

## Bridging the divide between fire safety research and fighting fire safely: how do we convey research innovation to contribute more effectively to wildland firefighter safety?

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**Abstract.** Creating a safe workplace for wildland firefighters has long been at the centre of discussion for researchers and practitioners. The goal of wildland fire safety research has been to protect operational firefighters, yet its contributions often fall short of potential because much is getting lost in the translation of peer-reviewed results to potential and intended users. When information that could enhance safety is not adopted by individuals, the potential to improve safety – to decipher the wildland fire physical or social environment and to recognise hazards – is lost. We use firefighter safety-zone research as a case study to examine how primary research is, and could be, transferred to fire managers, policy-makers and firefighters. We apply four core communication theories (diffusion, translation, discourse and media richness) to improve knowledge transfer.

**Additional keywords:** communication, fire safety, research delivery.

Received 4 August 2016, accepted 23 December 2016, published online 30 January 2017

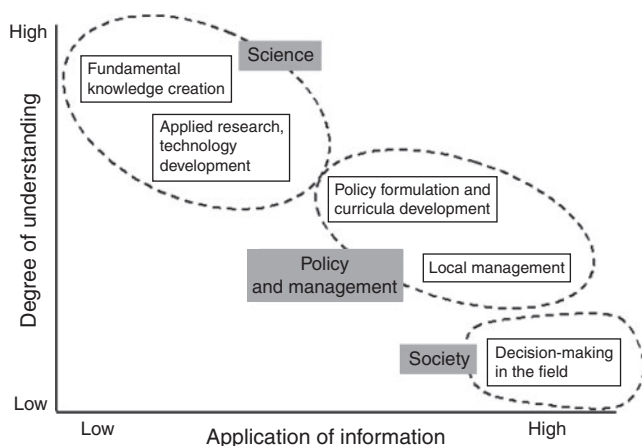
### Introduction

Encouraging safe practices continues to be a concern at all levels of the wildland firefighting organisation. Despite this, there have been 1099 on-duty wildland firefighter deaths since 1910 through 2015 in the United States (National Interagency Fire Center (NIFC) 2015). Internal investigations following fatalities have often led to changes in policy and practice. Examples include: creation of the 10 standard firefighting orders, requirements to carry fire shelters, a focus on identifying safety zones, and adopting the use of the acronym LCES – 'Lookouts, Communications, Escape Routes and Safety Zones' (Cook 2013). However, since the onset of the traditional investigation and report method, the firefighting organisation has not seen a decrease in firefighter accidents or fatalities (Pupulidy 2015).

Although changes in policy and operational procedures are valuable, there is also a substantial body of research that points

to the need to understand and attend to environmental, social and human factors to keep firefighters safe. Researchers have studied breakdowns in communication that can lead to tragedy events (Gabor 2015), how escape times and safety zones can affect public and firefighter survival (Butler and Cohen 1998a; Ruby *et al.* 2003; Fryer *et al.* 2013), and how organisational structure, safety climate and leadership contribute to firefighter awareness and therefore survivability (Bigley and Roberts 2001; Ziegler and DeGrosky 2008; Black and McBride 2013; Waldron and Ebbeck 2015). Although this pool of research is available to fire managers and firefighters, too often it remains in static, written formats and incorporation into operational practice does not occur.

In the present paper we address: dissemination strategies, their relative roles in cultivating understanding of new research and integrating this into fire-line decision-making. We argue that communication of results through published literature alone

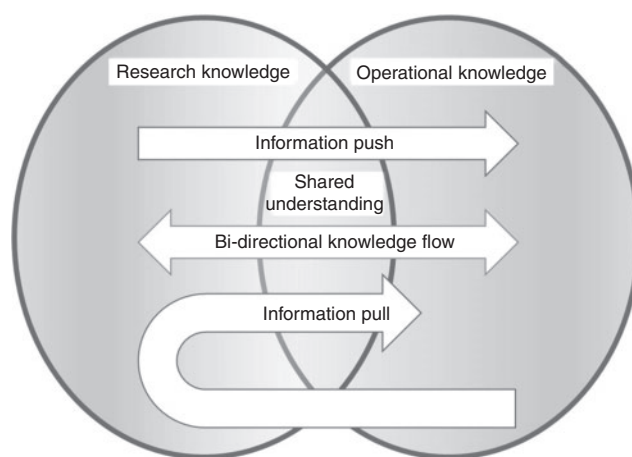


**Fig. 1.** Working group domains in the wildland fire organisation. Each group differs in their degree of understanding regarding fire safety research and the application of fire safety information. Adapted from Roux *et al.* (2006).

is insufficient to gain widespread field application. We believe this is due at least in part to different motivations and incentive structures, different backgrounds and work environments that, if acknowledged and explicitly incorporated into the information transfer process, may assist the fire community in reaching the goal – safe and effective wildland fire management. We propose methods we believe can increase effective adoption and integration of fire safety research results into practice.

The conventional path of research dissemination to the wildland fire organisation is typical of other fields (Roux *et al.* 2006; Green *et al.* 2009). Primary research is published in the peer-reviewed literature. Following publication, distribution methods include presentations at academic and management conferences, webinars, research notes and newsletters. As peer-reviewed information demonstrates potential application in the field, policy-makers then consider including the findings in policy, recommendations or teaching curricula. Information from each source filters to fire managers who incorporate what they find relevant into their fire programs (Fig. 1).

This model suffers from two disadvantages: (1) transferring knowledge to practitioners is not a commonplace research skill set (Cullen *et al.* 2001); and (2) it does not address the differing work-place incentives, work-environments and world-views. Roux *et al.* (2006) describes this as a knowledge transfer gap across which researchers push while managers pull information. Researchers develop a product that meets their professional advancement criteria – peer-reviewed publications in high-impact-factor journals. These scientists may have the expectation that their product will be received with enthusiasm and implemented straight away (findings are ‘pushed’). Managers, on the other side, seek immediately useful information likely to have a concrete and immediately positive impact on their work environment, productivity and output. However, the time and cognitive load involved in accessing, filtering and interpreting available knowledge is often overwhelming (Cullen *et al.* 2001; Roux *et al.* 2006). With such a substantial difference in perspectives (slow-tempo, exhaustive and passive in the academic realm; fast-paced, effective and active in the other), it is



**Fig. 2.** The knowledge interface between researchers and managers. The knowledge overlap presents an area in which researchers and managers can interface and contribute to understanding as knowledge flows bi-directionally. Adapted from Roux *et al.* (2006).

understandable that primary research is not always enthusiastically implemented by the intended practitioners (Cullen *et al.* 2001; Green *et al.* 2009). We recast this as an overlap (Fig. 2) and suggest that what is needed is more deliberate tending of this shared zone between researchers and managers. What appears necessary are interactive opportunities in which researchers and practitioners can find common ground. Such discourses are needed to increase the applicability and understanding of the findings (Roux *et al.* 2006). We turn to theory to help us further illustrate.

### Theories of communication

Models of communication range from a simple ‘sender and receiver’ model to lengthy and complex dissertations on speech and language acts (Searle 1969). Here, we explore four theories – diffusion, translation, discourse and media richness – to expand our thinking about effective transfer of fire safety research to fire managers.

#### Diffusion and translation

The current model of fire safety research dissemination can be effectively viewed through Rogers’ (1983) theory of communication as diffusion. An innovation is developed by an agent of study (researcher) and the information is communicated through an information network of early adopters (opinion leaders who are trusted information sources), until a critical mass of individual adopters is reached, at which point the innovation becomes incorporated into the organisational DNA (Rogers 1983; Wright 2004; Dearing 2006). Cullen and colleagues (2001) point out a critical factor: an innovation will not be adopted unless it is seen as enriching the current operational model. Yet it is not just quality or relevancy that determines success. Without effective opinion leaders, even great innovations will languish. Furthermore, in order for opinion leaders to effectively convince others, the audience must be receptive (Rogers 1983; Dearing 2006). Diffusion theory has four criteria

for success: innovation, effective opinion leaders, the perception that the innovation is enriching and a receptive audience.

Translational communication theory (Ogden and Richards 1923) can assist us in figuring out how to bridge the gap between the more passive researchers and the more active and engaged management-focused audience. To help potential users see the utility of an innovation, someone must position the innovation and convey its intent in a way that the audience can interpret and understand in their context and language. Yet, how we perceive and interpret the world around us is influenced by our experiences, education and culture, as well as by individual style and personality (Baxter 2006; Roux *et al.* 2006). Individuals come to a problem with different values, goals, priorities, cognitive abilities and experiences (Daft and Lengel 1986). A trained scientist might have a difficult time understanding the point of view of an operational firefighter, and vice versa. It is exceptionally easy for differing perceptions between sender and receiver to result in confusion and misinterpretation (Weick 1993; Baxter 2006; Güney 2006; Wright 2007). Recall the children's game of telephone. Each person who receives information processes it through their own experiences, knowledge and current understanding – their own lens of sense-making (Saludadez and Taylor 2006). The more lenses information passes through, the more filtered it becomes; yet, if the information passes back and forth through a translational lens, generation of intent occurs between each of the communicators. Translational communication encourages us to reword the message using metaphors and synonyms common to the audience. In doing so, the communicating agents can clarify their intent and craft a more cogent, useful message (Baxter 2006; Striphas 2006; Taylor 2006).

Combining the theories of diffusion and translation, we suggest that the complex ideas developed by fire safety researchers can be effectively conveyed and distributed by translating academic results into words, stories and metaphors that resonate with opinion leaders and translators. Next, we employ an illustrative theory of discourse in order to enrich our discussion of practical applications.

#### *Epistemic, deontic and taxemic discourse*

We now turn to the notion of intent. Our approach mirrors that of Ziegler and DeGrosky (2008) as they communicate intent within fire leadership. Their prose employs Taylor's (2006) description of 'epistemic', 'deontic' and 'taxemic' approach to organisational discourse. Each of these subcategories illustrates a difference in where the intent of the communicated message is generated during communication, both for theoretical information communication and practical metadiscourse.

In epistemic discourse, information is transferred from one person – the sender – to a second person – the receiver. Message intent is generated by the sender without much consideration given to the role of the receiver (Taylor 2006). This is analogous to the fire safety researcher who focuses on appealing to peers when writing up results for review. Effective communication from the researcher's perspective occurs when the paper is accepted for publication.

Deontic discourse posits that message intent develops as the message is interpreted, that is, in how the receiver

understands and interprets the message (Taylor 2006). Effective communication occurs when the receiver identifies understandable information (Wright 2007), regardless of its veracity. Because message intent is created in the world-view of the reader and applied to the readers' actions as they deem appropriate, the range of interpretations generated will vary as widely as do the levels of experience, training and understanding of receivers.

Taylor's third model, taxemic discourse, posits that understanding is co-created through interaction (Taylor 2006). This model embraces a relational conception of discourse: intention does not belong to the sender or receiver alone, but is generated through back and forth negotiation that enriches both along the way to a mutual and synergistic understanding. Complex organisations and collaborative teams have been shown to be more effective when discourse flows from knowledge providers to the intended audience and vice versa, regardless of hierarchy (Pentland 2012; Edmonson and Christensen 2013; Marquet 2015).

Unfortunately, academic reward structures (peer-reviewed publications) do not encourage the active discourse needed to generate understanding and build effective opinion leaders, to co-create a sense of the innovation's value at the operational level, or to improve audience receptivity (Roux *et al.* 2006). Although there seem to be fewer and fewer opportunities for researchers, managers and practitioners to meet face-to-face, there are options in the methodologies in which innovative information can be presented.

#### *Media Richness Theory*

Media Richness Theory encourages large organisations – the type of organisation too large to play telephone with critical information – to convey messages in ways to increase understandability and interpretability (Daft and Lengel 1986; Rice 1993). A central tenet is that there is rarely a lack of information in the message; what can be lacking is clarity (Daft and Lengel 1984). Success requires that a sender select a transfer mode to match message complexity. This does not refer to the type of platform on which the message is delivered (as in media platforms like Facebook, YouTube and Instagram), but instead, it seeks to increase the clarity of the message by using variable teaching techniques, visual and audible cues, and increasing feedback. Media richness theory suggests we seek additional avenues for facilitating rich, multifaceted discourse and interaction.

To recap, knowledge transfer seems to be most successful if it can be translated into actionable concepts that the intended audience (opinion leaders and late adopters) can readily connect to their operating environment and perceive concrete value in. The more complex the innovation is, the greater the need for interactions between researchers, early adopters and field practitioners to ensure appropriate and consistent interpretation and application. Moreover, owing to normal variations in learning styles, culture and experience, multiple modes of translation using a variety media platforms are likely to be needed. Our case study of the Safety Zone research conducted by Butler and Cohen (1998a, 1998b) provides a specific illustration of how peer-reviewed innovation has entered widespread use throughout the wildland firefighting organisation.

### Case study: safety zone requirements

#### *Research and delivery*

Fire safety research is currently conveyed through a variety of platforms and media that include policy documents, trainings and reference material (National Wildfire Coordination Group (NWCG) 2003, 2014, 2016). Information quantity is ample; however, clarity and interpretability are often only partially developed. This leaves firefighters on their own to complete interpretation and determine whether, how and where to apply their own understanding. In an effort to provide clearer direction, Butler and Cohen (1998a, 1998b) developed a mathematical model that describes adequate firefighter safety zones as a function of flame height: safety zones should have a fuel separation radius of four times observed flame heights. This physics-based research was published in a peer-reviewed, academic journal (Butler and Cohen 1998a). In an attempt to deliver the research to fire managers, it was reported in laymen terms in Fire Management Notes (Butler and Cohen 1998b). The 'four times flame height' separation distance was then widely accepted as a standard for safety zone creation and adopted widely in fire safety curricula (NWCG 2014).

#### *Application and result*

As many firefighters can attest, use of the safety zone model in the field has ranged from no use, to a general guideline for consideration, to a requirement that must be met in order to engage in firefighting activities (B. Bush, D. Williams, pers. comm; T. Adams, S. Brown, pers. exp.). However, the mathematical model was intended to be delivered to firefighters as a guideline, not a mandated expectation. Butler believed that there were far too many unknowns in the fire environment to expect that a study of this nature be rigidly adopted without consideration of local environmental conditions. Additionally, the model included several assumptions: 'Calculations are based on radiant heat only and do not account for convective heat from wind and/or terrain influences. Since calculations assume no wind and no slope, safety zones downwind or upslope from the fire may require larger separation distances' (NWCG 2014, p. 8). Because of this, fire leadership often defers to the field to locate safety zones. Yet, 'the field' comprises supervisors and subordinates, experienced and novice firefighters. In the blizzard of information that novices get in their intensive training, the simple 'four times the flame length' is an easy rule to remember. All firefighters are trained to maintain awareness of their proximity to the nearest viable safety zone, including both the site itself and the escape route to the safety zone (NWCG 2003; NWCG 2014). However, few novice firefighters have sufficient experience in the fire environment to process all of the caveats that the safety zone guidelines entail. Beyond that, there are woefully few opportunities for anyone to practice and discuss interpretation with the researchers themselves. Differing interpretations on how to apply fire safety research can lead to conflict and unrest during field operations, particularly when an identified safety zone does not exactly meet the four times flame height standard (B. Bush, D. Williams, pers. comm.).

We have complex research results that require significant interpretation based on deep experience and knowledge of the

fire environment. We have a translation of this complexity into a simple, numerical 'rule of thumb' being applied by novices and leaders alike, all with varying experience in the field, and the absence of opportunities to refine interpretation and application with the researchers.

### Discussion and conclusions

The old stand-by model that views information transfer as a one-way process in which concepts are either delivered or received falls well short of true knowledge generation and meaningful application of robust research (Roux *et al.* 2006). The adoption of communication methods that increase knowledge of research among the target audience will likely be more successful as a dynamic, multifaceted approach that includes multiple media to convey information and context in which to apply innovative research (Daft and Lengel 1986; Taylor 2006). Following the research-based suggestions we provide here may help reach the shared goal to develop 'a sound relationship between a nation's capacity to create and supply appropriate knowledge, and its capacity to absorb, translate, and exploit such knowledge' (Roux *et al.* 2006, p. 16).

Our brief review of communication and knowledge transfer theory suggests that creating a thorough understanding of fire safety research among firefighters is more likely accomplished through direct interaction than through the conventional, hierarchical delivery of information: from researchers to policy-makers, to managers, to professional firefighters. Robust communication among all members of the fire organisation and using richer media can increase taxemic discourse, resulting in a more thorough and shared understanding of contributors to fire safety and danger.

Increasing the understandability of safety research and clarifying intent is a feasible and worthy undertaking. We propose beginning with more intentional discourse over research results and interpretations. The purpose of these small or 'core' group discussions between researchers and subject matter experts (opinion leaders and early adopters) would be to exchange perceptions and co-create interpretations, and identify appropriate terminology, metaphors and examples through which to explain appropriate implementation. Discussions would also concern delivery platforms and options to increase media richness. These could then be incorporated into workshops, field tours, video presentations, webinars, classroom presentations and any other new opportunities. The suggestion here is to begin the translational process early and intentionally, then seek to increase the variety of methods in which the research message is delivered, increase the scope and style of message delivery to match audience diversity, and increase dialogue about the application of fire safety research.

Adopting a model of information transfer that creates actionable knowledge among the intended audience is the goal of both researchers and research users. Much is still needed to meet the intent of this goal. The underlying challenge in conveying fire safety research to an audience as diverse as the wildland fire organisation is determining how to ensure understanding is increased and knowledge is integrated, as opposed to simply delivering information.



When the research messages are combined with operational experience, fire managers can develop a better understanding of how the fire environment affects safety. This will take attention and resources; yet, if the desire is a more informed workforce that can make decisions in the face of a dynamic fire environment, investments must be made to help make sense of the world, take actions based on that knowledge, and learn about the world as those actions are taken. If firefighters are able to integrate all available information – both research-based and experiential – into a robust understanding of the fire environment, they can then fight fire having provided for safety first.

## Acknowledgements

This work was supported by funding provided through the National Fire Plan, the NWCG Fire Behaviour Subcommittee, and the Wildland Fire Management Research Development and Application Program. Authors appreciate comments provided by reviewers, which have significantly improved the manuscript. Authors would also like to thank Brian Bush (Payette National Forest – Central Zone Assistant Fire Management Officer and Former Superintendent – LaGrande Hotshots) and Dave Williams (Lolo National Forest – Missoula/Seely Lake Ranger District Assistant Fire Management Officer: Fuels and Former Assistant Superintendent – Lolo Hotshots) for their candid communication and sharing their meaningful experiences.

## References

- Baxter LA (2006) Communication as dialogue. In 'Communication as... Perspectives on Theory'. (Eds GJ Shepherd, J St John, T Striphas) pp. 101–109. (SAGE Publications: Thousand Oaks, CA)
- Bigley GA, Roberts KH (2001) The incident command system: high-reliability organizing for complex and volatile task environments. *Academy of Management Journal* **44**, 1281–1299. doi:10.2307/3069401
- Black AE, McBride BB (2013) Safety climate in the US wildland fire management community: influences of organisational, environmental, group and individual characteristics. *International Journal of Wildland Fire* **22**, 850–861. doi:10.1071/WF12154
- Butler BW, Cohen JD (1998a) Firefighter safety zones: a theoretical model based on radiative heating. *International Journal of Wildland Fire* **8**, 73–77. doi:10.1071/WF980073
- Butler BW, Cohen JD (1998b) Firefighter safety zones: how big is big enough? *Fire Management Notes* **58**, 13–16. Available at [https://www.fs.fed.us/fire/fmt/fmt\\_pdfs/fmn58-1.pdf](https://www.fs.fed.us/fire/fmt/fmt_pdfs/fmn58-1.pdf) [Verified 9 January 2017]
- Cook JR (2013) Trends in wildland fire entrapment fatalities ... revisited. Wildland Firefighter Training Annual Refresher. (National Interagency Fire Center: Boise) Available at [https://www.nifc.gov/wfstar/downloads/Wildland\\_Fire\\_Entrapment\\_Fatalities\\_Revisited\\_JC.pdf](https://www.nifc.gov/wfstar/downloads/Wildland_Fire_Entrapment_Fatalities_Revisited_JC.pdf) [Verified 29 November 2016]
- Cullen P, Cottingham P, Doolan J, Edgar B, Ellis C, Fisher M, Whittington J (2001) 'Knowledge-seeking strategies of natural resource professionals.' (Cooperative Research Centre for Freshwater Ecology: Bungendore, NSW)
- Daft RL, Lengel RH (1984) Information richness: a new approach to managerial behavior and organizational design. *Research in Organizational Behavior* **6**, 191–233.
- Daft RL, Lengel RH (1986) Organizational information requirements, media richness and structural design. *Management Science* **32**, 554–571.
- Dearing JW (2006) Communication as diffusion. In 'Communication as... perspectives on theory'. (Eds GJ Shepherd, J St John, T Striphas) pp. 174–179. (SAGE Publications: Thousand Oaks, CA)
- Edmondson A, Christensen K (2013) Thought leader interview: Amy Edmondson. *Rotman Winter* **2013**, 10–15.
- Fryer GK, Dennison PE, Cova TJ (2013) Wildland firefighter entrapment avoidance: modelling evacuation triggers. *International Journal of Wildland Fire* **22**, 883–893. doi:10.1071/WF12160
- Gabor E (2015) Words matter: radio misunderstandings in wildland firefighting. *International Journal of Wildland Fire* **24**, 580–588. doi:10.1071/WF13120
- Green LW, Ottoson JM, Garcia C, Hiatt RA (2009) Diffusion theory and knowledge dissemination, utilization, and integration in public health. *Annual Review of Public Health* **30**, 151–174. doi:10.1146/ANNUREV.PUBLHEALTH.031308.100049
- Güney S (2006) Making sense of a conflict as the (missing) link between collaborating actors. In 'Communication as organizing: empirical and theoretical explorations in the dynamic of text and conversation'. (Eds F Cooren, JR Taylor, EJ Every) pp. 19–37. (Lawrence Erlbaum Associates, Inc., Publishers: Mahwah, NJ)
- Marquet LD (2015) What is leadership? *Leadership Nudges*. Available at: <https://www.youtube.com/watch?v=pYKH2uSax8U> [Verified 30 November 2016]
- National Interagency Fire Center (NIFC) (2015) Wildland fire fatalities by year. (NIFC: Boise, ID) Available at [https://www.nifc.gov/safety/safety\\_documents/Fatalities-by-Year.pdf](https://www.nifc.gov/safety/safety_documents/Fatalities-by-Year.pdf) [Verified 2 December 2016]
- National Wildfire Coordination Group (NWCG) (2003) 'S-130: Basic firefighter training.' (National Wildfire Coordination Group: Boise, ID)
- NWCG (2014) 'Incident response pocket guide.' (National Wildfire Coordination Group: Boise, ID)
- NWCG (2016) Mission: National Wildfire Coordination Group. Available at: <http://www.nwcg.gov/> [Verified 30 November 2016]
- Ogden CK, Richards IA (1923) 'The meaning of meaning: a study of the influence of language upon thought and of the science of symbolism.' (Harcourt Brace Janovich: New York)
- Pentland A (2012) The new science of building great teams. *Harvard Business Review* **62**, 60–70.
- Pupulidy IA (2015) 'The transformation of accident investigation: from finding cause to sense-making.' (Tilburg University: Tilburg, the Netherlands)
- Rice R (1993) Media appropriateness: using social presence theory to compare traditional and new organizational media. *Human Communication Research* **19**, 451–484. doi:10.1111/J.1468-2958.1993.TB00309.X
- Rogers E (1983) 'Diffusion of innovations', 3rd edn. (Free Press: New York)
- Roux DJ, Rogers KH, Biggs HC, Ashton PJ, Sergeant A (2006) Bridging the science–management divide: moving from unidirectional knowledge transfer to knowledge interfacing and sharing. *Ecology and Society* **11**, art. 4. doi:10.5751/ES-01643-110104
- Ruby B, Leadbetter G, III, Armstrong D, Gaskill S (2003) Wildland firefighter load carriage: effects on transit time and physiological responses during simulated escape to safety zones. *International Journal of Wildland Fire* **12**, 111–116. doi:10.1071/WF02025
- Saludadez JA, Taylor JR (2006) The structuring of collaborative research networks in the stories researchers tell. In 'Communication as organizing: empirical and theoretical explorations in the dynamic of text and conversation'. (Eds F Cooren, JR Taylor, EJ Every) pp. 37–55. (Lawrence Erlbaum Associates, Inc., Publishers: Mahwah, NJ)
- Searle J (1969) 'Speech acts: an essay in the philosophy of language.' (Cambridge University Press: New York)
- Striphas T (2006) Communication as translation. In 'Communication as... perspectives on theory'. (Eds GJ Shepherd, J St John, T Striphas) pp. 232–241. (SAGE Publications: Thousand Oaks, CA)
- Taylor JR (2006) Communication as complex organizing. In 'Communication as ... perspectives on theory'. (Eds GJ Shepherd, J St John, T Striphas) pp. 132–142. (SAGE Publications: Thousand Oaks)
- Waldron AL, Ebbeck V (2015) The relationship of mindfulness and self-compassion to desired wildland fire leadership. *International Journal of Wildland Fire* **24**, 201–211.

- Weick KE (1993) The collapse of sense-making in organizations: the Mann Gulch disaster. *Administrative Science Quarterly* **38**, 628–652. doi:[10.2307/2393339](https://doi.org/10.2307/2393339)
- Wright V (2004) How do land managers adopt scientific knowledge and technology? Contributions of the diffusion of innovations theory. In 'Making ecosystem-based management work. Proceedings of the fifth international conference on science and management of protected areas', 11–16 May 2003, Victoria, BC. (Eds N Munro, P Dearden, TB Herman, K Beazley, S Bondrup-Nielson) Science and Management of Protected Areas Association: Wolfville, Nova Scotia, Canada [CD-ROM]. SAMPAA (Science and Management of Protected Areas Association): Wolfville, Nova Scotia, Canada. Chapter 8(3), pp. 1–9. Available at <http://leopold.wilderness.net/pubs/527.pdf> [9 January 2016].
- Wright V (2007) Communication barriers to applying federal research in support of land management in the United States. In 'Proceedings: international conference on transfer of forest science knowledge and technology 2006', 10–13 May 2005, Troutdale, OR, USA. (Eds C Miner, R Jacobs, D Dykstra, B Bittner) USDA Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-726, pp. 55–62. Available at <https://www.treesearch.fs.fed.us/pubs/29184> [9 January 2016]
- Ziegler JA, DeGrosky MT (2008) Managing the meaning of leadership: leadership as 'communicating intent' in wildland firefighting. *Leadership* **4**, 271–297. doi:[10.1177/1742715008092362](https://doi.org/10.1177/1742715008092362)