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Communication

Whither the paradigm shift? Large wildland fires and the wildfire paradox offer opportunities for a new paradigm of ecological fire management

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Abstract. The growing frequency of large wildland fires has raised awareness of the 'wildfire paradox' and the 'firefighting trap' that are both rooted in the fire exclusion paradigm. However, a paradigm shift has been unfolding in the wildland fire community that seeks to restore fire ecology processes across broad landscapes. This would involve managing rather than aggressively suppressing large fires. Examples of recent fire science publications demonstrating 'new paradigm' thinking or critical questioning of 'old paradigm' assumptions are offered as evidence of this shift in thinking. However, integration of fire ecology science is lagging in fire-related policies and legislation, media representations of wildland fires, and conventional management responses to most wildland fires. Sociocultural, political and economic factors are functioning as barriers to change in fire management policies and practices. However, the growing risks, costs and impacts of large wildland fires will continue to highlight the crisis of the dominant fire exclusion paradigm. The general inability to prevent and effectively suppress large wildland fires may be the means to break through these institutional and societal barriers and propel efforts to shift philosophy and practice to a new paradigm of ecological fire management.

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Introduction

The increasing frequency of large wildland fires and the escalating costs of suppressing them have forced the wildland fire management community to confront the 'wildfire paradox' (Calkin *et al.* 2014*a*, 2015) and the 'firefighting trap' (Collins *et al.* 2013). Essentially, the 'paradox' comes from the idea that fire management is ultimately failing owing to its own apparent success: all of the past wildland fires that were quickly contained and controlled at small size led to excessive fuels accumulations and vegetation growth that, in combination with climate change and sprawling rural development, now feed fires that defy aggressive suppression efforts. Well-meaning actions intended to protect timber resources from fire had unintended consequences that have degraded fire-adapted forest ecosystems.

Despite extensive scientific evidence that fire plays a vital role in maintaining ecological integrity in most western forests, land managers now feel that they have grabbed a tiger by the tail and cannot let go – they are 'trapped' by societal expectations to continue aggressively fighting nearly all unplanned ignitions because of the perceived high risks and hazards of letting fires burn. Thus, today's wildland fire research and management communities are increasingly experiencing the cognitive dissonance of knowing that ongoing attempts to exclude fire through aggressive suppression actions serve to increase the risks, costs and damages of fire over the long run, and run contrary to the community's land stewardship ideals and desires to restore fire ecology processes.

The process of paradigm shifts

Both the wildfire paradox and the firefighting trap are rooted in the fire exclusion paradigm (Cohen 2008) that has and continues to dominate wildland fire management in the USA. However, an alternative 'fire inclusive' perspective has been emerging among fire ecology advocates to challenge the assumptions and ideals of fire exclusion. This change in fire philosophy began several decades ago (Nelson 1979) whereas change in terms of management policies and practices have lagged behind. However, unlike a Gestalt shift that suddenly and radically changes perception from one view to another, a paradigm shift (Kuhn 1996) is more of a gradual, incremental process. Change is normally contentious, with early advocates of a new paradigm considered to be heretics facing various cultural or institutional sanctions. But over time, as the contradictions of a dominant paradigm accumulate and as its 'old guard' defenders retire or pass on, proponents of a new paradigm gain more mainstream social acceptance. Then, a new consensus develops in which the emerging alternative perspective becomes the new dominant paradigm.

Because these shifts can be prolonged and are usually strongly resisted by the established powers that be, it can be

difficult to locate when and how a dominant paradigm is declining and an alternative paradigm is ascending in social power. This is precisely the case with the decline in dominance of the fire exclusion paradigm, where the emerging paradigm shift could easily be missed if one focused exclusively on statements by the press or politicians portraying large wildland fires as 'catastrophes' and treating them like 'disasters'. And one could dispute that change in management is actually occurring if they focused solely on the 96% or more of unplanned wildland fire ignitions that receive aggressive initial attack responses. Although many previous attempts at forecasting the future of wildland fire and fire management have had mixed success (see papers in Davis and Martin 1987), a recent panel of professional futurists convened by the Forest Service predicts that a new 'fire resilience paradigm' is inevitable between now and mid-century (Olson *et al.* 2015). Recent fire science publications hint that a qualitative change in fire management philosophy and practice is possible and may be closer at hand than conventional wisdom realises. Though it has yet to be named, I will call this emerging paradigm 'Ecological Fire Management'.

Fire ecology as the antithesis of fire exclusion

Unquestionably, the development of fire ecology science and its growing number of advocates has been the major driver of the paradigm shift. First-generation fire ecologists like Harold Biswell were treated like heretics in their own time (Rothman 2007), but now are fondly viewed as pioneers or even revolutionaries of the field of fire ecology (Pyne 2015). The ecological role and beneficial functions of wildland fire are widely accepted in the fire management community although they remain controversial ideas among the majority of the public and opinion-makers (e.g. politicians and the press) where wildfire is still largely vilified as an agent of death and destruction. The media's negative representations of wildfire and perpetuation of the fire exclusion paradigm (Donovan *et al.* 2011; Paveglio *et al.* 2011), backed up by politicians' pressure on land managers to aggressively suppress all wildfires (Canton-Thompson *et al.* 2008), play major roles in the institutional inability to integrate fire ecology science in wildfire management. This should spark some discussion within the wildland fire community about strategies for spreading fire ecology knowledge beyond research publications, professional conferences and technical training geared for fire professionals in order to reach broader publics, elected officials and the media that could nurture a constituency for Ecological Fire Management.

Pyrodiversity and biodiversity

The fire exclusion paradigm has clearly waned among fire managers in terms of their near-universal support for the use of prescribed fire. But although there is growing tolerance and even a desire among land managers to prescribe more low-severity fire, the fire exclusion paradigm still dominates when it comes to attitudes opposing high-severity wildland fire. Recent publications that document the historical role and ecological benefits of moderate- and high-severity fires (Odion *et al.* 2014; Baker 2015; DellaSala and Hanson 2015; Hutto *et al.* 2016) are currently generating vigorous debate. Much of the controversy has centred on claims that high-severity fire was historically present even in low-severity fire regimes, disputing assertions that some contemporary large wildfires in dry-forest ecosystems are burning with 'unnatural' high severity. Similarly, other studies (e.g. Dunn and Bailey 2016) have concluded that low-severity fires play an important albeit unacknowledged ecological role in high-severity regimes. Although these studies may be judged harshly by some members of the fire community at this time, it is predicted that more of this kind of research will be pursued and published. Hutto *et al.* (2016) offer a glimpse at what may become the emerging paradigm's new scientific consensus: most forest ecosystems resemble mixed-severity regimes, and the full range of fire severities, or 'pyrodiversity', have important beneficial functions in maintaining diversity of species and habitats in nearly all forest ecosystems. Accordingly, large fires may one day be valued as major agents for restoring landscape heterogeneity and maintaining biological diversity.

Challenging assumptions of suppression effectiveness

Although fire ecology research has long been raising critical questions about the effects of fire exclusion, a significant new development has been work that critically examines the effectiveness of fire suppression. Although data reliability of historical wildfire activity vary significantly (Short 2015), several tens of millions of acres burned annually in the USA until the 1940s, and it was primarily in the post–World War II period from 1945 to ~1987 that the annual average number of burned acres plummeted (Littell *et al.* 2009). This period coincided with extensive road-building in the national forests, a massive influx in mechanised fire suppression, and the use of more advanced science and technology in fire management (Pyne 1982). But perhaps more significantly, this period was also characterised by a cool, wet period related to the Pacific Decadal Oscillation (Peterson *et al.* 2011). These climatic conditions certainly aided suppression efforts, and may have instilled a false confidence in the efficacy of human efforts to control all wildfires.

Indeed, researchers are now confirming what firefighters have known for a long time: human beings are unable to stop large wildland fires from spreading unless and until weather conditions significantly change or the fires run out of fuel. For example, Finney *et al.* (2009) found that large wildfires largely define their own boundaries, and it is only during 'quiescent' periods when severe fire weather conditions moderate that fire spread rates decrease and firefighters can achieve perimeter containment. The hard work of brave firefighters gets all the credit in the news media for corralling large wildfires, but this is after the fires have largely stopped spreading on their own, in a process analogous to the Lilliputians 'capturing' Gulliver after he had laid down and fallen asleep.

Aircraft dropping chemical retardants is the iconic media image of firefighting, but recent studies (e.g. Thompson *et al.* 2013; Calkin *et al.* 2014*b*; Stonesifer *et al.* 2015, 2016) have critically examined the assumed effectiveness of aerial retardant drops. Their analyses reveal that most of the wildfires where retardant is used during initial attack eventually escape to become large fires, and when airtankers are used in extended attack on large wildfires, they often drop retardant in the times, places and conditions where it is least likely to be effective. The USDA Forest Service (2016) is building on these initial studies

to gather more data in its Aerial Firefighting Use and Effectiveness Study, but how will these data and analyses affect policymakers who are pushing for huge investments in a 'next generation' firefighting air force? Advocates for an alternative paradigm to fire exclusion must think of creative ways to articulate and share their knowledge with citizens and policymakers outside the wildland fire community (Jensen and McPherson 2008; Moritz *et al.* 2014).

Examining the economics of fire suppression *v.* managed wildfire

Another set of recent publications question the effectiveness of fire exclusion and suppression from the standpoint of economics. With provocative titles like 'The irrationality of continued fire suppression' (Snider *et al.* 2006; see also Donovan and Brown 2007), these papers critique rising suppression expenditures that are distorting the Forest Service's budget and requiring frequent budget transfers and supplemental Congressional appropriations. Other research (e.g. Donovan 2005; Donovan and Brown 2008; North *et al.* 2012) demonstrates that wildland fire use or 'managed wildfire' can result in significant cost savings compared with aggressive suppression responses. Modified suppression and fire use strategies have been documented to drastically cut costs on a per-area basis compared with aggressive suppression with full perimeter containment strategies; however, Gebert and Black (2012) discovered that the cumulative costs of a large-scale, long-duration fire use operation can be higher than a wildfire that is contained and controlled at a smaller size or duration.

But cutting short-term costs through aggressive initial attack simply externalises long-term costs and risks to future fire managers, and prolongs the wildfire paradox. New-paradigm thinking would argue that the expense of managing large wildfires with fire use strategies should be viewed as *investments* rather than pure costs, with returns in the form of reduced fuels or restored ecosystems that will eventually free agencies from the firefighting trap (Houtman *et al.* 2013; Ingalsbee and Raja 2015). This new perspective would make large wildfires an opportunity for land managers to plan and prepare for, rather than a 'problem' to prevent (Ingalsbee 2015). It is possible that economic arguments may have greater influence than ecological arguments with Congressional policymakers, helping to usher in a new paradigm of Ecological Fire Management by imposing more cost constraints on aggressive fire suppression and offering more economic incentives for prescribed and wildland fire use.

The human dimensions of fire

Integrative, holistic thinking will be one of the core principles of Ecological Fire Management, and the concepts of 'socio-ecological systems' (Steelman 2016) or 'coupled human and natural systems' (Spies *et al.* 2014; Fischer *et al.* 2016) are examples of this new-paradigm holism. The essence of the wildfire paradox flows from anti-ecological human beliefs (e.g. the goal of controlling nature in the guise of attempted fire exclusion) and related human behaviours (e.g. systematic fire suppression) that conflict with the reality of living on a pyrogenic planet. The ways agencies manage this contradiction Fischer *et al.* (2016) have declared is 'pathological'. The scope of the pathology include societal factors such as those beliefs and behaviours that are driving anthropogenic climate change, sprawling rural development, federal budgetary priorities, and many other variables. Acknowledging and integrating the human dimensions into fire management vastly enlarge the task ahead for translating the paradigm shift into policies and practices (Thompson *et al.* 2015). Ultimately, it will require qualitative social change to fully resolve all the human factors driving the wildfire paradox.

New models and tools for risk management may offer practical means of implementing new-paradigm philosophy in wildfire prevention and response activities. For example, Calkin *et al.* (2011) explicitly call for adoption of a 'risk management paradigm' that, as one specific example, would reconceptualise wildland–urban interface (WUI) fire prevention work to focus on reducing the risk of structure ignition rather than vegetation burning (Calkin *et al.* 2014*a*). Looking holistically from a wider socioenvironmental perspective, wildfire response becomes an exercise of deciding risk trade-offs at different spatial and temporal scales among several different social-ecological values (Thompson 2014). The hope is that this risk trade-off approach may greatly reduce aggressive suppression actions intended to limit fire size or duration as the social and ecological risks and benefits of fire are adequately factored into decision-making.

Conclusion

It is beyond the scope of this short commentary to document the progressive reforms in fire policy over the last 50 years (Stephens and Ruth 2005; Stephens and Sugihara 2006; Steelman and Burke 2007). Never before have managers had such flexibility to use the full spectrum of strategies, tactics and objectives to manage wildland fires for ecological restoration objectives (Venn and Calkin 2011; Ingalsbee 2015). These policy reforms provide further evidence of a paradigm shift in the making; however, policies on paper are not yet resulting in significant institutional change in wildfire responses because there remain powerful cultural, sociopolitical, economic and institutional barriers to change with vested interests in perpetuating aggressive suppression that maintains the fire exclusion paradigm (Busenberg 2004; Ingalsbee 2006; Steelman and Burke 2007; Hudson 2011; Steelman and McCaffrey 2011; Calkin *et al.* 2015; Pyne 2015). But a paradigm is not necessarily represented by or reducible to specific policies or practices.

To be trite but true, the apparent absence of evidence of a shift in process is not evidence of its absence. In this regard, fire managers successfully implementing 'modified suppression' strategies and tactics (e.g. point protection, confinement, 'box and burn') that enable wildland fire to spread across more landscape have yet to be widely published or even publicly acknowledged. In time, we should expect to see researchers supply more data and analyses to reveal the socioeconomic and ecological effects of unfolding innovative practices that point in the direction of Ecological Fire Management.

The growing frequency of large wildland fires provides *prima facia* evidence of the failure of the fire exclusion paradigm, and presents a clear opening for fire researchers and managers to develop new concepts and models for managing the socioecological phenomena of wildland fire. In this endeavour,

large wildland fires should be welcomed by the fire community as 'teachable moments' and 'management opportunities' to help usher in a new paradigm of Ecological Fire Management that offers some hope of resolving the wildfire paradox.

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