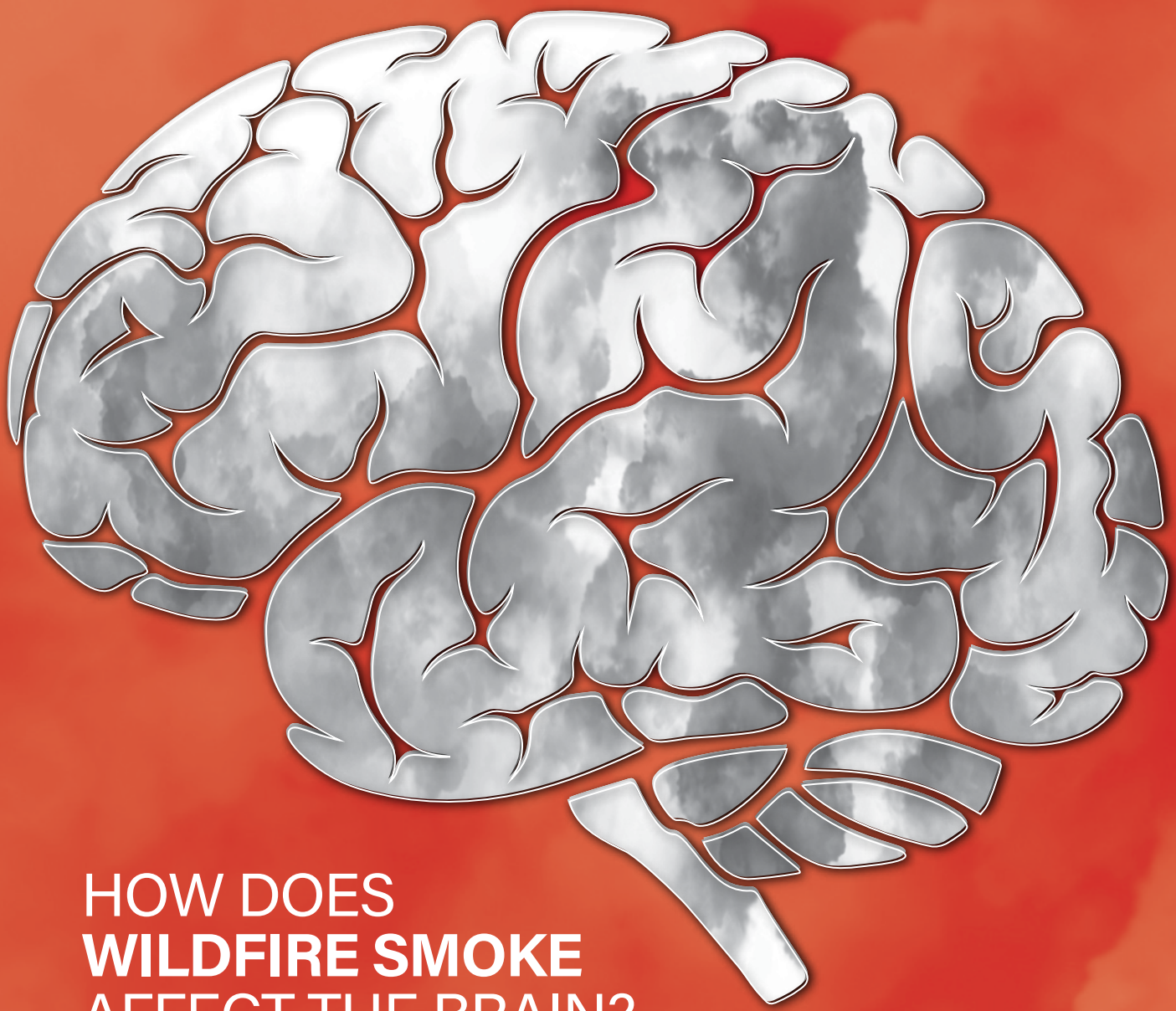
QUARTER 3, 2024
UNITING THE GLOBAL WILDLAND FIRE COMMUNITY

WILDFIRE

An official publication of the INTERNATIONAL ASSOCIATION OF WILDLAND FIRE



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NEWS AND OPINION

FEATURES

ON THE COVER
A study in Mexico City shows adults and children exposed to dirty air experience symptoms similar to those caused by Alzheimer's. See story on page 36. Illustration by Shauna Layton.

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PRIORITIZING PEOPLE

BY LAURA KING

There are lots of studies indicating that smoke from wildfires is dangerous. Governments tell people to stay inside when smoke from wildfires blankets their regions. While residents of wildfire-prone areas are accustomed to smoke, New Yorkers were cranky two summers ago when wildfire smoke from Canada drifted south and turned the sky sooty and grey. Maybe they were justified.

There's lots of research yet to be done, but a study in Mexico City that shows people who regularly breathe polluted air from factories and vehicles develop memory symptoms similar to Alzheimer's. The science about particulate matter from air pollution and wildfire smoke led researchers to connect A and B.

As Anthony White and Lilian Calderon-Garciduenas write on pages 36- 42, "a growing number of studies at both the population level (epidemiological studies), and cellular level, are providing evidence that wildfire smoke is as toxic as anthropogenic (human made) particulate matter pollution, resulting from combustion of fossil fuels."

White encourages firefighters to record their exposures to wildfire smoke to help researchers compare exposures to the potential impact on the brain.

What is also clear from wildfire research, according to Rick McRae (pages 28-32), is that the impact of climate change needs to be incorporated into strategies for dealing with extreme wildfires.

"A new strategy is required for rapid adaptation to extreme wildfires," McRae says. "The ongoing escalation suggests a need for the multi-pronged approach to be created as quickly as possible."

McRae's decades of work and research into fire thunderstorms, or pyroCbs, along with blow-up fire events (BUFEs), led him to develop a framework to predict dynamic fire events in south-east Australia, using hydrology, remote sensing and fire ground data.

Todd Linley and the team at the National Weather Service Forecast Office in Norman, Oklahoma, experienced extreme wildfire in Texas and Oklahoma in February (pages 20-25).

Hundreds of buildings burned, almost 12,000 head of cattle were lost, and two Texas residents died.

The NWS deployed the Integrated Warning Team Fire Warning paradigm and, according to Luke Kanlerz, head of Texas A&M Forest Service's predictive services department, probably saved lives.

During the February fires, several NWS forecast offices collaborated with fire, land, and emergency management agencies to transmit up to 20 Integrated Warning Team fire warnings.

Post-fire data showed reduced fatalities (compared to similar fires) and the successful evacuation of residents, which likely prevented more loss of life.

Back in 2017, 64 people died in a complex of fires in Portugal started by lightning strikes and contact between vegetation and a 25 kilovolt electrical line.

As Lily Mayers explains (pages 45-48), post-fire, land-management reform legislation was prompted, including the introduction of a 10-meter clearing rule between roads and vegetation, the banning of new eucalyptus plantings, and a shift away from purely reactive firefighting to prevention investment.

Mayers' story looks at the human toll from the fires: the still-grieving family of a volunteer firefighter who died, and the traumatic impact on a firefighter whose team was forced to leave others behind.

Bequi Livingston, our health and wellness columnist (pages 8-10), is working her way through grief after two separate fires devasted her community of Ruidoso, New Mexico, last summer. The fires consumed more than 1,500 homes and businesses. The fire chief, police chief, and several Smokey Bear hotshot crewmembers who were involved in the initial attack efforts lost their homes. Immediately thereafter, thunderstorms unleashed torrents of rain, and another 200 homes were flooded. Three people died, including a former hotshot.

"I thought I had done a great job healing from a lifetime of grief and trauma, until this happened," Livingston writes. "Then, it all came streaming back in an instant . . . "

Livingston has learned to work through her grief and, as always, offers empathy, insight and resources for anyone affected by wildfire.

This issue of *Wildfire* tells insightful stories about leadership, mental health, research, science, innovation, weather, climate, extreme fires, and, most importantly, people.

Managing editor Laura King is an experienced international journalist who has spent more than 15 years writing and editing fire publications. She is the Canadian director for the National Fire Protection Associaiton (NFPA), works closely with FireSmart™ Canada to help residents build resilience to wildland fire, and has partcipated in the development of the Canadian wildland fire prevention and mitigatgion strategy.

UNPRECEDENTED BECOMES THE NORM

BY KELLY MARTIN

Unprecedented fire season. Unprecedented scale. Most destructive and unprecedented. Fire season off to an unprecedented start. What term should we use when the word unprecedented becomes normal?

The size, velocity and loss of life and property almost seem like an inevitable passage into a global climate pattern that is hotter, drier, windier and includes more human interface development than just a few decades ago. Accepting what the wildland fire community knows to be true – it is in our nature to try to fight the inevitable – we proclaim to end mega / giga fires within the next decade, yet fire is a ubiquitous, integral part of our lives. There is no dispute that fire seasons are hotter and longer and there is little reason to believe this trend will reverse no matter the money or the will.

When I began my fire career in the mid-1980s I could not have imagined what wildland fire would be like 40 years into the future. I thought all fires were suppressed to save valuable trees; I believed I was doing good public service work. As the years rolled by, I became more intrigued by fire ecology and fire behavior and wanted to understand how I could balance my service to protect life and property but also learn how I might be able to harness the power of restorative fire for the good of people, communities and landscapes. This began my quest to engage with communities nationally and internationally to share and shift the mindset to a more balanced approach in favor of the use of beneficial fire. Indigenous cultures have applied the liberal use of fire prior to colonization but were eventually persecuted for sharing their lives with fire, not fighting fire. There is much work to do to undo the generational mindset that wildfires are bad. We have no time to waste to normalize the use of fire as beneficial and necessary for healthy landscapes and healthy communities.

It's hard to put into words what I know is happening on the ground. Most people – including the media – see planes and helicopters fighting fire. What they don't see are the women and men giving everything they have day in and day out as frontline first responders to these unprecedented wildfires. Fire seasons are taking an enormous toll on wildland firefighters and their families; they deserve the best opportunities to help protect communities, which means everyone in the wildland fire community from firefighters to policy makers must own these unprecedented wildfires and take positive, proactive steps to plan, prepare and mitigate fire conditions before wildfires arrive.

The world is warming faster than I can even comprehend. Everyone is impacted by these changes. I believe the global paradigm is beginning to shift and there is an understanding that fires will always be a part of our natural landscape. I hope that beneficial fires will one day outnumber the acres-burned-by-wildfires mindset. There are opportunities to be proactive by getting involved in community place-based collaboratives and locally led prescribed-burn associations, by supporting the use of more beneficial fire on the land, and by taking personal responsibility for home hardening.

There is no dispute that fire seasons are hotter and longer and there is little reason to believe this trend will reverse no matter the money or the will.

The protection and enhancement of communities and resources should be viewed as a public good. In the future I believe we will see a more balanced approach between wildfire suppression profit and planning, prevention and mitigation as a community public good. Presently, the scales are weighted in favor of allocating resources to wildfire suppression year after year with no end in sight. Perhaps if an equitable amount of human and fiscal capital is allocated to the front end of a wildfire the suppression cost might curve downward.

Wildland fire policy includes wildfires (which can be used both to meet protection objectives and enhance natural and cultural resources objectives) and the use of prescribed fire. The acres-burned metric has been normalized. Why not consider post-fire effects on communities and landscape condition after a wildfire as a new metric? The antidote to these unprecedented fires is to use more beneficial fire to help interrupt the magnitude and severity of peak-season wildfires.

To succeed, money and partnerships are required in the form of philanthropic ventures by small companies and large multi-nationals to help improve and advance technology systems and data. Access to data and information will help managers, firefighters and communities make better, more efficient strategic and tactical decisions to reduce the tremendous social, human and fiscal cost of wildfires.

When I reflect on my career, 40 years really does not seem like that long ago. The wildfire crisis is a crisis of how fire impacts people, not fire as the problem pe se. People will be the key to success in reducing future harms. The International Association of Wildland Fire is a known and proven leader worldwide in providing education, workshops and conferences on how to enage at a personal level and community level in adapting our lives to living with fire. We know the answer. Fires are inevitable whether they show up on our terms or Mother Nature's terms. The choice is ours.

Kelly Martin has been an IAWF board member since 2019, when she retired as chief of fire and aviation, Yosemite National Park, National Park Service, Pacific West Region. Martin began her federal career as a GS-3 with the Apostle Island National Lakeshore in 1984 while attending college and worked her way up through the wildland fire ranks during her 34-year career. Martin is the past chair of two National Wildfire Coordinating Group (NWCG) programs: Fire Environment Committee (FENC) and the National Fire Management Leadership (M-582) course. Martin is a strong advocate for diversity, inclusion and gender parity throughout the wildland fire community. Her most recent efforts include providing leadership for the Women in Fire Training Exchange (WTREX) since 2016.

PROCESSING GRIEF *through a* BURNED BEAR

BY BEQUI LIVINGSTON

According to *Psychology Today*, "grief is the normal human response that accompanies loss and can be complex, unpredictable and painful."

I never expected to write this column about grief. I had another column completed and ready to send, then life changed, in a heartbeat. That's how grief works – we have no idea it's coming, until it's here, on the doorstep, begging for our attention.

Our village of Ruidoso, New Mexico, was recently devastated by two separate wildfires, sandwiching the small communities of Ruidoso, Ruidoso Downs, and Mescalero within fire's mighty grip. Like forceps that were holding the communities hostage, slowly clamping down, forcing the evacuations of the affected residents. The wildfires, on opposing sides, forced the closure of two main exit routes during the evacuation, leaving only one way out, to the east, creating a nightmare of bumper-to-bumper traffic. Many residents chose to stay behind rather than face the traffic. Many who stayed ended up being unsung heroes, feeding and rescuing pets that were left behind, checking on people's properties, and ensuring that the people and pets that stayed had food and water. I have never seen anything like it. It absolutely warms my heart.

Sadly, the wildfires ended up consuming more than 1,500 homes and businesses. In a matter of hours, people's mementoes and livelihoods became distant memories. All the while, first responders were doing everything they could to protect the village while ensuring that residents were evacuated to safety. Sadly, many first responders, including the fire chief, police chief, and several Smokey Bear Hotshot crewmembers who were involved in the initial attack efforts, lost their homes while they were being of service to the community they love. How ironic that we celebrated Smokey Bear's 80th anniversary in August, on the heels of this disaster. The South Fork wildfire burned much of the Smokey Bear Ranger District on the Lincoln National Forest.

It was hard enough to come to terms with the wildfire devastation, but then Mother Nature unleashed her fury with flooding, the likes of which

our village has never experienced. Monsoonal thunderstorms camped over the burn scars, unleashing a deluge of water and ferocity, turning the highway into a raging river. And the rains continued, day after day after day, each time bringing another round of blaring emergency sirens, sending residents scrambling to safety, protecting their homes and loved ones. Sadly, another 200-plus structures were lost to the flooding, and three lives were lost, one a former retired Smokey Bear Hotshot who died during the evacuation.

Many residents and business owners chose to leave the area while others stayed to rebuild this amazing community. How do we come to terms with these unprecedented series of events? How do we begin to make any sense of what has occurred? And how do we, as a community, begin to heal together?

As wildland firefighters we experience so much grief, trauma and loss during a single fire season, yet as first responders, we've been conditioned to compartmentalize our grief and traumatic stress to get through fire season. Yet this compounded and chronic grief affects every fiber in our being, even when we don't recognize it. Grief always comes on the heels of loss – of a loved one, a pet, a home, finances, jobs, identity, possessions, health, and hopes and dreams. In the case of Ruidoso, all the losses are real and compounded.

When we look grief in the eyes, it has so much to tell us – so much wisdom, if only we'll listen. I thought I had done a great job healing from a lifetime of grief and trauma, until this happened. Then, it all came streaming back in an instant, on the back of a burned bear. I've been providing emotional support to residents and first responders alike. I was in the Upper Canyon area, where I once lived, driving down the quaint street along the Rio Ruidoso River. I stopped at two houses where I used to live, side by side, in disbelief. Just down the street, not 100 yards away, two houses were destroyed by the wildfire and the houses across the street, damaged by the deluge of continuous flooding. As I walked around one of the houses, I was stunned to see a carved bear in the remnant of a tree, burned and blackened beyond recognition. That's when the grief hit me: it literally took me to my knees, crying in agony of the immense loss in this community that I call home, and the beautiful thing is that I let myself sob.

It was hard enough to come to terms with the wildfire devastation, but then Mother Nature unleashed her fury with flooding, the likes of which our village has never experienced.

Grief comes in many shapes and sizes. There's no timeline and no expiration date when it comes to grief; we all experience it in our own way. There are systematic stages of grief that have been identified by Elizabeth Kubler-Ross that include denial, anger, bargaining, depression, and acceptance. Yet, none of those terms makes sense to me, at least not now. I use terms that I can relate to – shock, disbelief, numbness, guilt, connecting the dots, shutting down, and coming to terms with these losses the best way that I can. I always encourage others to find their own language and terms related to their experience with grief.

With grief also comes differing symptoms that manifest somatically (in the body), symptoms like depression, anxiety, insomnia, confusion,

dissociation, busyness, fatigue, despair, hopelessness, stomach issues, pain, illness, tension, and addictions, among others. Our bodies always tell us what they need, or don't need, especially when grief appears; it's the nervous system's way of protecting us and keeping us safe while helping us make sense of what doesn't make sense. This is the time to be gentle with yourself, and your experiences, as long as it takes, especially as a wildland firefighter. Grief and all the accompanying emotions are normal reactions to loss.

Although we can temporarily compartmentalize grief, I guarantee that it will not go away. Grief may take time to manifest, sometimes years, but it will always be there until we take the time to begin the healing process and face our grief. Humans were never meant to heal alone; we need others who understand our losses and can validate and empathize with our grief. We need community, camaraderie, peers, friends, family and professionals to help us navigate our way through grief.

To my fellow wildland firefighters, past and present, I hope you'll come to understand your own experiences with grief and loss and find ways to ask for support, as a crew and as a wildland community. We have all experienced grief, whether we believe it or not. May you be well and safe this 2024 wildland fire season.

Bequi Livingston was the first woman recruited by the New Mexico-based Smokey Bear Hotshots for its elite wildland firefighting crew. She was the Regional Fire Operations Health and Safety Specialty for the U.S. Forest Service in Albuquerque, New Mexico. Contact her at bequilivingstonfirefit@msn.com

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SHOULD YOU STAY OR GO?

BY MICHAEL DEGROSKY

Months ago, a friend and reader asked me whether I had ever considered writing about leaders knowing when it is time to move on. I loved the idea because knowing when to step aside and let others take the leadership reins is so important, but something we don't talk about much. Yet all leaders will, inevitably, confront occasions on which they must consider whether it is time to move on.

That conversation with my friend got me thinking about my experiences. I'm sure *Wildfire* readers have seen the same kinds of things I have, perhaps a beloved leader who left before people wanted him or her to, maybe a previously effective leader who stayed far longer than he or she should have. Those decisions can sometimes seem baffling, but deciding to stay or go can be very personal, very emotional, and often require leaders to weigh what is best for them and what is best for the organization. I've heard it said that sometimes being a good leader means knowing when to step away and let others lead. Conversely, many of us have experienced ambitious leaders hopping from post to post without producing durable results or worse, never experiencing and learning from the consequences of their decisions.

Leadership transitions can significantly influence organizational direction and have real impacts on people. For those reasons, knowing whether to move on from a leadership role and when and how, represents both an act of leadership and an essential leadership skill.

Leadership professor Benjamin Laker, writing for Forbes, discussed the benefits of making a graceful exit. I liked the idea of a graceful exit, which Laker described as a well-considered and timely departure that is beneficial for both the leader and the organization. From the perspective of the individual leader, benefits can include a positive legacy and an opportunity for change and personal development. The organization gains opportunities for fresh leadership, reinvigoration, and growth.

Other than a single study that found optimal CEO tenure to be 4.8 years, I am unaware of authoritative data on the ideal length of tenure in a leadership position. However, leaders have a life cycle and, regardless of early and mid-role effectiveness, many leaders eventually reach a point at which they have given what they can and accomplished what they could. That's not failure, but normal, and leaders are wise to occasionally evaluate their own effectiveness, constantly monitor the feedback they inevitably receive from the people they wish to influence, and consider where they are at in that leadership life cycle. Without this introspection we, as leaders, risk the common mistakes – either leaving too soon or staying too long.

Personal circumstances that change a leader's priorities may signal a need to move on: children are born; new interests and passions emerge; families experience joy and tragedy; leaders fall in love, get

LEADERSHIP TRANSITIONS CAN SIGNIFICANTLY INFLUENCE ORGANIZATIONAL DIRECTION AND HAVE REAL IMPACTS ON PEOPLE. FOR THOSE REASONS, KNOWING WHETHER TO MOVE ON FROM A LEADERSHIP ROLE AND WHEN AND HOW, REPRESENTS BOTH AN ACT OF LEADERSHIP AND AN ESSENTIAL LEADERSHIP SKILL.

married, get divorced; interests change. Life changes our priorities and leaders with integrity will strive to know whether their changing priorities are impeding either their desire or ability to lead.

It may seem counter-intuitive, but a sense of significant accomplishment may also signal a need to step away from a current leadership role. Leading the achievement of a major milestone for the organization can, of course, motivate a person in a leadership role to do more, achieve more, take the next step, drive on. However, success can also leave a person feeling as if they have peaked and as if future accomplishments might never measure up. Should that feeling occur and persist, it might be time to start seeking a new role before a loss of interest and passion sets in.

A loss of passion for the work can lead to stagnation, which is defined as a lack of activity, growth, or development. A loss of enthusiasm and drive can prove contagious and a leader whose disinterest is spreading to others is no longer serving the organization's best interests. Then again, leadership is hard, fatiguing work, so I am not suggesting that every time leaders are bored or hit a slow patch, they should start thinking it's time to find the exit, it might just be time for a rejuvenating vacation. But an extended period of feeling stuck without progress or innovation might be a sign.

From time to time, leaders find that their vision does not align with that of the organization or the people above them. A meaningful disconnect between a leader's vision and the organization's actual direction or between leaders and their superiors would prompt smart leaders to assess whether they could still be effective in their role and whether the time to move on had arrived.

A very positive signal that the conditions are right for a leader to step away is the presence of a capable and well-prepared successor. When I retired, I did so with the confidence that my greatest achievement in that organization had been building a team of experienced, dedicated, and very capable people including my eventual successor and his eventual deputy. I can attest that when making the very difficult decision to step down from leadership, it is a great comfort to know that you are enabling other capable leaders to take the reins.

Mike DeGrosky is a student of leadership, lifelong learner, mentor and coach, sometimes writer, and recovering fire chief. He taught for the Department of Leadership Studies at Fort Hays State University for 10 years. Follow Mike via LinkedIn.

CANBERRA TEAM DEMONSTRATES PRESCRIBED BURN

PARTNERS COLLABORATE TO SHOW CONFERENCE DELEGATES SUCCESSFUL PRACTICES

BY THE CANBERRA FIELD-TRIP TEAM

The dew on the grass was slowly evaporating with the warmth of the sun and a soft breeze whispered up the valley, between the hills and through the trees.

The smell of burning eucalyptus hung in the air as gentle flames crackled, snapped, danced and swayed against the wind, moving slowly through the grass and leaf litter.

Around the edges a team of burn practitioners shepherded the flames; a jet of water around the base of a tree, or an extra dot of ignition to straighten the line.

This was the scene that greeted delegates on the prescribed burn field trip on the last day of the Canberra node of the IAWF's tri-continental 7th International Fire Behaviour and Fuels Conference in April.

Adam Leavesley, former IAWF director and manager of prescribed burning at the Australian Capital Territory (ACT) Parks and Conservation Service, said local agencies took pride in their prescribed burning programs and were keen to show visitors what it was all about.

"We were really excited when we were offered the opportunity to host the IAWF Fire and Fuels conference in Canberra, but the timing was the pits," said Leavesley.

"It was right slap bang in the middle of our autumn burning season, in one of the critical weeks.

"So we thought we better make the best of it, seize the day and put on a conference burn.

Delegates to the 7th International Fire Behaviour & Fuels Conference in Canberra in April observed a prescribed burn hosted by local agencies. Photos courtesy of the Camberra field-trip team and Friedo Ligthart, Natural Hazards Research Australia.

"Then one thing led to another and our very good research partners at Australian National University (ANU) got in touch and our colleagues in ACT Rural Forest Service got involved, so we all joined forces."

Leavesley said there were three things conference organisers wanted to do for the delegates.

"We wanted to show them how carefully and skilfully experienced fire practitioners apply fire to the land.

"We wanted to show people the new technology that was being developed in Canberra, and we wanted to demonstrate how we were using a tenure-blind fire management strategy to protect a new Canberra suburb that will sit under a forested hillside in the path of an historic fire run.

"So there was plenty to see and talk about," said Leavesley.

ACT Parks and reearchers at the ANU have been working together to tackle the global climate-driven bushfire problem for more than a decade.

Director of the ANU Bushfire Research Centre of Excellence (BRCoE), professor Marta Yebra, said the mission of her research group was to identify cutting-edge technologies that can be combined to find fires and put them out before the fires exceed firefighters' capacity to control them.

"BRCoE at ANU is at the forefront of a transformative shift in bushfire management that will equip Australia to navigate the threat of fire in a world altered by climate change," said Yebra.

"The team is developing and validating a range of novel technologies to demonstrate proof-of-concept and support operationalisation.

"We used the burn to demonstrate our early fire detection methods including a drone, camera detection systems and a network of IoT ground sensors.

Australian Capital Territory Parks and Conservation Service and reearchers at the Australian National University have been working together to tackle the global climate-driven bushfire problem for more than a decade.

"BRCoE at ANU is at the forefront of a transformative shift in bushfire management that will equip Australia to navigate the threat of fire in a world altered by climate change," said Yebra.

"These sophisticated devices showcased real-time demonstrations of ignition detection and proactive wildfire mitigation.

"The times to detection differed from a minute or two by the drone to three to six minutes for the other technologies, giving the team the opportunity to explain to field trip participants the reasons for the different detection times and why an integrated detection approach is probably best."

The team at BRCoE also demonstrated a hyperspectral camera system being used for the calibration of Ozfuel, an instrument the researchers are developing for deployment in space.

"Ozfuel is designed as a payload for a low Earth orbit satellite and will collect data to identify areas that are most flammable and vulnerable to ignition," said Yebra.

"The information it provides is strategic, empowering practitioners to allocate fire detection technologies more effectively."

ACT Rural Fire Service (RFS) crews worked alongside ACT Parks crews to implement the conference burn, and demonstrated a camera detection system that has been installed in the ACT.

ACT RFS Operations Manager Ken Hall said that traditionally, fire detection in rural and remote areas has involved human observers staffing strategically located fire towers.

"But this method has several associated risks to the operators – during travel to and from remote towers across rugged trails and from working at heights in isolated locations – particularly at times of elevated fire danger when towers are most likely to be stood up," Hall said.

The mission of the Australian National Univerity Bushfire Research Centre of Excellence (BRCoE) research group is to identify technology that can be combined to find fires and put them out before the fires exceed firefighters' capacity to control them.

"The ACT RFS has placed two high-definition cameras at each of its four fire towers – one camera is on constant patrol, scanning the full compass every 90 seconds, while the other camera can be used to focus in on an incident when a smoke column is detected.

"The video feed from the camera network is passed through a smoke detection artificial intelligence (AI) system to detect potential fires and alert operations staff.

"The system allows for live streaming of video to computer or mobile devices, the ability to zoom and tilt cameras to get greater detail and situational awareness of fires ideally within 20 kilometres and often out to 70 to 80 kilometres.

"The AI now allows us to continue to monitor fires outside of the traditional elevated fire weather days and provide situational awareness with hazard reductions and landholder burns.

"The future of this technology will be to expand the network of cameras with agencies from within and outside the ACT as well assisting in the improvements of AI detection, improved situational awareness for fires and other weather events as well as a community facing platform that allows people to have a top of the hill view of what is happening around them," said Hall.

Yebra said that her involvement with the field trip had highlighted the complexity of the bushfire problem and underscored the need for continuous innovation and collaboration.

"As we reflect on the field trip, it is evident that our journey towards enhancing wildfire detection and management is marked by both progress and challenges.

Australian Capital Territory Rural Fire Service (RFS) crews worked alongside ACT Parks crews to implement the conference burn, and demonstrated a camera detection system that has been installed in the ACT.

"The discussions and exchange of perspectives [among] practitioners, researchers and delegates highlighted the multifaceted nature of our endeavours.

Leavesley was relieved that the prescribed burn was completed without any major issues.

"We are really proud of the burning program here in Canberra, and having the opportunity to showcase this for the wildland fire community in Australia was something we couldn't pass up.

"It was sensational to do that with our research partners at ANU our colleagues at ACT RFS and the whole global community at IAWF.

"But at the end of the day like any other burn, the most important thing by far was that we kept it in the box and nobody was hurt."

To learn more about the research and studies the Bushfire Research Centre of Excellence (BRCoE) at ANU visit https://brcoe.org/projects/.

Discussions among conference delegates, practitioners and researchers who attended the burn demonstration, and the exchange of perspectives, highlighted the multifaceted nature of the field trip and the conference.


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INTEGRATED TEAM APPROACH

FIRE DETECTIONS AND WARNINGS LIKELY SAVED LIVES IN HISTORIC U.S. WILDFIRES

BY TODD LINDLEY, DREW DAILY, MARK FOX, DOUGLAS SPEHEGER, CHRISTOPHER MASK, LUKE KANCLERZ, AARON WARD, MIKE GITTINGER, ROBYN HEFFERNAN, ZACH TOLBY, MICHAEL PAVOLONIS, AND STEPHEN BIEDA III

On Feb. 26-57, 2024, a historic wildfire outbreak devastated parts of the United States' southern Great Plains. In all, about 40 wildfires burned an estimated 555,196 hectares, primarily in the Panhandle of Texas and western Oklahoma.

At 428,352 hectares, the Smokehouse Creek fire began in Hutchinson County, Texas, on Feb. 26, and spread eastward more than 135 kilometers into Ellis County, Oklahoma, by the afternoon of Feb. 27. The Smokehouse Creek fire became one of the largest contiguous wildfires in modern U.S. history.

Also igniting on Feb. 26, the Windy Deuce fire destroyed parts of Fritch, Texas, and became a 58,380 hectare megafire.

In all, hundreds of structures were destroyed, and nearly 12,000 head of cattle were reportedly lost. Unfortunately, two Texas residents were killed in the fires. While the loss of human life was tragic, officials believe that an integrated team approach to the provision of fire detections and warnings saved many lives.

"At the community level, the fires that we experienced on [Feb.] 26 and 27 were the most proactively warned fires in U.S. history," said Mark Goeller, Oklahoma Forestry Services director and state forester.

The Integrated Warning Team (IWT) Fire Warning paradigm was developed and demonstrated in select jurisdictions of Oklahoma and Texas in 2022 and 2023; it allows multi-agency and multi-disciplinary considerations in real-time decision making that lead to proactive warning dissemination to the public and first responders for wildfires that are an imminent threat to life and property.

Fire warnings have traditionally been disseminated by the National Weather Service (NWS) at the request of local emergency management officials, typically to broadcast logistical information for ongoing evacuations. The IWT Fire Warning approach builds upon the NWS's use of prototype satellite-based fire detections and leverages the agency's IWT, which promotes effective messaging and mitigative actions among core partnering agencies for many weather hazards. With numerous local, state, federal, and tribal entities responsible for wildland fire planning, suppression response, and mitigation, wildfire emergencies present a unique opportunity to assimilate these technologies in potentially life-saving collaborative warnings – where multiple agencies efficiently message authoritative fire hazard information with one voice.

Built upon operationally forged interagency relationships with trusted reliance on each entity's contributing expertise, IWT Fire Warning procedures follow a prescribed workflow.

- First, predicted fire environmental parameters known to support extreme fire behavior, composed of both meteorological data and fuels intelligence, are collaborated among the NWS and its partnering state forestry and emergency management agencies prior to expected fire weather episodes.

Firefighters battle the Smokehouse Creek Fire on Feb. 27, 2024. Photo courtesy of Texas A&M Forest Service.

- Meteorologists then utilize National Oceanic Atmospheric Administration's (NOAA) Geostationary Operational Environmental Satellite technology (GOES-East and GOES-West), as well as other meteorological observing platforms, to monitor the near-fire environment and identify particularly dangerous fires.
- If, and when, a fire exceeds critical remote sensing thresholds and becomes a candidate for an IWT Fire Warning, NWS meteorologists alert key fire and emergency management personnel with a "Potentially Dangerous Wildfire Detected" hot spot notification.
- Fire analysts and emergency managers then verify the situation on the ground. In some cases, state forestry agency fire-spread modeling is used to enhance the understanding of potential threats to the public and at-risk values.
- Once an imminent threat to life and property is confirmed, the agencies request NWS dissemination of geo-targeted fire warnings, which alert both the public and on-site personnel of the danger.

The average IWT coordination period, or the time span from when meteorologists identify a potentially dangerous fire to when collaborated warnings are disseminated, is typically about nine minutes. This is an improvement over the legacy fire warning-practices which, when exercised, were documented to take upwards of 80 minutes to obtain authorized requests from local emergency managers. In many cases, the fog of war that is commonly experienced in emerging incidents contributed to such delays. IWT fire warnings have proven to precondition residents and hasten action if evacuations are ordered and have informed decisions by incident commanders to adopt strategies focused on protection of life and property – especially in circumstances when minutes matter.

For the first time during the historic Feb. 26-27 southern Great Plains firestorm, multiple NWS forecast offices collaborated with fire, land, and emergency management agencies to transmit up to 20 IWT fire warnings. Following the initial successful development and implementation at the NWS forecast office in Norman, Oklahoma, in partnership with Oklahoma Forestry Services in 2022 and 2023, meteorologists at the neighboring NWS forecast office in Amarillo, Texas, completed training and partner outreach toward adoption of IWT Fire Warning practices just one week prior to the outbreak.

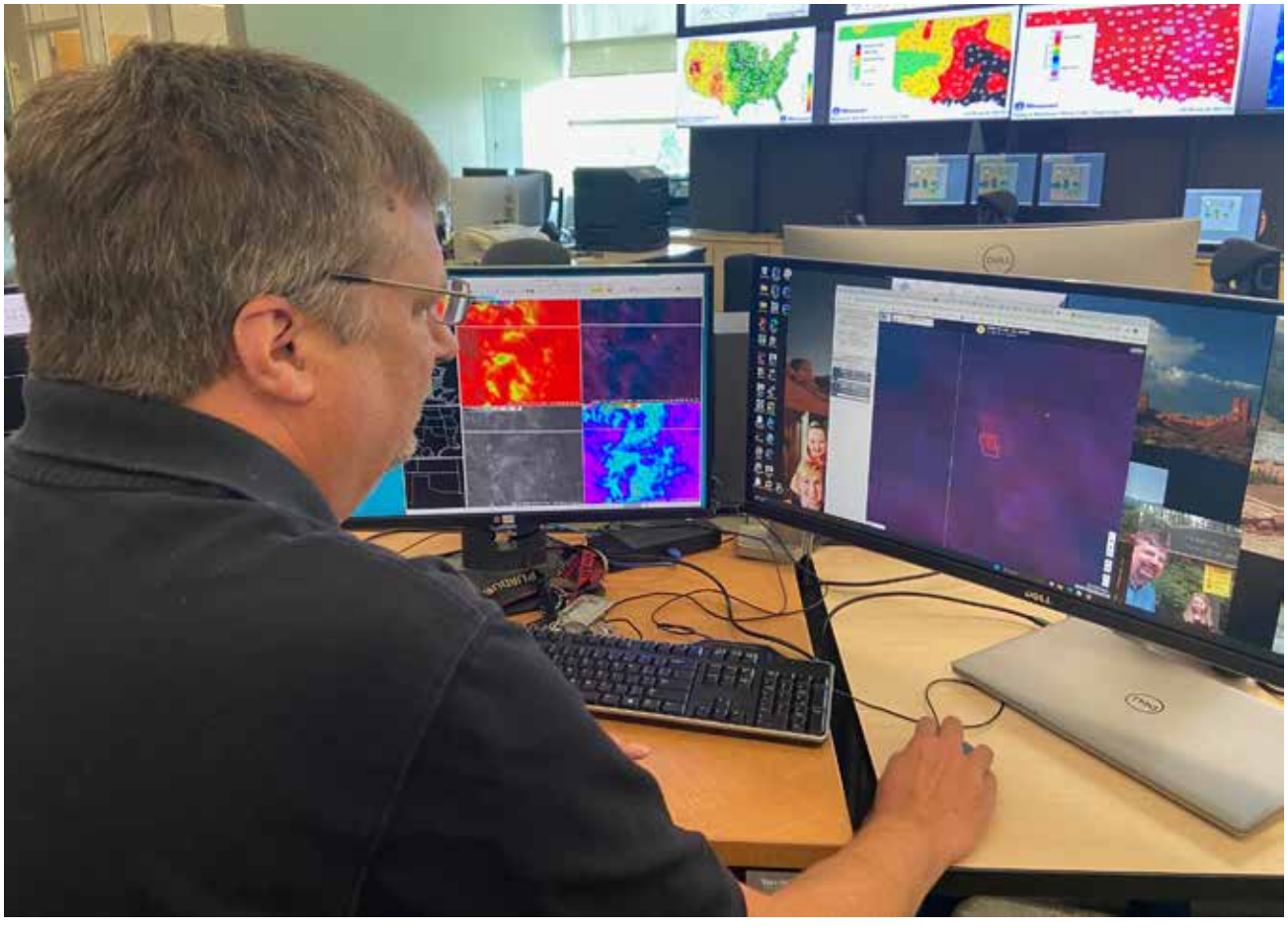
Texas A&M Forest Service's predictive services department head Luke Kanclerz said, "The effort and coordination [among] NWS offices, local and county emergency management, and forestry agencies for fire warnings, I believe, saved lives."

Kanclerz's sentiments were substantiated by preliminary analyses of census data in the burned areas, with fatality rates significantly reduced relative to recent similarly

destructive wildfires nationwide. While that data is still under review, early estimates are that the successful evacuation of thousands of Texans and Oklahomans from harm's way by local officials likely prevented much larger losses of life.

Scott Barrett, assistant chief of the volunteer fire department in Gage, Oklahoma, and unified incident commander on the Feb. 27 Catesby fire, which burned 36,295 hectares in Ellis County, Oklahoma, noted "Fire warnings were issued very quickly with Forestry co-ordinating with the National Weather Service while we were conducting the on-the-ground evacuations. Those warnings were updated as the fire progressed. We had no fatalities."

In the days following the Smokehouse Creek, Windy Deuce, and Catesby fires, meteorologists used enhanced satellite-based fire detection tools to notify first responders of new fires before local 911 calls were received. Dispatch was prompted by an NWS hot spot detection for the 149 fire in Harper County, Oklahoma, on March 2. The meteorologist-generated alert allowed for rapid and heavy initial attack efforts by local and state resources. An Oklahoma Forestry Services-generated fire-spread model based on the satellite-derived geolocation provided by the NWS indicated potential for the fire to consume approximately 6,000 hectares over the next eight hours in the absence of suppression. Responding firefighters arrived on scene and discovered the fire 20 minutes after initial NWS detection and found the fire burning 610 meters east of the coordinate location reported by NWS meteorologists, who first spotted the fire using the GOES-East satellite some 35,000 kilometers above the



National Weather Service Norman lead meteorologist Doug Speheger interprets satellite data of a fire using the NGFS. Photo courtesy National Oceanic Atmospheric Administration /National Weather Service.

equator. The timely precision of an integrated response enabled firefighters to fully contain and extinguish the fire at only 15 hectares, completely mitigating the threat.

Mooreland, Oklahoma, Fire Chief Travis Case, commented, "Forestry had the coordinates (satellite detection) from the National Weather Service to me before the fire was even called in."

At least three fires in Oklahoma that ignited on Feb 27 were discovered through the NWS's use of satellite-based fire detection. Oklahoma Forestry Service's Fire Management Chief Andy James praised the capability as "absolutely incredible for wildland fire response – detection, dispatch, size-up and warning continuum, increasing incident responder situation awareness and public awareness when time is of the essence."

The satellite fire detection component of the IWT Fire Warning concept will soon get a boost from new technology being developed at NOAA / National Environmental Satellite, Data, and Information Service. The Next Generation Fire System (NGFS) will automatically alert forecasters at NWS offices when a new fire is detected. This will help to proliferate these emerging capabilities across the country.

Until new tools like the NGFS are fully operational, the IWT Fire Warning paradigm is not yet ready for deployment across the country. Just 10 days before the devastating firestorm struck Texas and Oklahoma in Febuary, NWS director Ken Graham conducted a joint press briefing with Oklahoma Forestry Service's director Goeller at the National Weather Center in Norman, Oklahoma. Touting the early success of IWT fire warnings in Oklahoma, the directors announced a public comment period that gathered critical feedback on the hot spot notification services provided through October 2024.

The NOAA Fire Weather Testbed allows an objective evaluation of new scientific developments and tools so that NOAA can improve support to the nation. The Fire Weather Testbed's main objective is to bring the fire weather community together to transition advanced technologies and new applications to operational platforms as quickly as possible. In June the Fire Weather Testbed brought together experienced NWS fire forecasters and state forestry partners to evaluate and improve NOAA's new fire detection capabilities, and to determine how those detections are communicated to partner agencies,as well as how the IWT fire warnings could be implemented across the country.

Both NOAA's Fire Weather Testbed and NGFS for early fire detection are new initiatives funded through Congress' historic investments (Bipartisan Infrastructure Law) in wildland fire management to advance wildfire prediction, detection, observation, modeling, and forecasting capabilities. Scientific vetting through the multi-disciplined evaluation by professionals from other parts of the country will help to determine how the new warning approach could be implemented outside of Oklahoma and Texas, where it has been so successfully demonstrated. The testbed evaluation this summer helped identify the technological, communication, and partnership challenges that need to be overcome, as well as future research needed to expand use of the NGFS and a cross-agency warning service across the United States for the protection of life and property during wildfire events.

In its recently published NWS Transformation Roadmap, an evolution of services is described where future meteorologists will deliver "high-quality, science-based decision support services – telling people what they need to know in order to make life-saving decisions." That level of service is exactly what Beaver County, Oklahoma emergency manager Keith Shaddon experienced amidst the flames on Feb. 27. "I thought the IWT Fire Warning process worked very well. It provided great assistance in getting the message out to those [who] needed to evacuate and prepare. The whole process provided a great service to our community," Shaddon said. Through the power of collaboration, emerging technologies are enabling a transition of science to service through integrated wildfire detection and warnings which place NWS meteorologists, along with their partnering fire, land, and emergency management agencies, on the forefront of emergency response.

Todd Lindley is the science and operations officer at the National Weather Service Forecast Office in Norman, Oklahoma. He has worked as an operational meteorologist at five NWS offices in Texas and Oklahoma throughout his 28-year career. Lindley specializes in decision support to fire management agencies on the southern Plains. As a founding member of the Southern Great Plains Wildfire Outbreak Working Group, Lindley has authored and/or co-authored more than 30 publications, reports, and conference manuscripts on fire meteorology. The working group has produced interagency co-ordinated probabilistic wildfire potential products that informs pre-deployment of state resources, developed novel conceptual models in fire weather, and innovative uses of GOES-R era satellite-based fire detection and monitoring. Lindley previously chaired the National Wildfire Coordinating Group's Satellite Data Task Team, and briefly served as his agency's National Fire Weather Services senior advisor. Lindley was the 2023 recipient of the American Meteorological Society's Charles L. Mitchell Award for "seminal fire weather forecasting science and innovative applications" and his working group was recently cited by the Oklahoma Office of Homeland Security and Department of Emergency Management's Oklahoma Whole Community Preparedness Award for "building statewide resilience."

Drew Daily serves as deputy fire management chief with Oklahoma Forestry Services (operations and preparedness). Within this role, he is responsible for both fire suppression operations and prescribed fire management. Working alongside partners assessing the fire environment is a critical function of Daily's work for both wildfire readiness and application of objective driven prescribed fire. Daily is part of the Southern Great Plains Wildfire Outbreak Group and Southern Area Fire Environment Group. Additionally, Daily serves as operations section chief on the Northern Rockies Team 1 incident management team.

Mark Fox is the meteorologist-in-charge at the National Weather Service Forecast Office in Norman, Oklahoma. Fox earned his meteorology degree from the University of Oklahoma in 1989, after growing up fascinated by the weather in north central Oklahoma. Mark has experience across the entire integrated warning team, starting his career working for a private meteorology company in college. He then worked for 10 years as a broadcast meteorologist, mostly in Wichita Falls, Texas, before moving to the National Weather Service in 1999. Since moving to the NWS, Fox has worked in the Fort Worth, Amarillo, and Lubbock offices, and served four years at Southern Region Headquarters as the regional training officer. In 2009, Fox became the warning and coordination meteorologist at WFO Dallas/Fort Worth before serving as the meteorologist-in-charge of the Amarillo Weather Forecast office from late 2018 through September 2021.

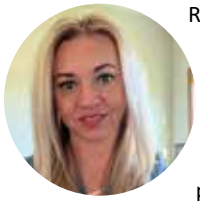
Doug Speheger has been a meteorologist with the National Weather Service in Norman, OKlahoma, for more than 30 years forecasting and studying weather in the Southern Great Plains. Speheger has been involved in research involving fire weather, tornadoes, severe weather, and radar meteorology.

Christopher Mask is an experienced GIS professional with a bachelor of science in cartography. With more than 25 years in the GIS industry, Mask has established himself as a seasoned expert in geographic information systems. Currently serving as a GIS manager at Oklahoma Forestry Services, Mask's passion lies in leveraging spatial data to solve complex problems and enhance decision-making processes. Christopher's dedication to his field has been recognized with the prestigious SCAUG Founders Award in 2019.

Luke Kanclerz assumed the role as Texas A&M Forest Service predictive services head in February. Luke has spent his entire 12-year career in wildland fire with the Texas A&M Forest Service, beginning with three years in mitigation and prevention. Kanclerz has spent the last nine years supporting Texas as a fire analyst with predictive services by providing decision support documents and fire environment intelligence to Texas A&M Forest Service fire management and multiple state and federal co-operators. Kanclerz regularly engages in fire suppression across Texas and the United States with multiple operational qualifications including crew boss and heavy equipment boss.

Aaron Ward is the science and operations officer at the NWS Weather Forecast Office in Amarillo, Texas. Ward has worked several high impact fire weather events since joining NWS Amarillo in 2016, and has helped facilitate several changes to the local fire weather program using the latest advancements in science and technology to improve communication, operational readiness, and tactical response. The most recent change has been the most notable – the implementation of the IWT Fire Warning concept just in time for the Feb. 26-27 historic wildfires.

Michael Gittinger is the meteorologist-in-charge at the National Weather Service Forecast Office in Amarillo, Texas. As MIC and previously as the warning coordination meteorologist (2015-2022), Gittinger has been working closely with fire weather partner agencies in the Texas and Oklahoma panhandles to facilitate significant programmatic changes over the past nine years. In total, Gettinger has 25 years' experience with the National Weather Service.



Robyn Heffernan is the NOAA National Weather Service fire weather services senior advisor at the National Interagency Fire Center in Boise, Idaho. Heffernan specializes in interagency coordination, strategic planning, and fire environment policy. She serves on several national teams including the Wildland Fire Mitigation and Management Commission, the White House Wildfire Resilience Interagency Working Group, and is vice chair of the National Wildfire Coordinating Group Fire Environment Committee. Heffernan also oversees new fire weather science and technology transition to operations, as well as fire weather training efforts. Previously, Heffernan worked for the Bureau of Land Management, in the predictive services program, where she assisted in managing the national fire weather program for the federal land management agencies.

Zach Tolby has more than a decade of operational forecasting experience, specializing in mountain meteorology and the fire environment. As an incident meteorologist, he is deployed to major wildfire incidents across the western United States. Recently, Tolby joined NOAA Research as manager and lead scientist at the Fire Weather Testbed in Boulder, Colorado. Tolby oversees the testing and evaluation of new fire weather tools, in close collaboration with the fire weather community, to rapidly transition advanced technologies to operational platforms.

Michael Pavolonis is the NOAA National Environmental Satellite, Data, and Information Service (NESDIS) Wildland Fire Program manager. Pavolonis earned his PhD in oceanic sciences from the University of Wisconsin – Madison; he also holds a bachelor of science degree in meteorology from Penn State and a masters of science in atmospheric and oceanic sciences from the University of Wisconsin.

Dr. Stephen Bieda III is the NOAA/National Weather Service Severe, Fire, Public, and Winter Weather Services Branch chief at National Weather Service Headquarters in Silver Spring, Maryland. Bieda plays a pivotal role in defining and co-ordinating the implementation of NOAA and NWS strategic plans while ensuring the execution of the service programs he oversees. Previously, Bieda served as the NWS national science and operations officer and the NWS Amarillo, Texas, science and operations officer. He also serves the American Meteorological Society's Weather Analysis and Forecasting Committee's chair and journal editor.

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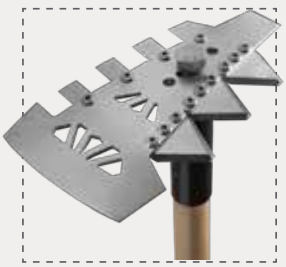

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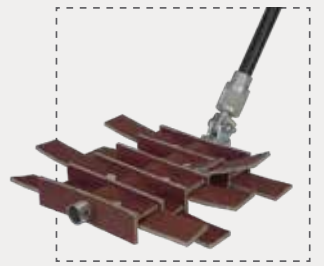

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NEW STRATEGY NEEDED FOR EXTREME WILDFIRES

IMPACT OF CLIMATE CHANGE MUST BE INCORPORATED

BY RICK MCRAE

After a career as an ecologist, senior emergency manager, and bushfire scientist I have a particular view of where climate change is taking us; it is fundamentally based on Australian conditions, but I have an international perspective that is both operational and scientific. A lot of people say a lot about this problem, but too many are saying different things. Who does one listen to, especially if you enjoy your comfort zone? You may disagree with my views, but rather than dismiss them, start a conversation with your colleagues and think about how what I am saying might affect both them and your collective goals. My career and my research has all been aimed at reducing wildfire risks. Here I simplify some topics, and omit a lot of necessary technical detail, but I completely support the outline that I present.

The global collective of fire management wisdom is clearly focussed on a fuel-oriented path forward in the face of climate change. The Landscape Fire Governance Framework that arose from the 8th International Wildland Fire Conference in Oporto in May 2023 is the latest element of a global framework. The framework states that fires are getting worse due to a combination of too much wildfire suppression, a lack of investment in fire management, and changes to how communities handle fire on the landscape. A common theme in discussions is the need for more fuel management, either through more fuel reduction burning or a switch to Indigenous practices.

To this end, planning typically includes a focus on risk reduction through hazard reduction via fuel management. Training, equipment, and systems are focussed on this system, matched by budget allocations. Satellites show that certain countries produce a lot of smoke from this risk-reduction effort. For normal wildfires, fire services and their communities do a very good job mitigating the risk. (Can this ever be enough?) Climate change is increasing fire danger as the world warms up, and fire services and land managers are correctly adapting to the heightened risks.

At the same time, the world is being severely affected by what are called extreme wildfires, which dangerously couple with the atmosphere above.

It is critical to correctly use the terms normal and extreme: normal fires spread by quasi steady-state fire behaviour – if you know the fuel and the terrain, then you largely know what the fire will do; extreme wildfires have one or more blow-up fire events (BUFEs), where the fire couples with the atmosphere and exhibits dynamic fire behaviour, which often involves feedback loops and so the details are largely unpredictable. Figure 1 shows their relationship.

For BUFEs, there is no explicit role for fuel load (beyond the need for a prior fire), indicating that fuel management – central to the framework – is unlikely to be an effective preventative action. We do, however, need to explore how fuel management can be targeted to prevent future dynamic fire escalation. Extreme wildfires do not occur in flashy fuels such as most grasslands: they are mainly a problem in forests and woodlands and they have, in recent years, occurred in new ecosystems (discussed below). (See figure 2.)

When an extreme wildfire couples with the atmosphere after being triggered by dynamic fire behaviour, a BUFE occurs, lasting up to three hours, and typically burning 50 to 100 square kilometres (20 to 40 square miles). With little opportunity for fire suppression the only real incident objective is to save lives. Saving structures may put fire crews at risk for little return. This minority of fires cause the majority of damage.

The incident action plan for affected sectors and divisions during a BUFE looks very different to that for a normal fire. Locally appropriate strategies and tactics need to be formulated to help save lives.

There is an archive of decades of high-quality satellite data that is informing many aspects of the challenges associated with extreme fires; it will become increasingly important that we get the full leverage off the datasets involved. The complexity of the changes already underway can be overwhelming. It will be important for end users to make clear what their needs are, and for them to accept the answers produced.

While many authors have used forward-looking climate models to anticipate how climate change will impact fire risks, observations are now showing a far more alarming picture overall.

Fire thunderstorms, called pyroCbs, are the most obvious manifestation of extreme wildfires. A recent study found that there has been no recent global trend in the frequency of pyroCbs. Global pyroCb activity has always been dominated by fires in and around Boreal forests. However, areas such as Australia, South Africa, South America, and the Mediterranean have only recently started having problems with extreme wildfire. Canada, in 2023, experienced the most protracted ever season for extreme wildfires, globally. Australia's Black Summer was just as prominent with record-breaking intensities.

An important step must follow on from recognition of the wildfire-type dichotomy: operational doctrine must be revisited. As an example, in Australia, the national doctrine for operations in the urban interface lacks any dynamic fire behaviour elements. This document is founded on decades

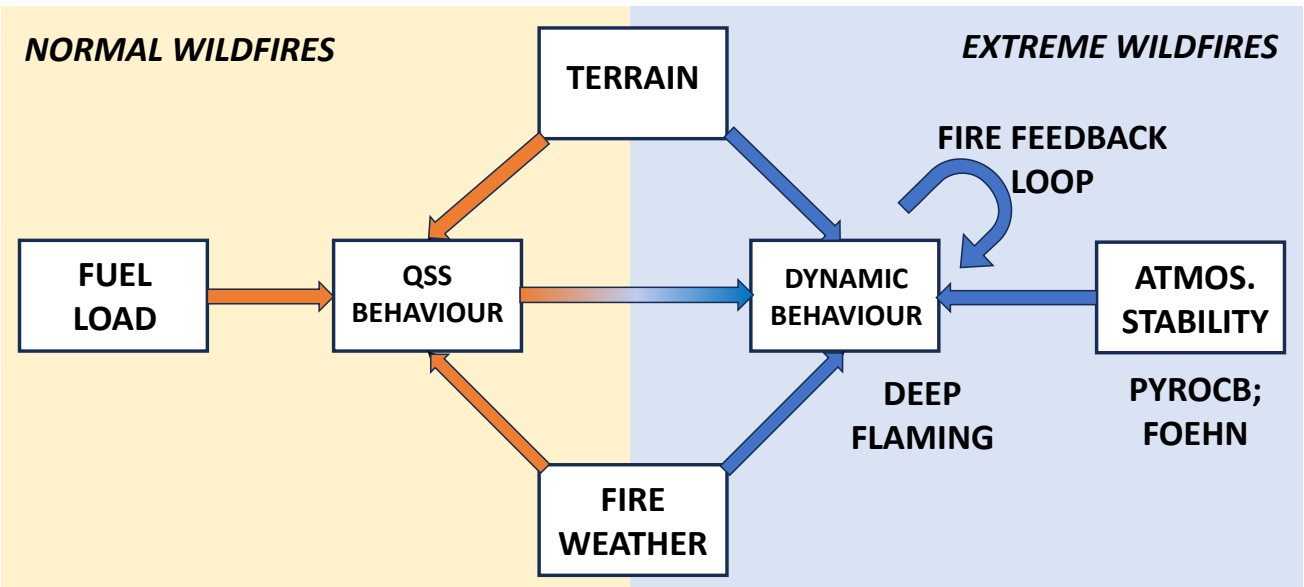

Figure 1. The relationship between the fire drivers for normal wildfires with quasi-steady state behaviour and the fire drivers for extreme wildfires with dynamic behaviour. The left is quasi-deterministic while the right involves unpredictable feedback loops.

	LANDSCAPE MOISTURE STATUS			
	High	Medium	Low	Depleted
Manifestations	High stream flows, wet soil.	Steady stream flows, drying soil.	Dry headwater streams, dry soil.	Dry rivers, dry soil profile.
Veg impacts	Strong growth.	Normal growth.	Drying out, foliage reduction.	Stand structure depleted. Canopy reduced.
Fine fuel impacts	Fuel loads rising strongly.	Fuel loads rising.	Fuel loads steady or declining.	Fuel load depleted. Little fuel load effect on fires.
Other fuel impacts (logs, peat, etc)	Not relevant	Not relevant	Involved in smouldering zone.	Fully flammable, able to contribute to deep flaming.
Flammability impacts	No flammability.	Limited flammability.	High flammability.	Unconstrained flammability.
Fire impacts	No fires.	Mild fires, fuel reduction burns.	Wildfires.	Extreme wildfires possible.
		This is where Fire Danger Indices apply.		

Figure 2. The drivers of fire risk. The "depleted" column is where dynamic fires usually occur.

or experience during fire fighting and is state of the art – for normal fires only. What is different? When a BUFE arrives at the urban interface, it is characterised by: (1) a lack of a headfire, with a switch to dense spotting, and a high chance of loss of overall situational awareness; (2) an ember storm (a sea of flowing pea-sized embers flowing over the ground), which is very different to typical ember attack (which is more like a mortar attack); (3) strong turbulence; (4) a darkened sky; and (5) much deeper penetration of the urban edge. Air ops are likely to be impeded.

Also, standard doctrine is often founded on past damaging fires, but key lessons from previous events may need revisiting if, as is often the case, those fires were driven by processes subsequently discovered, such as the key elements of dynamic fire behaviour.

Several past landmark fires have featured descriptions of the fire spreading sideways on the lee face of a ridge. We have seen this in news footage, with chief officers waving their hands sideways during media briefings, or even in official post-incident reports. After being identified in 2003 in the Canberra fires, a scientifically validated concept called Vorticity-driven Lateral Spread (VLS) is now known to be the cause. VLS is by far the main cause of forest fire damage in rugged landscapes, globally. Fire service operations based on key lessons learned need to adapt to this. A lookout at a fire where VLS might occur has to be trained to look to the rear at certain landform elements, as opposed to the prior practice of focussing on the headfire. To avoid VLS-driven BUFEs, it may sometimes be an option to burn-out VLS prone areas ahead of the main fire when fuels are too damp to support spotting. Another key instance of the need to rethink is that dynamic fire behaviour is often associated with large air tanker accidents. Climate change is leading to large aircraft flying out of aviation weather into fire weather while climate change is turbo-charging weather close to the ground.

It used to be that different countries had different types of fire, and therefore different operational approaches. Climate change is reducing these differences. I identified a fire near Canberra in 2004 as being foehn-wind driven. Some time after that my collaborators and I wrote a paper on this, introducing Australian firefighters to an idea that has long been a mainstay of training in North America and the Mediterranean Basin. Over the following decade we found only a few good cases of local foehn-wind driven fires. Then during Black Summer, with hundreds of BUFEs, perhaps 50 per cent of those were of this type. That is a massive escalation.

These changes clearly suggest that the world needs a multi-pronged adaptation strategy to climate change's impacts on wildfire risk. The strategy

for normal fire is well understood and must be implemented and continually improved upon. The strategy works better than is acknowledged, because the metrics for success were developed using data from both types of fire. The inclusion of dynamic events with bad outcomes biases the outlook.

In passing, a serious issue arising from lumping all fires together is the mis-training of artificial intelligence and machine learning systems being developed to help mitigate bushfire risks. Just because a fire was attributed as something in a database 25 years ago does not mean that that is correct in today's thinking. Climate change will not be forgiving to field crews using poor intelligence.

A new strategy is required for rapid adaptation to extreme wildfires. The ongoing escalation suggests a need for the multi-pronged approach to be created as quickly as possible. I have developed a framework for predicting dynamic fire events in the forests of south-east Australia, which aims to show the potential for new thinking (Figure 3). The framework seeks to predict BUFE events using hydrology, remote sensing, and fire ground data in a multi-scaled way.

For the adaptation strategy to work it is necessary to define the following: ownership (by a global body); working membership; protocols; data and accounting needs; professional development protocols; and dissemination channels.

The mandate for climate change adaptation for wildfires might include:

- Focussing on extreme wildfires (to complement on-going collaboration on normal wildfires);
- Defining, owning, and disseminating research goals;
- Providing a hub for research outcomes;
- Providing a forum for international exchange of relevant operational lessons;

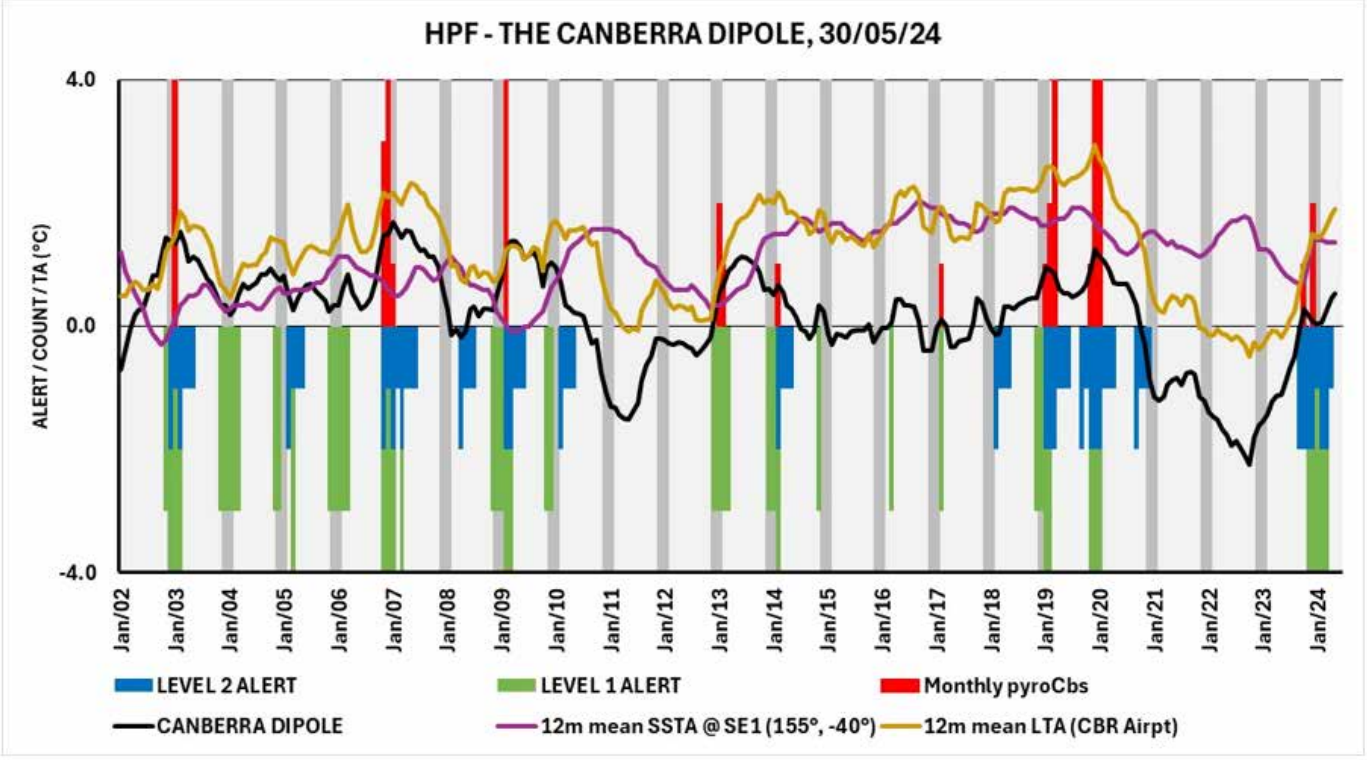

Figure 3. Two decades of predictive analysis on the potential for pyroCbs in the forests of southeast Australia. PyroCbs (red bars) occur when alerts are generated by the system, either due to temperature anomolies (green bars) or landscape hydrology (blue bars). The orange line clearly shows the impacts of climate change on air temperatures in Canberra, while the purple line shows a more worrying trend for offshore sea-surface temperatures. The difference between the two sets of 12-month average anomalies – the Canberra Dipole (black line) – is critical for BUFE potential. At the peak of Black Summer, Canberra had an extraordinary 12-month average temperature anomaly of 3C. Similar frameworks could work elsewhere.

- Maintaining a global overview of wildfire problems and tracking the overview's evolution;
- Rapidly disseminating new information or certified lessons from major fire events.

Students of the evolution of wildfire can look at the references cited in many new wildfire papers and see – from the references alone – where the paper was written and what technical specialty it is from (for both the authors and the journal). However, this Fire Tower of Babel situation is not good enough. In a similar vein, if we are to collaborate on these problems, we must standardise the terminology. The use of alternative terms, and the widespread misuse of others does nothing to aid adaptation – foundation terms such as pyroCb or megafire are key examples – and surely reinforces the previously mentioned issue with the training of machine learning systems.

The wildland fire sector needs to stop being overly distracted by fuel loads, otherwise we will all be affected by extreme wildfires and their impacts on ecosystems, communities, soils, hydrology, biodiversity, traditional practices, and the upper atmosphere – including the ozone layer.

Rick McRae served as a headquarters technical specialist in what evolved to become the ACT Emergency Services Agency in Canberra from 1989 until his recent retirement. He worked in business planning, arson investigation, multi-hazard risk assessment, as planning officer for major incidents, weather specialist, and as a research scientist focussing on extreme wildfires, and especially pyroCbs. McRae has conducted case studies, described new phenomena, and developed predictive tools. He maintains a website that aims to present operationally useful material on extreme wildfires – https://www.highfirerisk.com.au/. McRae is now an adjunct professor with the Bushfire Research Group at UNSW Canberra.

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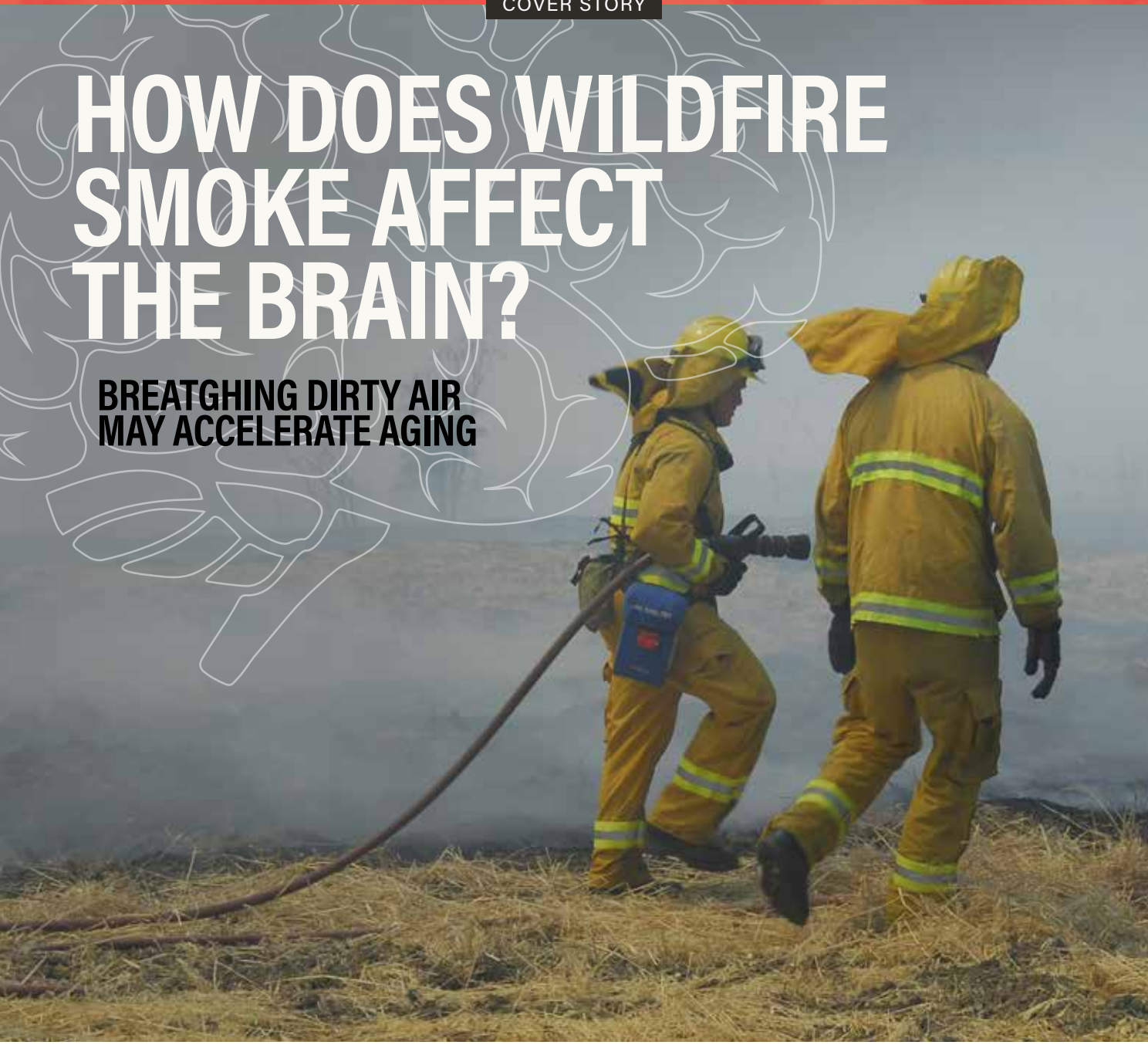
HOW DOES WILDFIRE SMOKE AFFECT THE BRAIN?

BREATGHING DIRTY AIR MAY ACCELERATE AGING



Researchers in Mexico City have determined that wildfire smoke has a determintal affect on chidlren and young adults who are exposed, and essentially fast forwards the aging process, resulting in cognitive defects similar to as Alzheimer's. Photo by Chris Boyer on Unsplash .

BY ANTHONY WHITE AND LILIAN CALDERON-GARCIDUENAS

As the threat of wildfires grows, firefighters and affected communities grapple not only with the immediate threat of flames but also with the acute and chronic brain health effects of wildfire smoke.

While the physical dangers of smoke inhalation are well documented, the toll it takes on brain health remains a lesser-known consequence.

After sustained exposures to wildfire smoke, people complain of memory problems and mental fatigue. Routine tasks can demand heightened concentration

and effort. Thought processes (known as cognitive function) appear to slow, suggesting impairment in information processing and decision-making abilities. Time and spatial perception can seem distorted, together with diminished attentional capacity.

David Vivian, an experienced Ranger with the Queensland Parks and Wildlife Service in Australia, has been exposed to smoke on many occasions, including heavy amounts of smoke inhalation when dealing with wildfires.

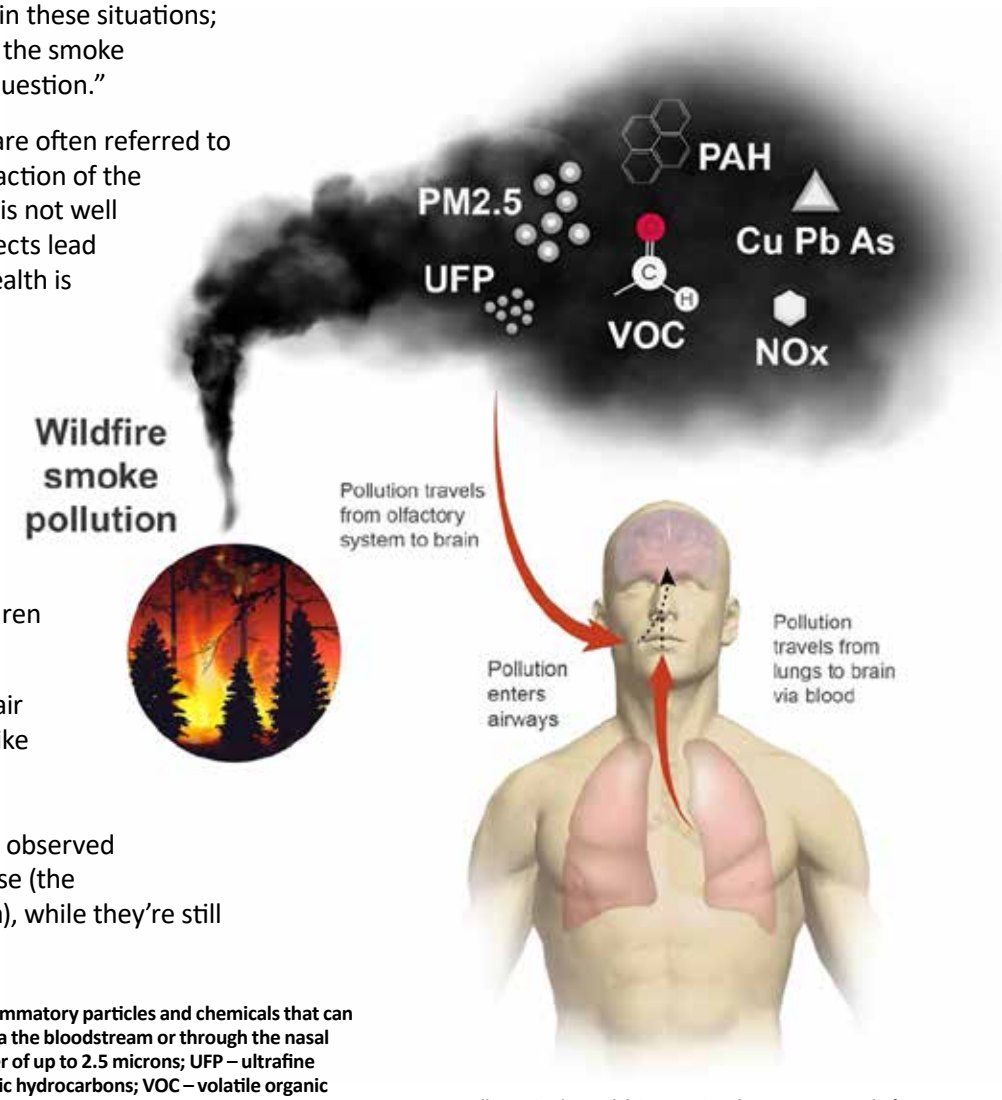
"When you 'cop' a lung full, it's usually because you have made an error in judgement or because the situation has changed rapidly, or dramatically," Vivian says. "Often the lapse in judgement is preceded by fatigue and stress. I believe that my cognitive functioning is at a reduced level in these situations; whether that is a direct cause of the smoke inhalation poses an interesting question."

These effects of wildfire smoke are often referred to as brain fog, but the underlying action of the smoke impact on brain function is not well understood. If and how such effects lead to long-term changes to brain health is only just being investigated.

A starting point for understanding how wildfire smoke affects people's brains could come from Metropolitan Mexico City, where we are studying the impact of air pollution on the brains of seemingly healthy children and young adults.

It turns out that breathing dirty air isn't just a hit to your lungs; it's like pressing the fast-forward button on brain aging. Imagine youthful minds showing cognitive deficits observed in people with Alzheimer's disease (the most common form of dementia), while they're still playing in the schoolyard; it's as if air pollution stole their innocence. It is extremely sad to see a nine-year-old complaining she does not remember very much from her daily classroom lessons.

Some of the startling findings from our research in Metropolitan Mexico City include the demonstration of substantial structural brain changes in young people exposed to the high levels of air pollution. Twenty-two million residents have been exposed daily to sustained concentrations of fine particulate matter (PM 2.5) well above the current U.S. Environmental Protetion Agency standard of 9 µg/m3 for the last three decades.



Wildfire smoke contains neurotoxic and inflammatory particles and chemicals that can enter the body and may travel to the brain via the bloodstream or through the nasal (olfactory) system. PM2.5 - particulate matter of up to 2.5 microns; UFP – ultrafine particles up to 0.1 micron; PAH – polyaromatic hydrocarbons; VOC – volatile organic compounds; NOx – nitric oxides; Cu Pd As (metals – copper, lead, arsenic).

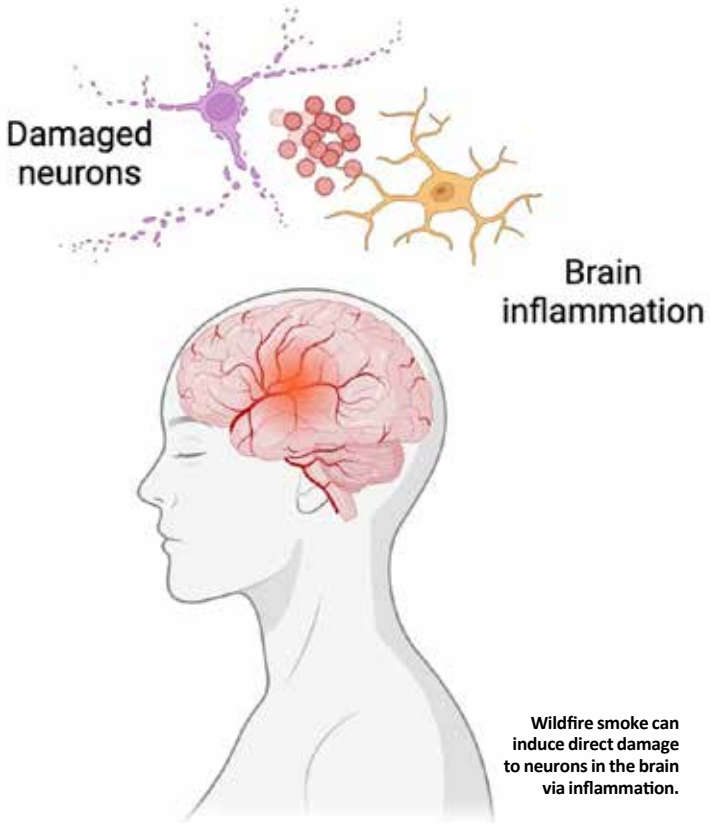
Illustration by Madeleine Kersting Flynn at QIMR Berghofer.

Alzheimer's disease is usually associated with ageing and affects people mostly in their 70s and 80s. However, forensic autopsy studies of children and young adults in Mexico City have shown the hallmarks of aberrant neural proteins as described in Alzheimer's disease, Parkinson's disease, frontotemporal lobar degeneration, and amyotrophic lateral sclerosis, including accumulation of major abnormal brain proteins – hyperphosphorylated tau, beta-amyloid, alpha synuclein and TDP-43.

How is this relevant to understanding the effects of wildfire smoke from forests and savannahs on the brain? Wildfire smoke is a major form of particulate air pollution, hence smoke levels are measured as changes in air quality. Like city pollution, which is largely from traffic and industry, wildfire smoke contains a range of microscopic particles called particulate matter. It is generally considered that particulate matter with a diameter of up to 2.5 micrometers (which is less than 1/10th the thickness of a human hair), including the ultrafine particle fraction (below 0.1 micrometer in diameter), is toxic because it can enter deep into the lungs and cross the barrier from the lungs into the blood stream. There are a number of additional chemicals and compounds in wildfire smoke that can add to the toxic nature of the smoke, including volatile organic compounds, such as aldehydes, and alkanes, together with polycyclic aromatic hydrocarbons, various gases (carbon monoxide, sulphur dioxide, nitrogen oxides), and heavy metals such as copper, iron, manganese, and arsenic, some of which can be stripped from soils by hot fires.

A growing number of studies at both the population level (epidemiological studies), and cellular level, are providing evidence that wildfire smoke is as toxic as anthropogenic (human made) particulate matter pollution, resulting from combustion of fossil fuels. These studies raise a major question regarding just how toxic is wildfire smoke to the brain: Can city pollution induce Alzheimer's disease, Parkinson's disease, frontotemporal lobar degeneration, and amyotrophic lateral sclerosis-like changes in young people? Furthermore, there are important questions to answer about how different types of vegetation smoke affect humans, how the toxicity changes with distance from the fire, and the short- and long-term consequences of wildfire smoke exposure.

First, consider how wildfire smoke can get to the brain, or if it even needs to, to impact brain health. Unfortunately, there are multiple ways wildfire smoke can affect the brain, which may be surprising given that the brain is protected by a tight barrier between the blood vessels and the brain cells (neurons), logically called the blood-brain barrier. In theory, this barrier tightly controls the movement of all toxic chemicals into and out of the brain, however it turns out, the tiniest particles entering the blood circulation are very capable of damaging this precious blood-brain barrier and thus, renders the brain helpless and vulnerable to toxins and the particles themselves. The ultrafine particles travel free in the blood, but also in the red and white blood cells, so indeed the Trojan horse is at play to reach every single region of our brains.



Wildfire smoke can induce direct damage to neurons in the brain via inflammation.

Illustration by Madeleine Kersting Flynn at QIMR Berghofer.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In an interesting recent study, Raissa Gill, Robert Fleck and colleagues at University of Technology in Sydney measured the size of some particles collected from filters after the devastating 2019-2020 Black Summer bushfires that blanketed Sydney and much of Australia in wildfire smoke for several weeks. The researchers found that the diameter of the wildfire particles was substantially smaller than that of particles collected from reference sites that included predominantly traffic and other ambient sources of air pollution. This finding could suggest that wildfire smoke particles, being smaller, may have an increased ability to cross cell membranes and enter body organs including the brain. In addition, we know from studies in mice performed by David Scieszka and colleagues at University of New Mexico in 2022, that when exposed to wildfire smoke particles, the blood-brain barrier is disrupted. Thus, more toxic smoke particles in the blood can access the brain through the damaged barrier. But this can also allow access to inflammatory cells from the blood; this is exactly what Sciezka found in the mouse studies. Several different types of inflammatory cells (white blood cells) were shown to be invading the brain after exposure to the smoke; this coincided with inflammation in the brains of the mice, and damage to the neurons.

The lung-blood-brain route is not the only way wildfire smoke can reach the brain. Wildfire smoke might also be hitching a ride to our brains through the nerve fibers in our noses. The cells in the nose that sense smells are closely linked to the brain through a region called the olfactory bulb. This part of the brain is linked to other regions including the amygdala and hippocampus, which are highly involved in processing emotions and thought processes, memories, and learning. Unlike the blood-brain barrier connection, the nasal (olfactory or the trigeminal) nerve systems are highways for the particles through their axons directly to the brain. But in terms of wildfire smoke pollution, if offers a potentially direct route for access of toxic particles into the brain.

Regardless of how the toxic wildfire smoke particles access the brain, there is increasing evidence that the particles are having important short- and long-term impacts on brain health. Studies investigating the cognitive function of people exposed to different forms of air pollution have found key links between wildfire smoke exposure and impairment of certain cognitive (thought) processes. A 2023 study by Boya Zhang and colleagues at the University of Michigan found that the two leading sources of PM2.5 associated with increased risk of dementia in the United States were agriculture and wildfires. The research, published in a *JAMA Internal Medicine,* points to the growing links between air pollution and Alzheimer's disease. In fact, based on the study, the authors estimated that if there is a causal relationship between agriculture and wildfire smoke PM2.5 and onset of dementia, ~188,000 new cases of dementia could occur each year in the United States alone from these exposures. Another recent study by found that air pollution in the UK was the second greatest modifiable risk factor for dementia-linked changes in the brain, after diabetes. A modifiable risk factor means something that could potentially be avoided or controlled, compared to genetic makeup, which can't be controlled. While the study did not specifically assess wildfire smoke pollution, when combined with studies such as the *JAMA* research, it's clear that exposure to wildfire smoke could be a leading risk factor for dementia, and that this risk may increase further with the combination of more wildfires, other occupational exposures, traffic pollution, tobacco, and age.

Other studies have shown links between exposure to wildfire smoke and impaired ability to perform thinking-related tasks, in adults and youth, and from short- and long-term exposure. Although the effects of wildfire smoke on brain development (termed neurodevelopment) in the fetus, infants and children has been poorly studied, some studies have shown ultrafine particles and industrial nanoparticles reach fetal brains early and thus, particulate matter exposures, including wildfire exposure, could indeed impair early brain development. Likewise, several studies have shown a relationship between air pollution and Parkinson's disease, however, there has been no dedicated research into whether wildfire smoke air pollution is a contributing factor.

How does the wildfire smoke cause these changes to our brains? Studies suggest that ultrafine particulate matter reaches blood vessels, neurons

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and glial cells and cause significant subcellular damage to both critical organelles (cellular machinery) and cell and nuclear membranes. Wildfire smoke drives inflammatory changes in the brain. It remains uncertain whether this inflammation comes directly from toxic interactions between the brain's immune cells, through invasion of the brain by white blood cells, or impacts on the brain from other inflammatory molecules in the blood (called cytokines), triggered by smoke particles in the lung or blood. Our research lab has found that exposing human brain immune cells grown in a dish to a preparation of wildfire smoke resulted in a major release of an inflammatory cytokine that is known to have an important role in Alzheimer's dementia brain inflammation. When we performed the same test with vehicle exhaust pollution, we did not see the same outcome, suggesting that human brain immune cells may respond differently (and worse?) to wildfire smoke pollution. We also observed greater effects of the wildfire smoke on brain immune cells from older people versus young people.

Air pollution particles such as those that occur in wildfire smoke are also known to directly affect neurons in the brain (the cells that control learning, thinking, and memory processes). Studies have shown PM2.5 to affect signaling processes within neurons and between them, causing changes to the critical connections between neurons (synapses). The same particles can impair other brain cell functions including one called autophagy, which is a process through which brain cells remove waste material from the brain. Impairment of this process can lead to accumulation of toxic proteins and other substances that can ultimately kill neurons. Likewise, the smoke particles can impair energy production in brain cells by interfering with a key energy producing organelle, called mitochondria. This is the powerhouse of the cell, and neurons, are very energy hungry, requiring a lot of power to maintain all the connections and electrical activity that leads to our thought patterns. Impairment of the mitochondria, which involves oxidative stress (increase in free radicals) can lead to lack of energy and consequently breakdown of the connections between neurons.

Wildfire smoke is also a known risk factor for stroke that can occur in the brain due to blockage of blood vessels and therefore block oxygen and nutrients from reaching brain cells, or through hemorrhaging of vessels (where a vessel ruptures and blood leaks uncontrollably into the brain causing neuronal death). Studies have found that wildfire smoke increases the likelihood of stroke, potentially through oxidative stress, and inflammation.

Another important factor that is rarely considered is that excessive heat can induce similar effects on the brain as wildfire smoke, and increasingly, extreme heat or heatwaves are occurring in unison with exposure to wildfire smoke; add to this is the extremely high temperatures to which wildland firefighters can be exposed together with wildfire smoke exposure.

Extreme heat can generate brain inflammatory changes, affect microvessels and impair function of neurons, leading to poorer cognitive function – all changes that are also induced by wildfire smoke. How these factors work in combination, and whether there are amplifying effects rather than just additive effects is unknown and requires research.

What do we need to do now? There needs to be an expansion of wildfire smoke health impact studies from focusing on (often short term) impacts such as respiratory health (although obviously this is also very important), to cover other critical targets of smoke pollution, especially the brain. Wildland fire authorities do not want to find ourselves in the situation that currently exists with traumatic brain injury and contact sports, where we are only now waking up to the damage that related knocks to the head can cause, including increased likelihood of dementia and neurodegenerative diseases later in life. There is enough evidence now that there are potentially significant impacts of wildfire smoke on the brain, and further studies and actions are urgently needed. What isn't known is the answer to key questions such as what components of wildfire smoke are the most damaging to the brain, what level of exposure is harmful, is it similar to other health impacts or very different, what are the time frames. Does a single exposure matter, or does it take years of repeated exposures to have a serious impact on brain health? Is there a threshold cumulative particulate matter dose beyond which the damage is progressive and irreversible? What about exposures in people who already have a neuropsychiatric illness – does wildfire smoke have a greater effect in

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Ultimately, we hope a test can be developed to allow current or past firefighters to determine their risk levels for brain impacts of wildfire smoke . . .

such people? There is also potential difficulty understanding the overlap between psychological effects of wildfire smoke exposure, such as post-traumatic stress (PTS), and physio-pathological effects (actual toxic effects of the smoke), as both factors can induce similar impacts on the brain.

Our research groups are two of several internationally that are building programs in this important area. While we are investigating the direct toxic and inflammatory effects of wildfire smoke on human brain cells, we are also in the planning stages of extending this to try to understand the risk of neurological illness in wildland firefighters, and especially whether there is an increased risk of dementia, and what additional factors may affect this, such as age, location, and time spent fighting fire.

Ultimately, we hope a test can be developed to allow current or past firefighters to determine their risk levels for brain impacts of wildfire smoke; this testing could be extended to members of the community who are increasingly exposed to high levels of wildfire smoke. In Metropolitan Mexico City we already know that there does not need to be a huge cumulative PM2.5 dose to develop the hallmarks of overlapping fatal pathologies; 11-month-old children are already showing a complex neurodegenerative picture.

In the meantime, aside from wearing the recommended protections against inhalation of smoke, and trying, where possible, to avoid breathing wildfire smoke, firefighters should consider recording their exposure to wildfire smoke. Firefighters' notes don't need to be extensive or detailed, but a record of where and when exposure to smoke occurred could help researchers compare exposures to potential impact on the brain.

The mother of one of the authors succumbed to the ravages of dementia. While she was not a wildland firefighter, she spent her life in a kitchen often filled with woodsmoke from a leaky woodstove burning local eucalypt firewood. Whether there was a relationship between the two is something the family will never know, but with ongoing research, hopefully we will be able to better determine the risks for people exposed to woodsmoke, whether that be outdoors or indoors, and that could potentially allow people to avoid some of these risks. With the rapidly increasing exposure to wildfire smoke air pollution, this knowledge is becoming increasingly urgent.

Anthony White obtained a PhD in neuroscience from Murdoch University in 1996, then undertook a post-doctoral position at University of Melbourne investigating dementia and related disease. He then worked at Imperial College of Medicine, UK, in 2001 studying immunotherapeutic approaches to infectious prion diseases. White obtained a federal government fellowship (2004-2008) and established a research group at the department of pathology, University of Melbourne, investigating the role of metals in brain disease and development of metal-based drugs for treatment of these disorders. He received a an Australian government Future Fellowship in 2011, was recruited to QIMR Berghofer Medical Research Institute in 2016, and was awarded an NHMRC Senior Research Fellowship in 2017. White's research has contributed to the development of first-in-class metal-drugs as a potential new therapeutic approach to treat motor neuron disease. He is currently developing new human patient-based models of neurodegeneration and has established a new research direction examining the impact of wildfire smoke on the human brain.

Lilian Calderón-Garcidueñas grew up in a small Gulf of Mexico town, the oldest daughter of two young physicians. She was raised in a nurturing environment where the daily contact with patients was the rule and over dinner conversations were delightful ways to start her in medical and literature subjects, two main interest of her parents. She knew she wanted to be a physician by the time she finished middle school and she started medical school at age 15. The following year, she was the TA to the Chair of Embryology at the National University Medical School in Mexico City and started her life-long passion for teaching. Her first day as a TA in medical school surrounded by ~40 much older first year students, she was told she was in the wrong place, the middle school was three blocks away. Her love for exploring disease causes started in medical school and she decided to pursue her studies in the United States and Canada. Her pathology and neuropathology training at the University of Toronto were followed by her fellowship at Harvard University and her first position as an assistant professor at Northwestern University in Chicago. She earned an American Board in Anatomical Pathology and Neuropathology in 1981. Literature was always in her mind, so she went back to school and earned a BS in English Literature and a MA in Comparative Literature in 1997. Her interest for clinical environmental research took her back to Chapel Hill, North Carolina, where she earned a PhD in Toxicology in 2001, followed by three years as a postdoctoral fellow in Environmental Pathology. She loves her work, her teaching is key to her way to transmit her contagious enthusiasm for medicine, science and her research work, and in her free time she paints, cooks and tenders her vegetable garden and cooks some more.


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THE OPEN WOUNDS OF PEDRÓGÃO GRANDE

THE AFTERMATH OF ONE OF PORTUGAL'S DEADLIEST MEGA FIRES

BY LILY MAYERS

ABOVE:Aerial view of a forest area between the villages of Pobrais and Nodeirinho, in the municipality of Pedrógão Grande, in the central region of Portugal. Photo by Mikel Konate for Sonda Internacional

RIGHT: Castanheira de Pêra firefighter Gonçalo Fernando Correia Conceição died during the mega fire of 2017. Maria da Conceição, 63, grips a portrait of her son, the only firefighter to die during Portugal's Pedrógão Grande mega fire of 2017. Gonçalo was severely injured after he and his team became trapped in the flames during the firefighting operation. Years after the fire, Maria remains grief stricken by the loss of her son who was well-loved by the Castanheira de Pêra community. Photos by Paulo Nunes dos Santos for Sonda Internacional .

The fire storm's intensity melted skin off hands and feet, liquified glass windows and reduced standing signs to puddles of metal. The ferocious wind whipped heat up from the burning forests, thrusting flames forward before crashing them down on the small towns dotted across Portugal's central region, suffocating the area in thick black smoke.

On the afternoon of Saturday, June 17, 2017, a complex of at least five wildfires ignited, spread and merged across 11 small towns surrounding the municipality of Pedrógão Grande in Central Portugal creating an unstoppable and catastrophic fire event. Sixty-four people died and 250 were injured. Over five days more than 46,000 hectares of land were destroyed. The fire struck territory carpeted by highly flammable, abandoned pine and eucalyptus plantations at a time of prolonged drought and enduring heat waves. The major triggers were found to be contact between vegetation and a 25 kV electrical line as well as lightning strikes.

Volunteer firefighter Rui Rosinha, 46, was called in as reinforcement. He was driving to one of the emerging spot fires when his team's truck collided with a car on the N-236 highway near Pobrais, southeast of Coimbra. The crash stranded them on the side of the road and trapped the three unconscious passengers of the car. As the firefighters struggled unsuccessfully to free the passengers from the wreckage, the wind, radiation and heat from the approaching fire became unbearable. They were forced to save themselves and leave the passengers behind. Huddled together on a small island junction of raised concrete in the middle of the highway, Rui and his four colleagues then endured an hour of exposure to flames, heat, cyclonic winds and the thrashing of airborne debris.

"We experienced temperatures that seemed impossible," Rui said "The radiation came in waves. I felt it as if it were extreme waves of heat, I remember not just once, but many times the impact and pain, as it hit my body."

Though severely burned, the group was able to

successfully shelter three adults and a child on the same junction. When help finally arrived Rui and the others were driven to medical centers before being airlifted to hospital and that's the last thing he remembers.

"If ever there was a hell on earth, for me it was there."

The fire moved at unbelievable ferocity, with more than 4400 hectares burned in a single hour, violently accelerated by intense wind gusts, emitting enough energy to propel itself and exceed the capacity to be extinguished within four hours of igniting. The severe speed of the fire, which by nightfall was advancing at 15 kilometers an hour, outpaced evacuation orders and knocked out communication networks, trapping hundreds and killing dozens in their cars as they fled on the N-236 highway.

It was the worst mega fire in Portugal's history. As a result of the disaster, family members of those who died and others who were seriously injured were compensated from a 2.5-million-euro support fund. A complete reform of land management legislation was also prompted including the introduction of a new 10-meter clearing rule between roads and vegetation, the banning of new eucalyptus plantings and a shift away from purely reactive firefighting to prevention investment. The reach of the Pedrógão Grande mega fire has left physical, psychological and generational scars, altering the social fabric of the small communities forever.

How have the lives of those touched by Portugal's worst mega fire changed since the smoke cleared?

RUI

Almost three months after the fire, Rui awoke from a coma to a new reality. He had suffered debilitating burns to his hands, back and feet, respiratory problems as well as partial paralysis to his left side due to injuries in a nerve plexus making him wheelchair dependent.

"Those first nights, when I began to realize what had happened and when I began to understand my body and what was happening to me, those first nights were horrible." He pleaded for psychological help as he grappled with suicidal thoughts, "I saw that I didn't have the capacity to deal with it [alone]."

Thrust into this new reality beside him was his family. Rui's distraught but resilient wife, Marina, 45, had anguished through the months he was in a coma with daily drives to the hospital two hours away and when he woke she became his full-time caregiver. His two young sons, Antonio and Francisco, 12 and nine at the time, were confronted by a jarring role reversal in prematurely being the able men and joint caregivers of the house. Among these harrowing realizations for Rui was that his close childhood friend and colleague with him in the fire, Gonçalo Conceição, hadn't survived. Rui says the guilt of surviving when his friend didn't and not being able to save the passengers of the car, are two of the most complex psychological hurdles he is working on overcoming.

"I'm managing to approach and exorcize some ghosts and it is an almost permanent mourning to face traumas and talk about certain subjects that were taboo for me or at least I couldn't face it." Over the years, Rui has been able to reconcile and overcome parts of the trauma in a process that he says will never end, just forever evolve.

Deolinda Henriques Simões and Antonio Dias Gonçalves cut back weeds and shrubs on their property in an effort to reduce the fire risk. The work is necessary but physically demanding and it will only become more difficult with age. Photo by Paulo Nunes dos Santos for Sonda Internacional

"These are the steps I am taking, that I am achieving to feel more at peace with myself and be at peace with others too."

Rui comes from a family of firefighters. With reduced mobility however he has been transferred away from active duties after 28 years of service and now the Castanheira de Pêra fire brigade, once a second home to his family, is a place he feels uncomfortable and alien within. Despite everything his family has been through, both his sons dream of pursuing the family tradition. For now, it's a dream Rui and his wife are conflicted in supporting.

ANA

Some see daily reminders of the fire written on their bodies, while others face stubborn mental barriers in evolving past June 17. Ana Luisa Bernardo, 51, lost both her mother and father, Maria, 71, and Manuel, 80 in the fire. Their car crashed on the shoulder of a road as they fled the town of Sarzedas de São Pedro.

"The descriptions from people were that the sky suddenly turned dark and they couldn't see anything. So, I believe he didn't realize that the turn was right there on a steep slope," said Ana. Having worked as a diagnostic and therapeutic technician in hospitals for 25 years, she says not being able to save her parents brings immense pain, "Every day I still think about the subject. I can't dissociate."

For two years Ana was so paralyzed by the pain of losing her parents she was unable to enter their family home. She would visit it every weekend and clean the lower patio but not cross the threshold. Even now, Ana is still gradually sorting her parent's belongings, a journey her daughter Sátia, 16, is helping her through. "What I'm trying to do is triage only what brings back good memories, what's bad is not worth keeping. It's very delicate."

From what was already a network of small towns where most people are known to one another, now exists a new subcommunity forged by their shared grief and loss after the fire. This web of survivors refer to each other as a family who speak the same language of experience. "We share the same pain, some in one way, others in another," Ana said of one of the tragic event's rare silver linings.

But from the community the fire created, it also took away. Many of the towns affected haven't been able to return to the bustling places they once were. Ana says in Sarzedas de São Pedro, the change is palpable.

DEOLINDA AND ANTONIO

Retired couple Deolinda Henriques Simões, 55, and Antonio Dias Gonçalves, 80, spend their weekends in the tiny town of Nodeirnho. The day before the fire struck, the renovations of their weekend home were finished. They escaped just in time but "in the blink of an eye" their new home was destroyed before they could enjoy it.

Once it was safe to return to the smoldering town, they drove back and found the remains of their home and all their life savings destroyed beyond repair. "All the windows and doors were wooden in the old-fashioned way. I remember getting there, I only saw the walls and that's what happened. So much so that the beams that I had placed in aluminum were all crammed together like snails," said Deolinda.

It is estimated more than 1,000 buildings were damaged or destroyed in the fire resulting in damages of up to 200 million euros. The Portuguese government committed to providing 30 million euros for the reconstruction of first homes. But for Deolinda and Antonio their old home had been registered as dilapidated by the previous owner, unbeknown to them, so it wasn't eligible for insurance cover or government aid. The couple were left with nothing and had to wait three years before investing again. They have now bought around the corner from their old destroyed home but their new view frames their past struggles.

"Unfortunately, we can see the skeleton of the old house, which is just the torn walls, there's nothing left." Antonio says their new home has the best insurance they could get.

The couple, now acutely aware of what fuels a mega fire, use their weekends to clear the land around their new home. The manual labor involves pulling weeds, clearing gutters and cutting back the forest's understory. It's back-breaking work for the couple who are noticing the difficulty their age brings to the task but are limited by the cost of outsourcing it.

CÉU

Their town of Nodeirnho was once described as a lively place filled with young families and weekenders. But when the June 17 fire came through it killed 11 of the town's 50 residents. Those who remain still live among burned houses, hauntingly permanent reminders of the night their neighbors died.

Maria do Céu Silva, 52, is one of them. Céu (as she's known) survived the fire by sheltering in the water tank beside her home with a dozen others. She is lucky to have lived, but it was at a cost. She and the others with her had to endure the sounds of their neighbors dying within earshot. "We heard screams and cars crashing, and then we realized there were a lot of people in the village who were already dead. We never thought there would be so many. It was horrible but we couldn't do anything. We didn't have the means to help."

The fire and the evidence of its destruction across the town mean residents like Céu are trapped in a time capsule, unable to move forward. "I used to actually be a very fun person, and I think that since that happened, I'm not. Because we leave the house, I speak for myself and go to my work and pass by several places where victims died. It marks us every day no matter how much we go through and forget, we remember every day."

Among the town's victims were two children aged three and four, and several people in their 30s. Céu says much like in Sarzedas de São Pedro, they had filled the town with activity and dynamism. Now the chemistry of the tiny village has changed dramatically. Deathly quiet and still ash-stained, it feels ghostly with virtually no passing foot or car traffic. Céu says many of the remaining population are elderly and mostly stay inside their homes. In summer, when the wind picks up Céu fears fire will return to the town.

GONÇALO

Monuments dedicated to the victims of the Pedrógão Grande fire are scattered across the region. Written on all of them is the name of the only firefighter who died, Gonçalo Fernando Correia Conceição. The charismatic and well-loved firefighter was known as "Assa" or "Dr. Assa" (from the Portuguese *assar*, meaning to grill) due to his renowned barbequing skills and restaurant of the same name.

The 39-year-old is missed by many within the community he was so involved in, but none feel the loss more than his family. Years on from the fire, his parents strain to speak through the grief. They, and Assa's 17-year-old son David, live with the consequences of his selfless decision to routinely run into danger to help others, "It's the life he chose, that's it. It was his way to help others." said his father, Joaquim Domingos da Conceição, 69.

Hotelier Joaquim and his wife, Maria da Conceição, 63, have kept their son's house in pristine condition in the hopes their grandson, who had to move away after Assa's death, will someday return to the town and take over his father's restaurant. Like many families, they experienced a double desolation when the death of a loved one prompted other family members to move away.

Inside Joaquim and Maria's lakeside hotel in Castanheira de Pêra a huge quote has been painted on the wall of the dining hall, it reads, 'May my presence never be forgotten in my absence! Thank you friends. – Dr. Assa.' His parents say they have no fear their son will ever be forgotten.

THE PEDROGAO GRANDE MEGA FIRE

The Pedrógão Grande mega fire shaped a region by tragedy, causing profound human consequences that have left scores of people battling their own memories, questioning their safety and working through trauma. For those, the fire is unfathomable to forget. But in the wider community others are eager to leave it in the past and focus on the future.

While these communities oscillate between the two outlooks, the vegetation surrounding them has been quietly regrowing. Now the build-up has reached levels higher than before the fire and many fear history could repeat when the region almost inevitably faces future weather extremes.

Government forestry workers are attentively cutting back trees close to roads and houses while homeowners like Deolinda and Antonio race tirelessly against the growth of the pines closing in around them. Looking at the dense forests threaded throughout his town Joaquim Conceição says the work doesn't go far enough, "Another similar tragedy could happen tomorrow," he said. Meanwhile, the graves of Ana Bernardo's parents lay claustrophobically encircled by the same thick vegetation that accelerated the fire that caused their deaths.

Lily Mayers is a cross-platform freelance journalist from Sydney, Australia, based in Madrid, Spain. Mayers' career began in television and radio news for Australia's national broadcaster, the ABC. Since moving to Spain in 2020, Mayers' work has focused on the long-form coverage of world news and current affairs.

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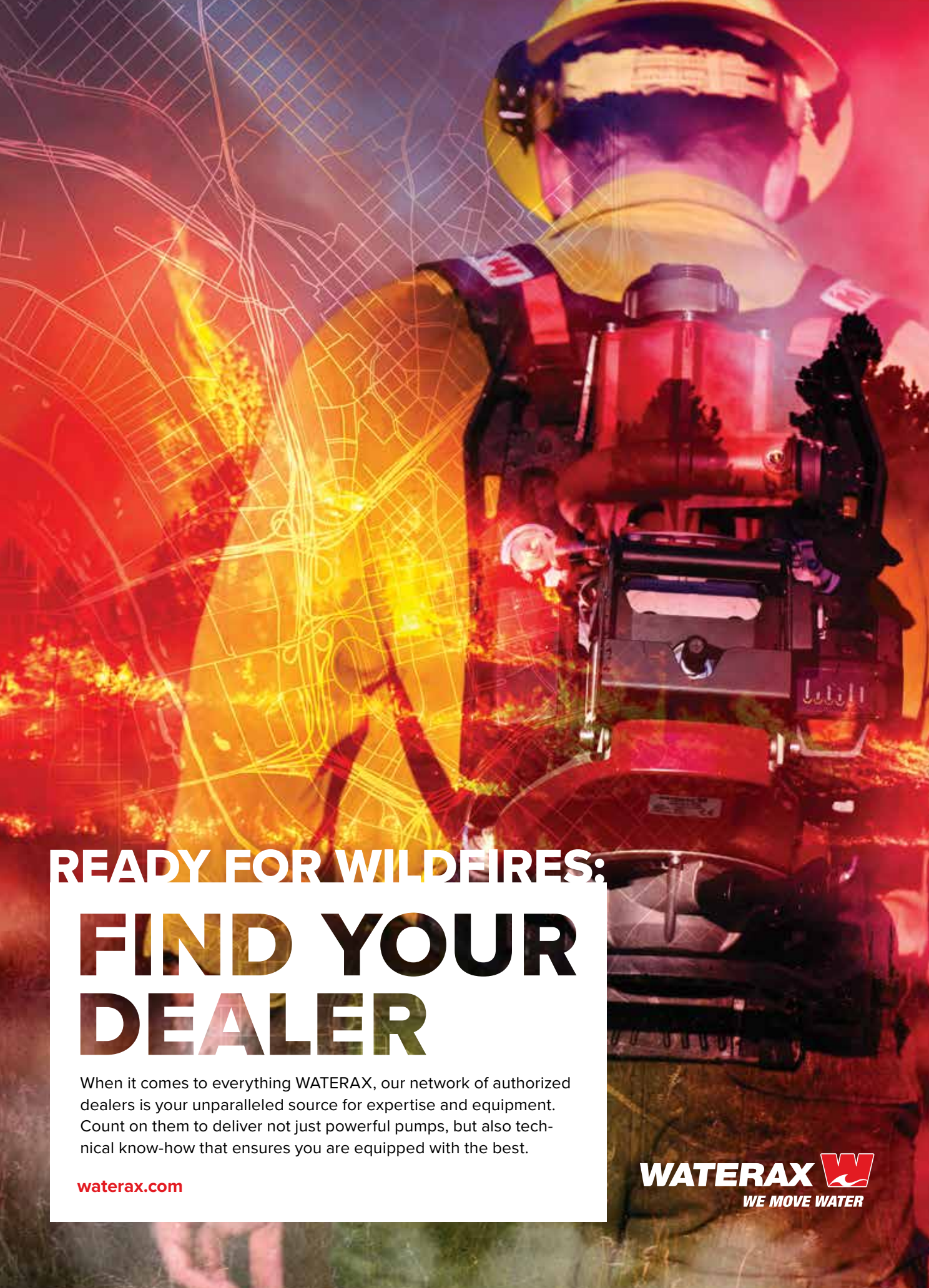

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