.526	
GroupCulture				3.685**	almost all > none
LearningOrientation				1.279	
MissionClarity				4.994**	almost all > none
KnowledgeOfGroups'SkillsAbilities					
(All)	$F = 3.295$***	0.028	1.000		
HROPractices				4.585**	very well > not at all
Leadership				1.021	
GroupCulture				8.305***	very well > not at all, a little, somewhat
LearningOrientation				3.999**	very well > a little
MissionClarity				7.455***	very well, fairly well > a little
IncidentPosition					
(All)	$F = 2.876$***	0.039	1.000		
HROPractices				5.334***	FFT1, Command-LG, Command-SM > DIVS/TSK/STK, SingleResource, Support
Leadership				2.81**	FFT1 > Command-SM

GroupCulture				3.265**	FFT1 > DIVS/TSK/STK, Support
LearningOrientation				3.343**	Command-LG > Dispatch, SingleResource
MissionClarity				2.291*	Command-SM > SingleResource
Gender					
(All)	$F = 2.961$*	0.025	0.858		
HROPractices				3.067	
Leadership				0.215	
GroupCulture				0.481	
LearningOrientation				9.638**	male > female
MissionClarity				0.054	

				Simple regression	
				F	η^2
YearsInFireMgmt					
(All)	$F = 2.461$*	0.021	0.776		
HROPractices				1.371	
Leadership				.023	
GroupCulture				2.634	
LearningOrientation				6.944**	0.007
MissionClarity				4.547*	0.001
YearsSuppression					
(All)	1.720	0.015	0.596		
HROPractices					
Leadership					
GroupCulture					
LearningOrientation					
MissionClarity					
YearsRx					
(All)	1.621	0.014	0.566		
HROPractices					
Leadership					
GroupCulture					
LearningOrientation					
MissionClarity					
YearsWFU					
(All)	1.762	0.015	0.608		
HROPractices					
Leadership					
GroupCulture					
LearningOrientation					
MissionClarity					
Age					
(All)	1.443	0.013	0.51		
HRO Practices					
Leadership					
Group Culture					
Learning Orientation					
Mission Clarity					

Table 5. Results of Pearson's Chi-square analyses between each combination of categorical variables ($n = 566$ complete cases)
ns, not significant; ***, $P < 0.001$; **, $P < 0.01$; *, $P < 0.05$

	Agency	FireType	FireSize/ Complexity	Knowledge-OfGroup's-SkillsAbilities	Proportion-ofGroup-Known	Incident-Position	Gender
Agency	–	***	*	ns	ns	***	ns
FireType		–	***	*	***	***	ns
FireSize/Complexity			–	***	***	***	ns
KnowledgeOfGroup'sSkillsAbilities				–	***	***	ns
ProportionOfGroupKnown					–	***	ns
IncidentPosition						–	***
Gender							–

abilities, KnowledgeOfGroup'sSkillsAbilities was more important than simply having worked with group members before.

Individual influences

Individual characteristics, with the exception of Age and experience in a specific type of fire, had a significant effect on the perception of safety climate (Table 4).

The most complex and potentially important differences in perceptions of safety climate appear to be the consequence of respondents' IncidentPosition, which reflects both experience and relative centrality of the respondent to incident communications and operations. In the following section, we present an overview of patterns, followed by presentation and discussion of position-specific results.

There were remarkable similarities (see Table 4):

- MissionClarity and GroupCulture were ranked highest (1st, 2nd) by all positions;
- Leadership was ranked lowest (5th) by all except those in FFT1 positions, who ranked Leadership 4th and Learning-Orientation 5th; and
- LearningOrientation had the greatest rating variability of the components.

Significant patterns of differences include (see Table 4):

- Differences were strongest for HROPractices and weakest for MissionClarity.
- Those in FFT2 and Agency positions were the only positions to show no significant results, quite possibly because these categories had the greatest internal variability.
- FFT1, Command-LG and Command-SM tended to rank safety climate as significantly stronger than did those in other positions; whereas respondents in DIVS/TSK/STR, Single-Resource, Support and Dispatch positions tended to perceive safety climate as significantly lower than did other positions. For instance: FFT1 respondents ranked GroupCulture and HROPractices significantly higher than did DIVS/TSK/STK; HROPractices higher than SingleResource and Support; and Leadership significantly higher than did Command-SM.
- Respondents in SingleResource positions on their last incident ranked all components (except for GroupCulture) lower than other positions, significantly so for HROPractices, LearningOrientation and MissionClarity.

One potential contributory factor to the significantly higher scores of the FFT1 group for HROPractices, Leadership and GroupCulture might be the recent emphasis on leadership and crew dynamics in the national fire curricula. Over the past fifteen years, the interagency wildland fire community has substantially re-vamped entry-to-intermediate level fire curricula, placing greater emphasis on leadership, crew cohesion and HRO principles. FFT1 is the entry-level supervisory fire-line position and can only be attained by serving successfully as a FFT2 and completing additional training (NWCG 2011). Successfully serving in the FFT1 position is a prerequisite for all other incident positions (except Dispatch). Because many of those currently in the more advanced positions may not have been exposed to the new curriculum with its emphasis on entry-level group processes and dynamics, one might expect that FFT1 would score higher than does more advanced positions. One might also expect to see a significant relationship with YearsInFireMgmt; however this is not the case (Table 4).

The Command-LG group scored significantly higher than did most other positions for HROPractices and LearningOrientation. These respondents have the experience and qualifications to fill top command and operational roles on Type 1, 2 and 3 IMTs – those chartered with managing the larger, more complex incidents of all fire types. The ICs are responsible for providing overall leadership of incident response and the IMT, including: implementing the managing Agency's objectives; overseeing operations, planning, logistics, finances and information services to internal and external stakeholders; establishing and maintaining liaison with other agencies participating in the incident; directing staff to develop and implement the daily tactical plans and overseeing the transfer of command to an incoming commander (FEMA Emergency Management Institute 2012). This group is responsible for developing and providing daily objectives to each of the ground units, then overseeing implementation. For respondents in this category the need to attain and maintain the 'big picture' view of an incident requires significant cross-hierarchy communication (HROPractices), and success is dependent on continuous reflection and adaptation (LearningOrientation).

Respondents in the DIVS/TSK/STK group scored significantly lower than did other positions with respect to HROPractices and GroupCulture. DIVS/TSK/STR personnel often serve as temporary supervisors of several crews or teams that each

have permanent internal supervisors. Only rarely are DIVS/TSK/STR personnel standing members of an IMT; rather, they are temporary liaisons between existing groups. Their responsibilities as liaisons require them to physically move between the IMT and ground teams; thus, they are vulnerable to being considered the 'odd man out,' strangers trying to provide critical communication links between different, geographically dispersed and internally cohesive groups.

Respondents in the Support group also scored significantly lower than did most other positions with respect to HROPractices and GroupCulture, though likely for a somewhat different reason than for DIVS/TSK/STR. These are non-command and non-operations positions, generally providing skills and services such as GIS, finance, logistics and public information. Most respondents in these positions have no fire-line responsibilities, nor are they part of the line of authority for operational decision-making process. Support positions may not perceive a need to have – or simply do not have – the 'big picture' view of the incident, nor perceive as great a need to explicitly emphasise group culture and cohesion. This perspective of the incident may explain the lower scores of respondents in Support positions.

Like respondents in DIVS/TSK/STR and Support positions, respondents in the SingleResource group scored significantly lower than did other command positions on HROPractices, and lower than top command for LearningOrientation and MissionClarity. This result is somewhat puzzling. SingleResource positions, although one step more advanced than FFT1 and one step below DIVS/TSK/STR, are internal supervisors of small somewhat independent units on a fire (such as a helibase or an engine module). As such, they are sometimes leaders of independent and autonomous sub-units and at other times embedded leaders in larger units. Lower scores might reflect a perception of being left out of briefings (e.g. IMT, morning and crew-level briefings that assist in building a common picture of daily and overall objectives) and reflection processes (e.g. After Action Reviews participated in by units both higher and lower in the hierarchy to capture nuances, insights and lessons).

Respondents in Dispatch scored significantly lower on LearningOrientation than those in other command positions on the most complex incidents (Command-LG). This result might be explained by the indirect nature of the tasks involved. Dispatch positions are not 'on the ground,' thus, some types of mistakes or oversights on their part may not be as likely to result directly in an accident or fatality. As such, these positions may perceive less need for reflection and learning.

Respondents in Command-SM positions include personnel occupying an incident command function on a prescribed fire (e.g. burn bosses) or a smaller suppression event (e.g. Type 4 and 5 Incident Commanders) on either initial or extended attack. Respondents in these positions were 'split,' scoring significantly higher with respect to HROPractices and MissionClarity and significantly lower with respect to Leadership than the overall mean. This might result from the fact that these positions lie at the top of the operational decision-making hierarchy, with a key task to build and maintain close communications across the hierarchy, maintain a broader perspective and ensure that decisions flow to those with the necessary expertise (HROPractices). As leaders of smaller incidents, their mission, objectives and associated strategies are likely to be clear and straightforward (MissionClarity). Yet, there may also be no direct 'boss' with whom to interact frequently. Because these incidents typically have little political or inter-agency coordination issues (in sharp contrast to Command-LG) there may be little reason for them to interact frequently with Agency leads (Leadership).

Gender effects on the overall safety climate were driven by significantly different responses for LearningOrientation, with males perceiving a significantly higher group orientation than females to learning (Table 4).

The significant positive relationship between YearsInFireMgmt and overall perception of safety climate was due to significant influences on LearningOrientation and MissionClarity (Table 4). That is, experience directly influences perceptions of learning and clarity on the daily mission and objectives, and knowledge and comfort with how to achieve that. However, YearsInFireMgmt did not significantly affect perceptions of GroupCulture, HROPractices or Leadership. Neither Age, YearsRx, YearsWFU or YearsSuppression were significantly related to respondents' scores. These results seem intuitive: first, it is generally assumed that if one is 'in the business' long enough, one will experience an undesired event (e.g. a near-miss, an injury, loss of control of a prescribed fire or loss of a colleague in the line of duty) and will have placed increasing emphasis on the practices of learning as a result. Also, MissionClarity includes items that naturally increase with experience, including greater understanding of a range of goals and objectives, and clearer knowledge of how to perform a task.

Statistical significance and practical limitations

MANOVA and follow-up ANOVAs can easily reach levels of significance when sample sizes are large, as is the case with this study. Although the effects detected by this study were indeed statistically significant, their practical significance also needs to be considered. It is common to assume practical significance when the explained variance for an effect (η^2) is greater than 10% (Field 2009). The greatest amount of variance explained in this study was for IncidentPosition (~4%; Table 4), lending further strength to the conclusion that IncidentPosition is likely one of the strongest predictors of perceptions of safety climate in the federal wildland fire management community.

Summary and conclusions

Although the overall perception of safely climate among federal wildland fire personnel (as measured by perception of HROPractices, Leadership, GroupCulture, LearningOrientation and MissionClarity) is positive there is room for improvement. Not all sub-units of incident organisation perceive safety climate conditions similarly and the differences are illuminating. This cautions against complacency, particularly given the findings of Barton and Sutcliffe (2008) who reported connections between HRO practices, goal clarity and perceptions of performance, particularly under conditions of uncertainty.

For instance, although overall ratings for MissionClarity are relatively high compared to the other aspects of safety climate, results suggest that increasing attention on larger, more complex fires (particularly suppression events) would be valuable. Paying close attention to ensure all units on these incidents have a

clear understanding of their overall and daily mission as well as comfort in knowing how to achieve those is likely to improve MissionClarity. This is likely to be particularly important given recent changes in US federal fire policy that eliminated WFU as a separate type of fire. One way to address this might be to incorporate more explicit communication of end-state goals and objectives into briefings, such as is recommended for prescribed fire in current guidance (USDI–USDA 2006*a*, 2006*b*).

Several practical implications stem from the finding that different IncidentPositions perceive safety climate practices and behaviours quite differently. It appears that most individuals serving in operational roles engage frequently in the types of safety practices measured by the five components. However, those serving either at the bottom or at the top who work within single, well defined groups (FFT1, Command-LG, Command-SM) score higher than do those who supervise independent and often multiple tight-knit units (DIVS/TSK/STR, SingleResource). The strikingly lower ratings regarding HROPractices by those who knit the bottom and the top together (DIVS/TSK/STR and SingleResource) is somewhat disconcerting. HROPractices reflect the health of the critical information and knowledge flows that create the rich, nuanced situational awareness required for safety. Lower ratings at this location in the hierarchy indicates that either potentially critical information about the broader goals of the incident may not be moving down to the ground, signals indicating an important change in the fire environment may not be moving up and out, or both of these. This creates a weak link in safety, particularly so as uncertainty increases such as is likely on large, complex fires.

The DIVS/TSK/STR positions also report significantly lower perceptions of GroupCulture, a measure that provides a window into the level of psychological safety within the group. Psychological safety directly influences 'upward voice' (Edmondson 1999), the willingness of a group member to speak up when they note something 'dumb, dangerous, or different' or simply have a question. Lower values of GroupCulture indicate less likelihood that weak signals will surface. In this light, the middle rungs of the larger incident organisation may be inadvertently filtering out the very sorts of weak signals that are essential for the organisation to pick up and address early. Results suggest that incident managers may improve safety and performance by ensuring these positions are well integrated into incident communications, culture and feedback systems. Additional research to understand when, where and how these barriers function should lead to more specific recommendations.

Further consideration of the lower rating for Leadership relative to other components of safety climate is warranted both by managers and researchers. Why are these lower, and why is there so much variation among perceptions of leaders by the base ground forces (FFT2)? Lower scores imply that at least some leaders of these positions are not perceived to be actively encouraging robust discussions, or actively listening – the skills of social intelligence (Goleman 2006). Are these practices included in the current leadership curricula; if not, should they be, and if so, are they successful? Lower ratings may point to the need for further training and mentoring emphasis, such as explicit incorporation of emotional and social intelligence skills. Alternatively, results may say more about perceptions of behaviours than about actual behaviours, or may indicate the need to adjust measurement items. Perhaps the relative ratings, or even the content, of safety climate constructs *should* differ for top, middle and lower levels of the incident organisation. Further investigation may allow for further refinement of understanding and more specific implications for action.

Finally, do the low scores for LearningOrientation relative to other components of safety climate generally, and for Dispatch and SingleResource specifically, reflect a general difficulty in carving out time for reflection as Wright (2010) found in looking at fire managers in their day jobs, or lack of priority placed on reflection? What are the barriers to practicing a Learning-Orientation overall, and for Dispatch and SingleResources in particular?

This study has statistically revealed and forwarded tentative, provacative interpretations for several insights into incident operations. It has raised several reflective questions that may assist fire managers in thinking about how best to mentor and engage the various aspects of incident management to enhance organisational performance and reliability. It has also identified additional research areas and questions, the answers to which would provide a more specific framework for assessing and improving safety climate in wildland fire operations.

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