The Official Publication of the
International Association of Wildland Fire

IAWF: It's *Still* About the WUI Facts

WILDFIRE®

A Penton Media Publication

JULY/AUGUST 2013

Reducing the Risks of Prescribed Fire

How to successfully ignite a stand-replacing burn in the Northern Rockies — in August.

OPERATIONS & PLANNING:

Hurricane Sandy, an Urban Wildfire & ICS

BEST PRACTICES:

Your Fastest Escape Route

FIELD REPORT: Mapping Carbon in the Outback | **LEADERSHIP: Hardwired Research**

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July/August 2013
Volume 22 Number 4

Andrew Edwards collects post-burn data in the Kimberley region of Australia as part of an applied bushfire research program to assess carbon sequestration in savanna fuel types. For more, read *Mapping the Burning Bush.*

PHOTO: RON STEFFENS

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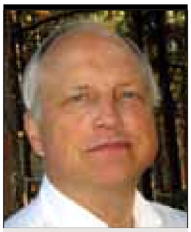
On the Cover
In Alberta, Canada, aerial heli-torch ignition combined with fuel amendments allow for safe management of an August prescribed burn. The burn was reverse-engineered to both mimic and prevent the stand-replacing fires typical of conifer forests in the Northern Rockies.
Photo: Rick Arthur (Alberta Environment and Sustainable Resource Development)

It's *Still* About the WUI Facts

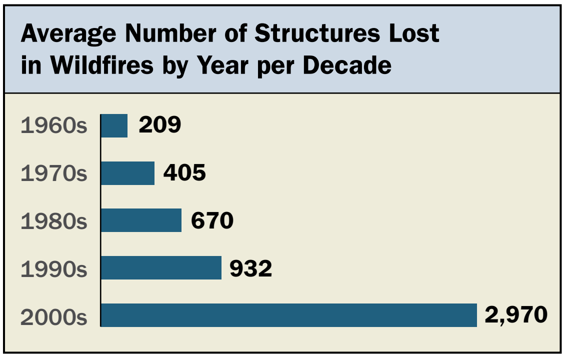


Dan Bailey

As you may recall from the previous column, the absence of basic statistical information about the U.S. wildland fire problem — specifically, the wildland/urban interface (WUI) — is frustrating to those of us in the wildland community.

In the last column, the final discussion about the 46 million homes in the WUI needs an update. What census figures are telling us today is that of these 46 million homes, 25 million, or 54%, are more than 10 years in age; 21 million, or 46%, are less than 10 years old. Even in our sluggish economy, projections are that more than 8 million new homes will be constructed in the next 10 years; with a bullish economy that figure triples.

We have very good statistics as to the number of wildland fires, acreages and costs, thanks to the National Interagency Fire Center (NIFC) in Boise, Idaho. On average, nearly 100,000 wildfires burn approximately 7 million acres of land each year. Most of the past century's wildfire activity has been seasonal in nature. However, recent years have proven otherwise, and we have experienced fire activity in every month of the calendar year.



Firefighters are successful in extinguishing 97% of these 100,000 fires and containing them to less than 10 acres in size. No other country comes close to this benchmark of success, and America's first responders are given high marks. But, the 3% of fires that escape initial action occur during critical weather conditions and are usually located in the WUI.

The fact sheet next looks at the numbers of structures lost to wildfires by year per decade. It shows, again, that since the 1960s when we lost on average about 209 structures per year, each subsequent decade shows growing numbers in this escalating trend. (See chart, left.)

As we look at structures destroyed from wildfires just since 2000, it becomes a bit overwhelming: the grand total since 2000 is 38,601.

The document then looks at costs that are averaging about $4.7 billion per year for federal (USDA, DOI, DOD and other federal agencies), state and local governments for suppression of these wildland fires that escape initial action. When you see the breakdown of numbers, it becomes very evident we have a growing problem.

The document gives a good overview of the 70,000+ communities at risk of wildland fire, and provides a telling story that with a decade of federal/state funding and support, we still have a long way to go to make a dent in the statistics. About 2% of the 70,000 at-risk communities have been designated as Firewise, Firesafe, Fireready or Firesmart Communities. About 11% of the communities have completed Community Wildfire Protection Plans (CWPPs), or approximately 8,000 plans. Less than 10%, or about 7,000 communities in the United States that are at risk of a WUI fire, have adopted or utilize a WUI code.

As budgets are cut, personnel are being reduced; it is interesting to see an overview of just how many firefighters are dealing with wildland fire in the United States. There are 56,000 wildland firefighters within the federal and state government; this includes all employees utilized for firefighting, even if it is not their primary job. This is a dramatically declining figure in today's world of budget cuts and downsizing. In the Fire Service, there are about 1.1 million structural firefighters, roughly 825,000 volunteer and 275,000-paid career. It is estimated that about 100,000 are involved with wildland firefighting to some degree or another. It is interesting to see that there are estimated to be about 18,590 contract wildland firefighters, helping to fill the gap in personnel needs in very active fire seasons.

It is a very compelling list of facts and figures that makes one think about this important issue. Yet it is only a start. We still need solid statistics, historical data and research to help all of the stakeholders involved in solving this issue make a difference. If you would like a copy of the report, you can download a PDF at *www.iawfonline.org*.

Dan W. Bailey

Contact the IAWF

International Assn. of Wildland Fire
1418 Washburn St.
Missoula, MT 59801

ph: 406-531-8264
execdir@iawfonline.org

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Letters

Send them to:
WILDFIRE Magazine

Attn: Beverly Beckert
beverly.beckert@penton.com

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IAWF Awards Student Scholarships

This is the seventh year the IAWF will be awarding two scholarships valued at $2,500 to promote the scholarly pursuits and graduate-level training within the global wildland fire community. The 2013 scholarship program received several applicants from students around the world in a range of science disciplines including social, environmental and physical sciences.

This year's scholarship recipients are **Hector L. Martinez-Torres** from the Univeridad del Nacional Autonoma de Mexico (UNAM) and **Elizabeth A. Schneider** from the University of Tennessee, Knoxville.

Mr. Martinez-Torres is in his second year of his Ph.D. studies in the Laboratory of Ecology of Forest Management at CIEco – UNAM. His research focuses on the traditional use and management of fire by indigenous and non-indigenous rural inhabitants in forestry, agriculture and livestock management at the Monarch Butterfly Biosphere Reserve, one of the most emblematic Natural Protected Areas in Mexico.

Ms. Schneider is a masters student in the University of Tennessee Department of Geography. Her concentrations are in biogeography, paleoclimatology and dendrochronology. Schneider's research focuses on low-frequency climate oscillations and their influence on the occurrence of wildfires in the Southwest. Her goal is to increase the knowledge of fire-climate interactions and provide fire managers with in-depth information on the changing patterns of wildfire. Her interest in fire and dendrochronology began as a lab assistant at the University of Oregon. She is now a graduate teaching assistant at the University of Tennessee and is working in the Laboratory of Tree-Ring Science.

"We see these scholarships as a cornerstone of our Association, helping join together our members and our rising experts in the field to better understand and address current wildfire issues and to learn from each other," says IAWF President Dan W. Bailey. "I congratulate them and look forward to their future contributions to our broader knowledge of wildland fire."

THE BEST PRESENTATIONS AT RALEIGH

At the 4th Fire Behavior and Fuels Conference in Raleigh, N.C., the International Association for Fire Safety Science, IAWF's conference co-host, gave best presentation awards in three different categories.

The best research paper overall was given to "First Look at Smoke Emissions from Prescribed Burns in Long-unburned Longleaf Pine Forests." Presented by Timothy Johnson (Pacific Northwest National Laboratory); authors, Johnson, T., Akagi, S., Yokelson, R., Burling, I., Weise, D., Reardon, J., and Urbanski, S.

The best applied or tech transfer paper of research to end-users was given to "Fire Behaviour Prediction Tools for Fire Managers – Lessons Learned from Tools Development in New Zealand." Presented by H. Grant Pearce (Scion, Rural Fire Research Group); authors, Perce, H.G. and Clifford, V.R.

The best student paper was given to "Observations of Fire Behavior on a Grass Slope During a Wind Reversal." Presented by Dianne Hall (San Jose State University); authors, Hall, D., Charland, A., et al.

INTERNATIONAL JOURNAL OF WILDLAND FIRE

IAWF members have free online access to all research articles and back issues, a great member benefit. The IAWF member page directs you to the *Journal,* where you can search for your paper, author and/or fire subject of interest. All papers that have been accepted, even those not yet published in hard copy, can be found on the site.

The third issue of the *International Journal of Wildland Fire* in 2013, Volume 22 (3) 2013, contains the following papers:

• "The importance of affect, perceived risk and perceived benefit in understanding support

At-a-Glance

International Smoke Symposium
October 21–24, 2013
University of Maryland University College, Adelphi, Md.

Large Wildland Fires: Social, Political and Ecological Effects
May 19–23, 2014
The University of Montana

For a complete list of events, visit *www.iawfonline.org.*

Correction

The South Canyon Fire referred to in the May/June 2013 issue occurred in 1994, not 2004.

We Know Wildland Fires | The IAWF is an acknowledged resource for local to global-scale scientific and technical knowledge, education, networking and professional development. We are prepared to address questions about a spectrum of wildland fire issues. You can view our subject matter expert list online at *www.iawfonline.org.*

for fuels management among wildland–urban interface residents," Timothy J. Ascher, Robyn S. Wilson and Eric Toman;

• "Historical fire regimes in a poorly understood, fire-prone ecosystem: eastern coastal fynbos," Tineke Kraaij, Johan A. Baard, Richard M. Cowling, et al;

• "Lightning and fire weather in eastern coastal fynbos shrublands: seasonality and long-term trends," Tineke Kraaij, Richard M. Cowling and Brian W. van Wilgen;

• "Characterising fire regimes in Spain from fire statistics," M. Vanesa Moreno and Emilio Chuvieco;

• "Pixel and object-based classification approaches for mapping forest fuel types in Tenerife Island from ASTER data," Alfonso Alonso-Benito, Lara A. Arroyo, Manuel Arbelo, et al;

• "Predicting continuous variation in forest fuel load using biophysical models: a case study in south-eastern Australia," Thomas J. Duff, Tina L. Bell and Alan York;

• "Assessing the flammability of surface fuels beneath ornamental vegetation in wildland–urban interfaces in Provence (south-eastern France)," Anne Ganteaume, Marielle Jappiot and Corinne Lampin;

• "The influence of fuel moisture content on the combustion of Eucalyptus foliage," Malcolm Possell and Tina L. Bell;

• "Exotic annual grass invasion alters fuel amounts, continuity and moisture content," Kirk W. Davies and Aleta M. Nafus;

• "Effects of fire regimes on herbaceous biomass and nutrient dynamics in the Brazilian savanna," Immaculada Oliveras, Sergio T. Meirelles, Valter L. Hirakuri, et all;

• "Duff mound consumption and cambium injury for centuries-old western larch from prescribed burning in western Montana," Michael G. Harrington;

• "Ecological implications of standard fire-mapping approaches for fire management of the World Heritage Area, Fraser Island, Australia," Sanjeev Kumar Srivastava, Lee King, Chris Mitchell, et al;

• "Fire history and forest structure of an endangered subtropical ecosystem in the Florida Keys, USA," Grant L. Harley, Henri D. Grissino-Mayer and Sally P. Horn;

• "Effect of heterogeneity in burn severity on Mexican fox squirrels following the return of fire," Sandra L. Doumas and John L. Koprowski. W

BRIEFING | How Did We Get Here?

Farmers, baseball fans and firefighters all talk about the coming season.

This year, in our corner of Wyoming, the talk is of wet months and dry and a hope for a normal summer of thunderstorms. Yet, along with most of the West, we're in long-term drought. Spring flushed green with hints of a normal fire season, yet the green up seems rushed, the morel hunting a bust. When I wondered aloud — we're predicting a normal fire season, yet each day we're drier — a colleague simply declared, "There is no normal."

No normal? What we've known as normal is evolving, building extreme on extremes, moving northward, hotter, drier. In state after state, the worst fire season and worst fire of the prior season is topped by the next. Yet, this new normal is evolving with some relationship to history. If only to remind us that today's extra-normal requires our memory of what normal is (or was).

Don't be surprised, but be prepared for surprise. We've heard this phrase enough that we've made it our jobs to manage the normal fires and the extreme events with a similar if broad selection of tools and organizational principles.

Building this issue of *Wildfire*, we found ourselves remembering a phrase from the Talking Heads' *Once in a Lifetime* anthem to surprise. In your fire seasons, you might find yourself in a bust of early-season fires, but you arrange your strike team effectively — as we learn in "After Action." Or, you might find yourself applying wildfire ICS strategies when a hurricane's gale fuels a conflagration — as we learn in a compelling study of the role of ICS in the FDNY's response to Hurricane Sandy. Or, you might need to manage fuels in Canada — to prevent an untimely return of landscape-scale fire that burned this part of Alberta 75 years ago. Or, you might find yourself investigating fire-mapping innovations in the Kimberley, in northwest Australia.

Surprise is an abrupt change from the normal So, we prepare. In this issue, as in our fire seasons, you might find yourself exploring the many ways that luck favors the prepared mind.

—Ron Steffens, Chair, Editorial Advisory Board

Hardwired: That's the Way We Work

Mike DeGrosky is chief executive officer of the Guidance Group, a consulting organization specializing in the human and organizational aspects of the fire service, and an adjunct instructor in leadership studies for Fort Hays State University. Follow him on Twitter @guidegroup or via LinkedIn.

We understand leadership in many ways: as a function of personality, as behaviors in which we engage, as the ability to influence and persuade others, as our style, and our ability to adapt to the situation, as charisma, credibility, and the ability to inspire and motivate. All serve to explain some aspect of leadership and contribute something to our overall understanding.

Now, there comes an opportunity to know much more. The flourishing field of neuroscience may blow the lid off our understanding of not only how leadership works, but why.

NEUROSCIENCE

Neuroscience is the scientific study of the nervous system and the brain. In 2011, John R. Ryan, president of the Center for Creative Leadership, wrote in *Bloomberg Businessweek* that the rapidly expanding field of neuroscience had hit the mainstream, and people were moving quickly to turn insights from neuroscience into practical workplace applications.

SO WHAT DOES NEUROSCIENCE HAVE TO DO WITH LEADERSHIP?

I have often found myself wishing that I could know what was going on inside someone's head. Perhaps that's why I find the promise of neuroscience, and its application to the study of leadership, fascinating. I am not alone. Increasingly, leadership scholars are talking about how rapidly improving knowledge of neuroscience offers potential to improve leadership effectiveness in organizations.

The flourishing field of neuroscience may blow the lid off our understanding of not only how leadership works, but why.

Our ability to lead, and our willingness to follow, depends on our capacity to form relationships in which we can influence one another. Few people would disagree that a person aspiring to lead must understand human behavior, both the behavior of others as well as their own. We have been trying to fully understand leadership for a long time, and we have made lots of progress. However, because big gaps remain in our understanding of human behavior, similar gaps exist in our understanding of how leadership works and why.

We are only now beginning to understand the part neurobiology plays in much of human behavior. However, a growing body of evidence suggests that neurobiology affects our leadership capacity. If recent research results are any indication, the more we know about the human brain and nervous system, the better we can understand how people influence one another and each other's motivations. Over the last few years, neuroscientists have studied decision-making under stress, persuasion, problem-solving, mindfulness and self-regulation, among other human and organizational behaviors that most students of leadership would agree prove essential to effective leadership.

A recent study appearing in the journal *Leadership Quarterly* provides an effective example. Richard Boyatzis of Case Western Reserve University Weatherhead School of Management, and colleagues from Case Western as well as the Cleveland Clinic, used functional Magnetic Resonance Imaging (fMRI) to scan the brains of executives as they answered questions about their experiences with both what Boyatzis and his colleagues called "resonant leaders" as well as with "dissonant leaders." A resonant leader is one with whom our interactions produce a positive emotional tone and interpersonal alignment. Conversely, we would call leaders, with whom our interactions produce a negative emotional tone and interpersonal strain, "dissonant." The results of this study illustrated the possibilities of research like this.

Using fMRI, Boyatzis and his colleagues observed which portions of people's brains either activated or deactivated as the study participants responded to questions about their prior experiences with either resonant or dissonant leaders. Recalling notable interactions with resonant leaders activated neural networks in participants' brains that neuroscientists associate with being open to new ideas and new emotions, as well as the ability to scan one's environment.

When participants recalled similar interaction with dissonant leaders, those same neural networks deactivated significantly while areas of the brain known for focused attention lit up. One can imagine many implications to this finding, but I was particularly interested in the idea that positive leaders facilitated their constituents' engagement with their working environment. Knowing how one's leadership approach either contributed or detracted from a constituent's mindfulness and situational awareness could prove enormously valuable for fire service leaders.

Boyatzis and his colleagues also suggested that interactions with resonant leaders might put people in a frame of mind in which they could build relationships, think creatively, remain open and engage. Perhaps more importantly, these research findings suggest that people would feel themselves drawn to a resonant leader.

Conversely, the study found that contact with dissonant leaders pushed people to avoid additional interaction with such leaders and to disengage. The implications of these results seem pretty clear. A person attempting to lead will struggle to influence, persuade, inspire or otherwise motivate people, absent the opportunity to engage them.

No student of leadership is surprised that dissonant leaders arouse indifferent behavior in their constituents. Nor are we surprised that resonant leaders tend to arouse inspiration and motivation to use one's talent, adapt to the operating environment and innovate. Thanks to prior leadership research, we have known these things for 30 years. What is exciting is the potential to understand why, particularly the possibility that our reactions to attempted leadership may, essentially, be hardwired — a function of our neurobiology.

Neuroscience is a young and emerging field, and its application to the study of leadership even newer. We should not immediately dash out thinking that we know how your brain "looks on leadership," so to speak. I am sure that like any new scientific discipline, there will be false starts and dead ends. However, researchers are exploring ideas with direct relationship to our interest in leadership development, high reliability organizing (HRO), situational awareness, emotional intelligence, nonverbal communication and critical incident stress. I find that incredibly exciting and believe that the blossoming field of neuroscience has the potential to dramatically improve our understanding of leadership in the next few years. W

How Much Time Does it Take for a Wildland Firefighter to Reach a Safety Zone?

A field study of fire crews using escape routes provides insights into a key element of firefighter safety.

By Martin E. Alexander, Gregory J. Baxter and Gary R. Dakin

Good question. When fire behavior becomes threatening, wildland firefighters disengage the fire and travel along escape routes to reach safety zones to avoid being entrapped or burned-over. In spite of the fact that the concept of escape routes has been a formally recognized element of wildland firefighter safety for almost 55 years, there is surprisingly little quantitative data or information available on firefighter travel rates using escape routes.

ALBERTA-BASED STUDY UNDERTAKEN

In 2001 to 2003, the Wildland Fire Operations Research Group of the Forest Engineering Research of Canada or FERIC (now FPInnovations), based out of Hinton, Alberta, undertook a study of the rates of travel on simulated escape routes by individual members of the three types of fire suppression crews used in the province of Alberta.

Travel rates were determined on the basis of individually timed runs over 820-feet (250 metres) courses in six different fuel types/slope situations involving both natural or unimproved and improved routes (i.e., cleared trail and flagged). Runs were made with and without a pack/tool. The pack weighed 15 pounds (6.8 kilograms), and the tool complement consisted of a fire shovel.

A total of 39 firefighters, including three females, of varying ages, heights and weights participated in the project. As expected, travel rates do vary among and between the type of fire crews, the fuel type/slope steepness, the route condition (i.e., natural or improved) and whether one is carrying a pack and tool or not.

THE GENERAL RESULTS

On the basis of 360 timed runs, the following conclusions were reached:

- The fastest overall times occurred in the improved-no pack/tool courses, followed by the improved-pack/tool courses, the natural-no pack/tool courses, and finally the natural-pack/tool courses.
- The grass and slash fuel types were the easiest to travel, and the dense spruce type was the hardest; the mature pine fuel type was of intermediate difficulty.
- There was less variation in travel rates among individual crew members on improved routes.
- Traveling uphill dramatically decreases the pace a firefighter is able to achieve.
- Carrying a pack and tool slows down a firefighter's rate of travel regardless of whether on an open, improved route or in a natural, standing timber cover type. Dropping one's pack and tool could allow a firefighter to increase his travel rate by up to 20 percent.
- Firefighters can be expected to move up to 40 percent faster on improved routes. Thus, simply constructing a rudimentary trail (e.g., removing or cutting through large deadfall) and flagging or marking the route in some manner can decrease the overall time taken to reach a safety zone.
- By using an improved escape route and dropping one's pack and tool, firefighters can travel up to two times faster than if they attempted to travel over an unmarked/unimproved route with their pack and tool. Precious seconds gained by these actions could mean the difference between life and death on the fireline.

WAS ANYTHING LEFT IN THE TANK?

The question naturally arises: Could the firefighters that participated in this project have gone any faster? They appeared to have given a maximal effort, and it is unlikely that they could have gone much faster.

A crude way of answering this question, though, is to look at the peak heart rate recording with heart monitors during each run and compare that to the maximal heart rates achieved on the shuttle run test, which is supposedly a maximal test. It was found from these analyses that in every run undertaken, the mean heart rate was within approximately 95 percent (range: 94.0–98 percent) of the maximal heart rate, which was impressive considering the short duration of the individual runs (usually less than 2 minutes). Therefore, it appears that the firefighters used in this project gave a maximal effort during each course run and were, therefore, unlikely to have been able to go much faster than they did.

VALUE ADDED

While confirming the presumed influence of equipment dropping on travel rates, the FERIC study provided new insights into the dynamics associated with travel over escape routes by wildland firefighters. For example, the study showed the advantages of improving the condition and identification of an escape route on a firefighter's performance level.

Simply carrying out the study increased the awareness and appreciation for the values of escape routes in regards to wildland firefighter safety.

The information generated by the study has refocused attention on the importance of time in relation to fire behavior and firefighter safety. A safety zone isn't much good to firefighters if they aren't able to reach the safety zone before the fire does!

For more information on the study, see *Wildfireworld.org/articles/time-to-reach-a-safety-zone.* **W**

Dr. Marty Alexander is a member of the IAWF Board of Directors and is currently an Adjunct Professor of wildland fire science and management at the University of Alberta in Edmonton. He retired from the Canadian Forest Service in November 2010 after nearly 35 years of service. Greg Baxter is a Senior Researcher and Gary Dakin is an Associate Researcher with the Wildland Fire Operations Research team of FPInnovations in Hinton, Alberta, Canada.

For access to articles featured in *Wildfire* magazine, visit *www.wildfiremag.com* and *www.wildfireworld.org.*

Average sampled travel rates (chains per hour) of the three types of Alberta wildland firefighters for various conditions.

Crew Type	Fuel Type	% Slope	Pack/Tool		No Pack/Tool		Number of Course Runs
			Natural	Improved	Natural	Improved	
I	Black spruce stand	0	283	501	328	603	12
II	Black spruce stand	0	280	471	298	587	7
III	Black spruce stand	0	254	426	337	513	8
I	Black spruce stand	26	205	-[a]	230	-[a]	8
I	Standing grass	0	400	710	587	799	8
II	Standing grass	0	379	647	465	799	9
III	Standing grass	0	277	457	355	668	8
I	Standing grass	26	-[a]	256	-[a]	307	8
I	Lodgepole pine stand	0	385	582	405	647	7
II	Lodgepole pine stand	0	342	540	426	665	8
I	Conifer logging slash	0	420	677	552	710	7
II	Conifer logging slash	0	370	587	519	734	8

Type 1 Crew = Rappel or Helitack. Type 2 Crew = Contract Firefighters. Type 3 Crew = Emergency Firefighters.
[a]Combination not sampled.

When a **Hurricane** Becomes a **Wildfire**

When the gales of Hurricane Sandy pushed flames through New York City, an all-risk commander called on his wildfire experience to craft the strategy. But that was just the first night.

By Kat Sonia Thomson

A firefighter surveys the damage in Breezy Point, one of many neighborhoods destroyed by fire during Hurricane Sandy.

© NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION/SUSAN MCCORMICK

The Breezy Point neighborhood in Queens, one of many neighborhoods destroyed by fire during Hurricane Sandy.

If we train for, "engage" in and review our responses to all risks, we're more likely to respond effectively to the unforeseen hazards we haven't planned for.
– Lessons from the FDNY

Just after midnight on October 30, 2012, Chief Robert Maynes, Borough Commander of Queens, in New York City, found himself in chest-high surge waters from the Atlantic Ocean in the middle of a hurricane. As he waded his way to the scene of Box 1407 at Beach 130th Street in Belle Harbor, he came upon a situation amid this multi-state emergency. Several homes were engulfed in flames and winds were gusting to 90 miles an hour. Fire was communicating from the burning house to the downwind exposures via softball-sized firebrand transport. Just like, well, a wildfire.

A few hours earlier, one of the last things on Chief Maynes' mind might have been his time spent as operations section chief on the East Zone Complex Wildland fire in Idaho in 2006. But the situation at hand called for exactly that. With limited resources available and access impeded throughout the initial attack phase of the response, Maynes knew he'd need an unconventional approach in order to stop the ember transport that was accelerating spread rates in sustained winds of more than 60 mph. Rather than revert to a structure-by-structure approach, where the next exposure would be the first line of defense, the chief drew on the use of contingency lines (in this case, it was Crontson Avenue to the north of the Belle Harbor incident), applied direct attack methods at the "head of the fire" when it was safe to do so, and focused his resources in a "flanking action." This was their only hope for controlling the conflagration.

With the fire mimicking the behavior of a wind-driven wildfire, Maynes patterned his strategy on wildland fire suppression tactics. It was his time spent working in the wildland arena, Maynes says, that proved key in helping to craft and apply a wildland strategy that was going to work in suppressing an urban conflagration.

The fact that Chief Maynes was reaching into his wildland strategy and tactics tool box in the middle of a hurricane was no accident. By design, the Fire Department of New York (FDNY) had been gearing up to handle complex incidents through a mandate for agency preparedness after the World Trade Center disaster that included system-wide incorporation of the Incident Command System (ICS), the purposeful crafting of an All-Hazards Incident Management Team (IMT) and an 11-year track record of training and deployment on live and simulated large-scale incidents.

HISTORY OF THE IMT

On September 12, 2001, Incident Commander Van Batemen and his Southwest Area Type I IMT were dispatched by the federal government to New York City. The team arrived at ground zero and was promptly referred to Central Park. By September 14, with great exhaustion felt citywide by local first responders, the Southwest Team managed to convince FDNY chiefs and administrators that they could organize local and mutual aid resources. According to FDNY Assistant Chief of Operations James Manahan, the effect of ICS through the IMT on the response was instant. The ability of this group of wildland firefighters to make sense of the logistical needs of ground zero so impressed the FDNY that with each day, the IMT was given added areas of responsibility including planning and finance sections in addition to logistics — coordinating key agencies including the FDNY, NYPD and Port Authority.

From that introduction, the FDNY has taken several steps to institutionalize the wildland staple of organizational success. Beginning in 2006, the department formalized the adoption of ICS into its day-to-day emergency response and fireground operations. ICS organization, terminology and leadership concepts brought operational continuity during transition periods, enhanced situational awareness and improved efficiency, according to Manahan. "Sectors" are now assigned to areas of a structural

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PHOTO: JAMES MANAHAN

Incident Commander James Manahan outside the IC's command post, decorated with a Christmas wreath. After coordinating some 93,000 visits to affected dwellings, the team was relieved shortly after Christmas.

incident such as the "fire floor" or "exposure buildings," facilitating improvements in incident organization and resource tracking.

The FDNY has also managed to furbish and maintain enough individuals to fill a certified Type II All Hazard IMT plus the capacity to fill a second team should the need arise. When the FDNY became sold on the value of the IMT, someone from the USFS quipped: "The good news is, they now know what IMT teams are; the bad news is, they now know what IMT teams are," according to Maynes, who currently holds the spot of Incident Commander.

The team was Type II certified in 2005, and training has been funded by FEMA's Urban Area Security Initiative (UASI) Grant. To date, the team has a Type I certified Operations Section Chief, two PIOs and two Logistics Chiefs. According to Maynes, certification of the team to the level of Type I requires maintenance and resources. "It is impossible with just one Type I Operations Section Chief to mentor another into the positions during Type I events, such as Hurricane Sandy." The goal is to have a Type II team with the capacity to handle Type I events.

With the support of top FDNY officials including Commissioner Salvatore Cassano, Chief of Department Edward Kilduff and former Chief of Operations Robert Sweeney, the team's CV has grown to encompass an impressive range of all-hazard deployments both locally and nationally. Direct hurricane deployments began in 2005, when the FDNY's IMT and 327 FDNY firefighters assisted the New Orleans Fire Department with Hurricane Katrina. Hurricanes Rita, Gustav, Lee, and in August of 2011, Irene, followed.

A myriad of other deployments makes the breadth of experience garnered by the team invaluable to All Hazards preparedness. These deployments included the team's first wildland fire assignment, in 2006, when Chief Maynes went to the East Zone Complex in Idaho to work in unified command with the Atlanta National Incident Management Organization team. Since that time, qualified FDNY IMT members have deployed on the Southwest, Northwest and Southern IMTs in the wildland as a part of the FDNY's approach to training and maintaining capacity.

THE IMT IN ACTION

The FDNY's Type II team was activated two days prior to the storm's arrival through the third week of January, 2013. For the response phase of the hurricane, IMT incident commanders — Chief Manahan and Battalion Chief James Kane — assembled a short team of 45 to identify hurricane-related objectives that would facilitate the continuity of fire, emergency and medical 911 call response by the agency's 353 fire and approximately 210 EMS apparatus[1]. The IMT was furbished with 45 reserve engine, ladder, rescue and squad companies plus special units such as swift water boats and brushfire units and an additional 100 mutual aid ambulances.

During the height of the storm, the Incident Action Plan (IAP) was drawn especially to facilitate the removal of barriers to patient and incident access using reserve fire apparatus, while mutual aid ambulances were used in patient transport and evacuation for flood-zone hospitals and senior care facilities. The IMT also aided in boosting situational awareness between the city's five boroughs and FDNY headquarters. By pre-assigning Computer Aided Dispatch (CAD) designations to the reserve apparatus, the Ops Section chief could also supply IMT resources to the boroughs if needed for the 911 response.

As the incident peak passed, the scope of IMT objectives shifted to accommodate the rescue/recovery phase. The IMT targeted flooded areas of the city and divided each affected area into sectors staffed with taskforce leaders and a division supervisor. IMT task forces were composed of reserve apparatus, special apparatus under Special Operations Command (SOC) and several mutual aid resources including urban search and rescue teams. Completed objectives included the search and rescue of more than 30,000 dwellings in the first 72 hours, dewatering, tree removal and the evacuation of numerous patients from care facilities in flood zones.

After 11 days of supporting FDNY 911 response continuity out of Brooklyn headquarters, Chief Manahan's team accepted a role in facilitating the long-term recovery plan for the city's Office of Emergency Management (OEM). The incident was named "Sandy Support" and was staffed with 65 FDNY IMT members and activated through the end of January. The IMT coordinated FEMA, AmeriCorps volunteers, New York National Guard Task Forces and assisted city agencies. Objectives included collecting and disseminating incident and public needs data with relevant city agencies; organizing field outreach and commodity distribution and IMT mentoring.[2] Manahan's team located their incident command post in an area directly accessible to the heaviest hit area of the city at Floyd Bennett Field in Queens. Situated on a large parking lot, and outfitted with USFS-style IMT tents, propane heaters, bagged lunches, plastic outhouses, hand sanitizers and a Christmas wreath over the door of the incident commander's tent, the FDNY essentially *nailed* the USFS command post look and feel.

LOOKING BACK TO MOVE AHEAD

By most accounts, the use of the IMT and ICS concepts during Hurricane Sandy aided the FDNY in both overcoming storm-related impedance to 911 call response and facilitating inter-agency and mutual aid delivery of recovery service in the aftermath. Looking forward, the role of the IMT during large incidents can still be enhanced.

In the month surrounding the hurricane (October 18–November 18, 2012), the number of fire and EMS incidents in New York City increased by 22,292 in comparison to the same time period in 2011. On the day the storm hit the city (October 29), fire incidents increased 306% and EMS incidents jumped by 171%.

FDNY engine companies are staffed with Certified First Responder-Defibrillation (CFR-D) firefighters and officers and regularly respond to 23 life-threatening classes of segment 1-3 EMS calls including cardiac arrest, choking and major injuries. Between October 29 and November 1, the number of CFR-D runs conducted by engine companies were *down* by 33% (at least 306 fewer runs) compared to the 2011 daily average. This would have been attributable to the fact that engine companies were responding to fire incidents and unavailable. However, approximately 4,227 additional EMS incidents occurred between October 29 and November 1 compared to the same time period in 2011.

Each year an average of 17.1% of EMS calls are responded to by FDNY engine companies, with approximately half of all EMS calls identified as CFR-D response eligible.[3] Therefore, it is possible that at least 1,450 of these extra EMS calls would have been CFR-D eligible, and approximately 725 would have otherwise received CFR-D engine company response. This makes for over 1,000 CFR-D incidents that were possibly under-resourced during the storm. In 2012 alone, engine companies performed almost half of the FDNY's pre-hospital saves (417 individuals were saved by engine companies and 472 by EMS).[4]

On the fire side, 75 serious incidents occurred between the onset of the storm on October 29 and November 1, 2012. Incidents that occurred early, such as the Midtown crane collapse, were adequately resourced; but later incidents in flood zones were under-resourced.[5] By the time the most devastating fire at Breezy Point was reported, FDNY units citywide were so inundated with pre-existing calls that it took an hour and a half to assemble the basic first alarm assignment of four engines and three ladder companies to the scene. In total, 126 homes were lost at that incident. Seventeen residential and commercial structures further east along the Rockaways on Beach 115th Street were handled by just two apparatus for the first several hours.

At Belle Harbor, Chief Maynes was dealing with another 29 homes, two businesses and three garages on fire. The Rockaway incidents were severely inaccessible due to the surge, but the FDNY still had a major problem on its hands with resource availability. Even if there were no issues of incident access, engine and ladder companies first on scene to Breezy Point had traveled as far as 18 to 25 miles from Midtown Manhattan.

According to FDNY engine and ladder company availability calculations during the storm (produced hourly), there were inconsistencies in the levels of resource depletion by borough. A rigorous post-disaster analysis of the FDNY's response to fire, medical and emergency incidents during Hurricane Sandy will be invaluable. Through disaggregation of call volumes by incident severity over time in critical time segments (i.e., in the lead-up to the storm, as the surge began, during the height of the storm and in time increments following), a *timeline of demand* can be more adequately identified. Next, analysis of actual incident resourcing outcomes (response times, alarm assignment deployment time, network analysis of distances travelled and frequency of out-of borough assignment of resources) should take place by incident type. This will reveal the actual *resource trajectory.*

A key recommendation of the McKinsey & Co. report post 9-11 was operational decentralization to the five boroughs in order to boost response efficiency, especially during a city-wide disaster. During Hurricane Sandy, the level of operational autonomy afforded each borough commander was further enhanced to facilitate the response. Overall, response deficits during Hurricane Sandy appear to pertain to issues of resource allocation and incident resourcing between boroughs.

By exploring which hurricane-related objectives are best served centrally versus those objectives better served at the borough-level, the use of the IMT will improve. One possible solution could include expansion of the IMT to track and reassign resources more effectively between areas of discrepancy. Alternately, the activation of smaller IMTs for each of the five boroughs plus the activation of an Area Command team at headquarters may work.

Borough IMTs — much like Chief Maynes' Queens IMT — could go about solving objectives relating to *incident access — locally.* A centralized Area Command could focus on intelligence and *incident resourcing — citywide.* One key output of Area Command could be assistance in upgrading real-time triage and priority guidelines as incident types expand or shrink with the disaster's trajectory. Another key output would be optimum inter-borough resource movement.

Finally, and perhaps most crucially, it is clear that demand was well in excess of supply during the storm. Both fire and medical incidents were at record highs. Effectively, the FDNY bolstered its force by 600 uniformed members (the rough equivalent of an 11% increase in staffing), whereas incident demand increased on average 234% for fire incidents and 131% for EMS incidents for days surrounding the storm. By re-creating the *demand timeline* and estimating the *actual resource* trajectory for Hurricane Sandy, shortages will become a known quantity and matching supply with demand for next time will become realistic.

SHARING OPERATIONAL KNOWLEDGE

It is clear that wildland fire organization concepts have found a home in New York City. Arguably, the FDNY's All-Hazard IMT success can now be used to inform the wildland urban interface environment in a multitude of ways. Yet, the wildland and structural fire response communities share a key operational unknown. The instance of multiple-structure, wind-driven conflagration is becoming far too common to continue to ignore.

As demonstrated in New York City during Hurricane Sandy, it does not take a wildland fire to create a situation that requires wildland strategies and tactics. In Queens alone, five simultaneous multiple-structure incidents occurred on the night of the hurricane. Each incident displayed unique issues in communicating both the exposure and the strategies, based on housing stock characteristics and on-scene weather conditions.

In addition, outside of hurricane-driven fires, the region experiences brushfires that have caused many operational problems in the New York City area, including one fire in Staten Island that destroyed 125 homes in 1963.[6] Both communities must now work together to collect, analyze and implement a new typology of conflagration operations that incorporates concepts from wildland and structural operations. W

Kat Sonia Thomson, BA Urban Studies, MPA, Ph.D. Candidate, has worked in wildland fire and aviation operations since 1998, and currently serves as an Air Attack Officer for the Government of Alberta. In the off-season, she consults on structural fire department operations and performance management in New York City.

[1]The FDNY staffed an average of 634 tours per day in 2012, and there are three tours per ambulance per day. EMS Tour information is available at: *http://www.nyc.gov/html/fdny/html/general/vital_statistics.shtml*

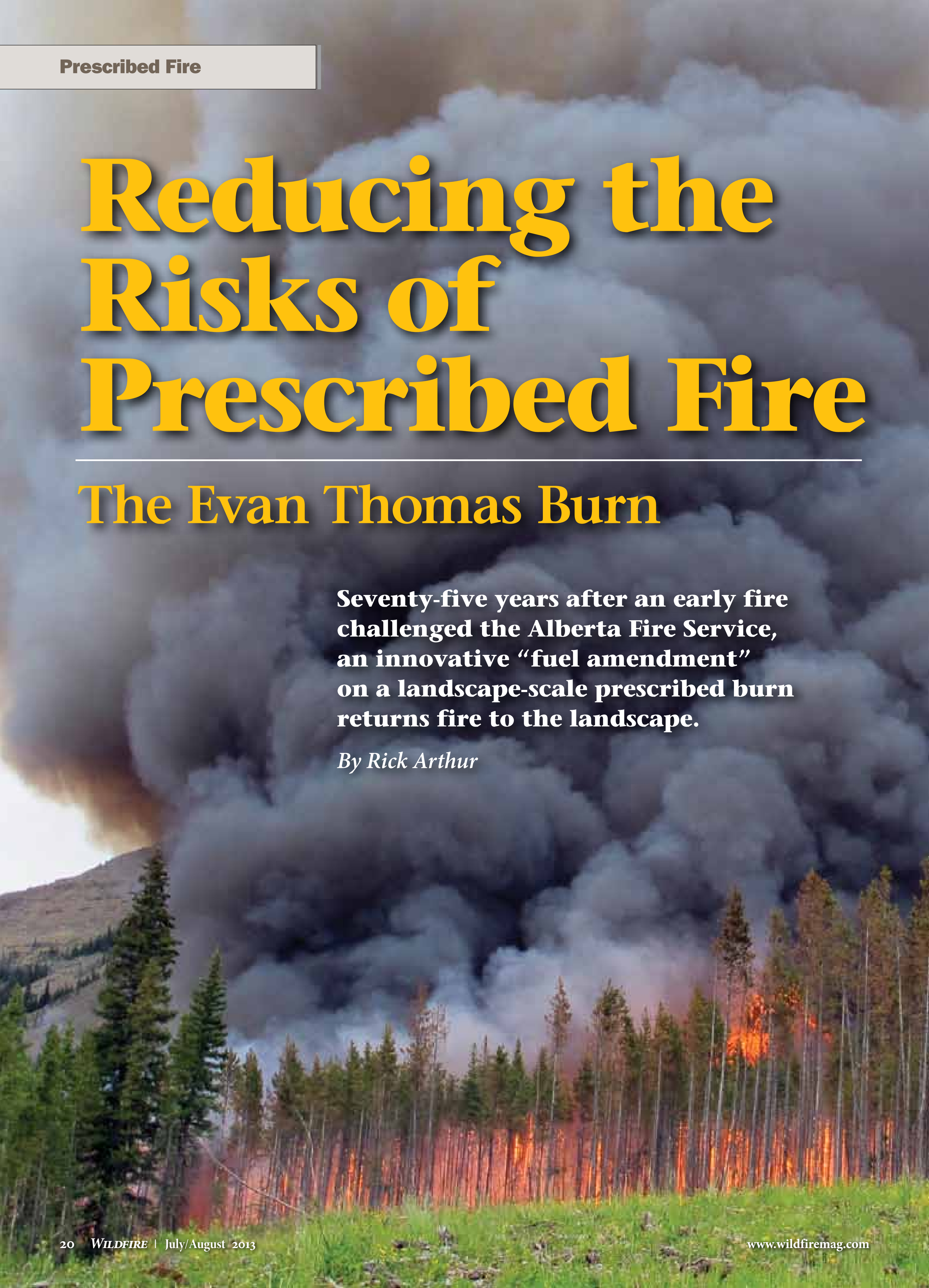
[2]FDNY Sandy Support IAP, Sunday Dec. 16, 2012, Incident Objectives- ICS202.

[3]FDNY Vital Statistics 2008- 2012, available at: *http://www.nyc.gov/html/fdny/html/general/vital_statistics.shtml*

[4]FDNY Vital Statistics, 2012 Calendar Year. Available at: *http://www.nyc.gov/html/fdny/pdf/vital_stats_2012_cy.pdf*

[5]This claim is based on the analysis of alarm classifications and actual resourcing levels derived for all 75 incidents by the author using time-stamped incident history data.

[6]City of New York, Parks and Recreation, Community Wildfire Protection Plan For the East Shore of Staten Island, 2012.



Reducing the Risks of Prescribed Fire

The Evan Thomas Burn

Seventy-five years after an early fire challenged the Alberta Fire Service, an innovative "fuel amendment" on a landscape-scale prescribed burn returns fire to the landscape.

By Rick Arthur

The 1936 fire season in Alberta was long, hot and dry and had taken its toll on men and equipment by early August. The numbers of fires, persistence needed to control and extinguish them, limited resources and long distances with little access were all factors in wearing down the fledgling Alberta Forest Service that had been established in the province just a few years earlier. Heavy smoke and haze limited visibility for the few lookouts in existence to spot new fires, and aerial patrols were non-existent.

A new start in Galatea Creek was burning, a holdover from a lightning strike a few days before. As it gained in intensity, the cry went out with the discovery of the new fire. Men and equipment were dispatched, and they fought to contain the fire as it came into the Kananaskis Valley, but it was too little, too late.

The fire erupted with blow-up conditions, jumping the breaks they were building and spotted well beyond, entrapping the crews. Tactics quickly changed as efforts doubled from trying to control the fire to survival. The fire roared northwards, past Evan Thomas Creek, over top of the Boundary Ranger station and beyond, burning most of the broad valley from rock to rock.

When fire's growth slowed and stopped near the upper end of Skogen's Pass, it had spread nearly 10 km down the valley and consumed more than 8,000 ha in a few short hours. Good fortune and hard work spared the men with only minor injuries. Other than timber, there were few other losses in respect to values at risk. Even the Boundary Ranger Station cabin, only a few years old, had survived.

PHOTOS: RICK ARTHUR, ALBERTA ESRD

Left: The burn in progress, demonstrating the fire response in fuel-modified area.
Above: Alberta ESRD crews hand ignite a fire break in preparation of aerial ignition operations.

TODAY'S FIRE CHALLENGE

Three quarters of a century later, the Kananaskis Valley is the heart of the most valued recreational area in Alberta. Hundreds of thousands of visitors flock to the area each year for day trips; to camp in the large developed campgrounds and remote backcountry campsites; or to stay in the comfort of five-star hotels and spas. They golf, hike, tour, fish, climb or engage in any one of dozens of outdoor pursuits. With access through countless trails, visitors can be found in the most remote parts of the valley and the various steep drainages that feed into the Kananaskis watershed. Highway 40, the single access in and out of the valley, is heavily used by these visitors.

In 1936, the vegetation cover in the valley was a mosaic created from numerous fires over the years, many of which were from aboriginal burning prior to European settlement. Today, the vegetation cover is largely a continuous Lodgepole pine fuel type that grew in undisturbed since the 1936 fire. Most of the lands within the valley are now managed by Tourism, Parks and Recreation (TPR), but fire management and suppression remain the responsibility of Environment and Sustainable Resource Development (ESRD), the successors to the old Alberta Forest Service.

With recent fire regime studies and a better understanding of past fire history and disturbance trends, both agencies recognize the need for ecological restoration, fuel reduction and the value of strategic breaks in the fuels in the valley. A number of projects were identified in the valley, but putting disturbances back on the landscape is not necessarily an easy process.

TPR's mandate is to protect the province's natural landscapes in Alberta, but the use of mechanical equipment or logging to remove the trees is limited. Prescribed fire was considered to be an acceptable alternative, as fire has been both a natural and anthropogenic process in the valley. The problem faced by fire managers was how to safely create a high-intensity, low-severity, stand replacement fire within the continuous, homogenous fuel type that now exists through the entire valley with the limited use of mechanical equipment.

Usually with interagency planning processes, challenges and conflicts would be expected due to different cultures, mandates and perspectives of agencies. Recognizing that both agencies desired the same outcomes, staff from both ESRD and TPR used the planning process as an opportunity, rather than a challenge, to broaden each agency's outlook, share its skills and learn from each other.

PHOTO: RICK ARTHUR, ALBERTA ESRD

Aerial fire strip ignitions create a fuel break and allow for stand-replacing fire.

DESIGNING A 21ST CENTURY PRESCRIBED BURN

The Evan Thomas prescribed burn was chosen as the first of several vegetation management projects identified within the Kananaskis Valley. Its objectives included creating a landscape level fire break, improving elk habitat, restoring goat habitat, restoring age class diversity, etc. However, putting a large (400+ ha), high-intensity stand replacement fire on the landscape with so much development in the area was a major concern.

The solution was to reverse engineer what is already done in the wildland urban interface (WUI): fuel modification. In the WUI, fuel modification (thinning, removing dead and down fuel, pruning, etc.) is commonly used to reduce fuel loads in an effort to minimize fire intensities near communities. In this case, we wanted to increase the surface fuels inside the burn unit to improve the flammability of the fuels within the burn unit itself. This would provide a fire behavior response of higher intensity fire in lower fire danger indices, thus decreasing the risk of the prescribed fire escaping and threatening the numerous values within the valley.

To avoid confusion with the term "fuel modification," which is synonymous with fuel reduction and the WUI, the term "fuel amendment" was used to describe the process. Fuel amendment simply refers to increasing stand flammability by adding to, or increasing, the surface fuel load of the stand.

The design of the burn unit took advantage of topographic changes. Evan Thomas Creek was used as the boundary on the bottom end. Two small tributary creeks were used as boundaries along the sides of the burn unit, and the top of the burn unit was capped off with an Alpine meadow. Within the main burn unit, an objective of falling from 10% to 30% of the stems within the stand was established. This would increase the slash loading at ground level and, after a short period of curing, would increase the flammability within the burn unit. In addition, by opening up the forest canopy, the forest floor becomes more open to sunlight and wind, which helps to dry the stand

PHOTO: RICK ARTHUR, ALBERTA ESRD

Aerial ignition by the Elbow River Helicopters Bell 407.

quicker. The range of 10%-30% reduction would help to ascertain how much fuel amendment was necessary to achieve a response in lower indices.

While using mechanized equipment within the provincial park is very restricted, it was agreed that a feller buncher could be utilized to fall the trees. This would both expedite the process as well as provide an increased safety margin over hand falling on steeper slopes.

During the planning process, several operational concerns for the fuel amendment were noted. Although the use of the feller buncher was permitted, if there were indications of rutting or excessive ground disturbance, operations would cease. Buffers would be required along creeks as well as a recreational trail that went through the center of the burn unit along the Evan Thomas Valley. Cross-slope openings would need to be left to maintain wildlife travel corridors.

Burn operations would also face restrictions. The presence of a nearby resident mountain goat herd meant no burning from mid-May to mid-June to lessen the disturbance to the animals during kidding season. Heavy recreational use occurred through July and August, and fall hunting would also be affected. Smoke management was a concern within the immediate area but also eastwards towards Calgary. Planners linked in and worked closely with the Calgary Regional Air Zone, a committee established by local municipalities to manage air quality in the region. Communication strategies and plans related to the burn were designed to be inclusive so that anyone on the list would be advised of all operational activities.

Prior to the commencement of the fuel amendment, plots were established to determine the location of existing pre-disturbance fuel loads. A tracked feller buncher was used for the fuel amendment. Once operations began, the team found that it could operate the buncher parallel to the slope but could not effectively operate cross slope with any efficiency.

A decision was made to use the buncher to cut strips going up the slope with varied widths between the strips to achieve the 10%-to-30% objective. In addition, the operator varied the cutting pattern by either leaving the cut trees within the cut strip or laying them alternatively into either side within the leave strips.

Attention to resource values was core to the fuel amendment process. Leaving wildlife travel corridors was simplified by flagging the corridor locations, and the operator could ensure that they were not blocked by slash during the felling operation. Buffers along both sides of the trail and watercourses were also flagged and then pre-cut on the outside of the buffers early in the operation. No rutting or excessive ground disturbance occurred during the operation.

Altogether, the fuel amendment process took approximately four weeks during the late winter/early spring. The fuel loading plots were re-measured after the fuel amendment and determined that fine coarse woody debris had increased between 7 to 15 tonnes per ha.

Determining what indices and conditions under which the burn unit could be safely burnt became an issue with fuel amendment. By applying fuel amendment to the burn unit, the fuel type changed, as well. The Canadian Forest Fire Behavior Prediction System uses fuel types that have been developed through years of field research and plot burning. The fuel type for a mature Lodgepole pine stand is a C3 fuel type, and pine slash in a cut block is an S1 fuel type. Both fuel types have a significantly different response.

"Blending" or "merging" the two fuel types to try to come up with a new fuel type is at best a guess. To solve the problem, reverse engineering was used again. Rather than try to "guesstimate" the indices needed to ignite the burn unit safely, matrixes were developed using the less flammable surrounding C3 fuel type as well as indices that would be needed to make it respond. By burning in lower indices, the more flammable fuel-amended burn unit could be burnt safely with little chance of escape.

THE SUMMER BURN WINDOW

Some drying and curing of the slash was necessary to ensure a good response from the amended fuels. It was decided that no burning would occur until the fuels had at least four months to cure. A burning window briefly presented itself in early September, but an unexpected heavy rain shower hit the burn unit just moments before ignition was to commence.

Cooler and wetter weather dominated the fall, leaving no options for burning. Heavy snow over winter and a late spring eliminated any potential for a spring burn, as well. By early summer, the concern was that the needles on the slash were now starting to drop. If burn operations were not completed before winter, the slash loads would start to decrease through a loss of the fine fuels. It was agreed that with consultation to local stakeholders and with good public communications, burning could occur in August, outside of long weekends, with the temporary closure of the area.

In early August, a suitable burn window presented itself. During the weekend, crews and equipment were deployed and set up in preparation for the burn. Researchers completed the final measurements of the fuel loading plots, in-burn cameras were set up and the area was closed to the general public. The burn unit and surrounding areas were flown over to ensure that no people or ungulates were within the burn unit and surrounding areas.

In early August of 2011, almost 75 years to the day of the 1936 fire, aerial ignition operations commenced. The temperature was 23 C, RH 26% with winds W at 6 km. The first test ignition drops occurred in nonamended fuels to validate that limited spread would occur in that fuel type. Operations then progressed to the main burn unit starting on the upper slopes and working downwards with two helicopters with aerial ignition torches.

Fire behavior within the amended fuels varied between a very hot surface fire with torching to a continuous crown fire. As expected, some runs above the amended fuels occurred on the steeper slopes (Engelmann Spruce/Lodgepole Pine) to the Alpine areas. Minimal surface spread occurred from the edge of the fuel-amended areas, and no spot ignitions were observed outside of the main burn unit. Limited spread downslope along a southeast-facing slope occurred, but it self-extinguished.

Ignition operations progressed, moving back and forth across the slope until they reached the bottom end of the ignition unit along Evan Thomas Creek. Most of the burn unit was completed by the end of the first day, with burn operations continuing for a second day in an effort to clean up small patches of unburnt fuels. Crews that had been deployed in readiness to contain the burn if necessary were assigned to mop up the burn itself to reduce the potential impacts of smoldering and smoke.

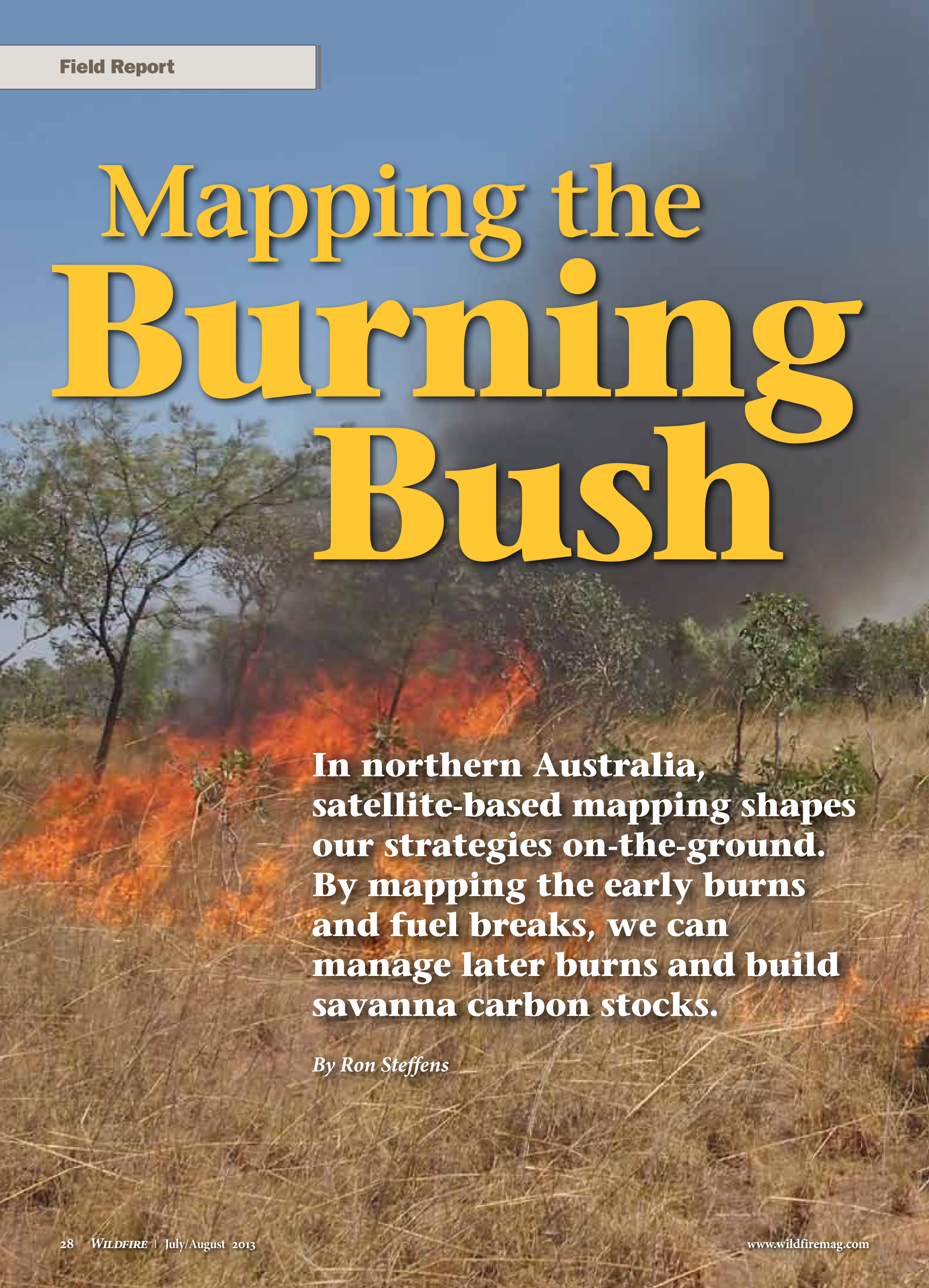
A SUCCESSFUL BURN

By every standard, the Evan Thomas prescribed burn was a success. A high-intensity fire burnt through the main burn unit resulting in an estimated 80% mortality. Under the lower burnt indices, the surrounding homogenous fuels would not respond, creating a very safe environment in which to conduct a prescribed burn.

Post-burn measurements within the plots demonstrated significant consumption of the fine-to-medium fuels with low severity effects. With the burn being central to a highly valued recreational landscape, the visibility to the general public was very high and resulted in excellent lessons of the safe use of fire.

There is little doubt that wildland managers are feeling the effects of change. Climate is changing; with it, our aging forests are in declining health and increasing flammability. The public purse is limited, and values at risk continue to skyrocket. Implementing new concepts and new tools such as fuel amendment is necessary to avoid disasters in the future.

Rick Arthur recently retired after a 38-year career with ESRD. He worked in many positions across the province, finishing his career as the Wildfire Prevention Officer for the Southern Rockies Area. Arthur was the lead for the Evan Thomas Prescribed burn planning team and served as the IC during burn operations.



Mapping the Burning Bush

In northern Australia, satellite-based mapping shapes our strategies on-the-ground. By mapping the early burns and fuel breaks, we can manage later burns and build savanna carbon stocks.

By Ron Steffens

A map is a mark of our lives in time, a journey transcribed. And it was a map, in part, that drew me to Australia, to better understand what fire maps can mean in our climate-change era, and to learn how a robust commitment to geospatial knowledge can help us manage what may be our most hazardous and valuable resource — the carbon that's either released or sequestered in every fire-affected forest, bush, savanna and grassland.

My own journey, by jet, train, bus, Land Cruiser and helicopter, burned a carbon debt I'll work most of my career to pay back. In the fall of 2012 I flew some 14 hours across the Pacific Ocean from the United States to Australia, then four hours from Sydney to Perth. After the Australian Fire Authorities (AFAC) and Bushfire CRC meeting, I flew north to Broome, the west coast gateway to mining, tourism, and the aboriginally managed lands. From Broome, I was driven northeast via Land Cruiser by Philip De Bruyn, the fire planning coordinator for the Kimberley Ranger Program. We bounced through red dirt and the squat gum forest, past wallabies and cattle and free-roaming fires and into the sandstone and red-rimrock country of the Kimberley, one of the more remote parts of a continent that gave us the type specimen for "outback."

I had other reasons to travel this far, but this particular leg of a larger journey was inspired by a map I'd first seen in a talk at a fire conference in South Africa; it conveyed information on the North Australian Fire Information (NAFI) website and network. I needed to witness firsthand what anyone with a computer and slow Internet connection can observe from afar: that the Australian bush burns every few years (even every year), and it burns wide and far across the land.

The NAFI maps were telling the diurnal and seasonal story of man and fire across a big land. This was the smell of smoke to a smoke-chaser. To know fire you must know Australia, and NAFI seemed the tool to guide us to where cutting-edge science meets our original fire-stick tool.

It's a familiar story: the bush has burned across the epochs of evolution and fire adaptation that predates human timekeeping — the first people here walked with fire sticks, and before them (and today) the pre-monsoon lightning ignited the landscape. Now, as the fires burn, we can watch the heat signature progress in near real-time, thanks to satellites and the calibration and mapping work of the fire researchers and practitioners I was joining in the bush.

The carbon burns and out-gasses into the sky. Yet if we manage the fires, return to less frequent and patchier cool-season burns that steal the fuel from hot late-season burns, we can conserve the carbon in the soil and roots, in regenerating bush and resilient trees. This is what we know to do and are doing, thanks, in part, to teams of researchers and practitioners like those I'm traveling with, who ensure that tools like NAFI pull the satellite data down in order to serve the needs that grow from the ground.

THE BURNING BUSH

After the day's drive, we meet with the rest of the team members to camp at a wet billabong near Karunjie. They've come from the opposite side of the outback, a day-and-a-half's drive from Darwin at the north-central top of the continent.

Left: Philip De Bruyn lights a research burn that will later be correlated to fire intensity mapping provided by MODIS satellites.

Andrew Edwards, a research fellow with Bushfire NT and the Darwin Centre for Bushfire Research at Charles Darwin University, had invited me here after we'd chatted at AFAC. He shakes my hand and asks, "So Ron, what's your question? Why are you here?"

My question? De Bruyn, with whom I'd chatted for hours, suggests my deeper motive: "To have a good walkabout in the Kimberley?"

To which I agreed, though I did offer a purpose — to see, first-hand, how the science and practice are coming together — to see how fire science, applied fire and carbon management can support each other as we face the challenge of climate change. And to see it on the ground, to better apply these lessons elsewhere.

For the next few days and later, in Darwin and by Skype, Edwards and colleagues, including Peter Jacklyn, the NAFI web architect, explain the details of the science and resulting scheme (which is a word, outside the U.S., that lacks our illicit sense of underhandedness). When early cool-season burns dominate, the burns are patchier; less litter is consumed, and less of the grass and bush biomass, so that the grasses re-sprout and scorched eucalyptus starts to bud and leaf out before the dry season stunts the growth, thus drawing carbon from the atmosphere into the biomass. This compares to a late-season burn, which out-gasses more carbon and begins, over time, to convert the resilient bush into over-dominant exotics, which are, in turn, more flammable, and the carbon sink degrades.

To reach the point where NAFI can support a carbon scheme, three key questions had to be answered, by fuel model and habitat type, and by early and late burns:

1) The CO_2 emissions released
2) The emissions conserved
3) The emissions sequestered

The potential for carbon sequestration in the tropical savanna is based on definitive research by Jeremy Russell-Smith, Peter Cooke and others that concluded that the carbon sequestration can occur in fire-managed savanna that receives more than 1,000 mm precipitation a year, as does the northern tier of Australia.

The tropical savanna covers some 12% of the globe and is one of our richest sources of carbon sinks and biodiversity. This week, though, we were seeking to expand the original premise: can lower rainfall sites, from 600-1,000 mm, also sequester carbon, if we burned smarter.

So it was time for the research teams to re-measure old burns and light new hot-season burns. For this scheme to work, you need 10 years of prior baseline burn data, plus this sort of field and satellite work to determine fuel accumulations. Finally, you can start to measure each year's savings, by comparing a year in which you're managing fire (for carbon and biodiversity and cultural values) against the earlier years. You need horizontal burn patchiness and vertical impact of scorch height. You need to sample from soil to grass/herbs to shrubs and trees, from fine to course fuels. And you need to confirm this on foot and by helicopter to correlate it to the satellite data, all of which feeds the NAFI maps.

The process is based on tallying "Burning Efficiency," a formula that multiplies "Patchiness" by "Combustion Completeness" to calculate your greenhouse gas emissions. Building on decades of work, the team has determined that fire seasonality can become a proxy for and key mechanism that, when combined with Moderate Resolution Imaging Spectroradiometer (MODIS) data, can yield a robust and real-time tool for fire severity mapping.

Edwards et al are working on a model for a Normalized Burn Ratio (combining seasonality with MODIS and other tools) that's nearing 94% accuracy for mapping severity, compared with 50%-60% accuracy with MODIS alone. The result is that you can press a few buttons on a NAFI map to generate a seasonal and annual burn report, which can help you interpret the key impact of burn seasonality: that early season burns have from 10%-20% more patchiness and 10% less combustion than late-season burns — which equals carbon sequestered.

The North Australian Fire Information mapping website offers near-real-time maps of fire spread and fire history. Here, the blue and red pixels are current fires, burning into prior burn scars (left) and unburned areas (right).

This process, intuitive as it is complex, is why I found myself helping to ignite research burns in the Kimberley in early September, the start of hot season burns. The team was seeking to fill the data gaps, to measure what burns and what remains, to compare with the earlier cool-season burns and measure the comparative impacts on both biodiversity and carbon sequestration. This is a form of valuation, as key to climate's health as depositing a paycheck in a bank machine.

De Bruyn drags the torch for these burns and I'm running ahead to scout a good line. We turn the corner and De Bruyn's drip torch hooks the head of the fire and we both stop, breathing equally hard. Then we turn to the fire to take photos of the flames, which crackle with an occasional internal whoomp as the ground fuels ignite a tree's canopy. We catch our breath and then take fire back to the gravel road where we started. Most of the burn's intensity has cooled within 10 minutes. The grasses and forbs and the lower leaves of the trees are burnt to nothing. The upper leaves are singed but alive, and in a week, the basal roots and stems will be flushing green.

A small finger of fire burns in 5-foot flames across the road. In the interior, the flames have crossed our burn line. I ask, "Should we put this out?" No, I'm told, this fire will burn out in the evening's humidity or when the fires reach an area that's been previously burnt out. And we think it does, which we can confirm, by satellite, via a low-bandwidth NAFI download via a sat-phone. Two days later, on a helicopter flight to map burn severity to the southeast, we do see a column suspiciously near our research burn; but as we fly, we determine that it's further west than our fire.

FROM SPACE TO PLACE

Fast and shiny satellites track our skies night and day, but an effective satellite-based fire mapping program doesn't just drop from the sky.

If a fire burns in the forest or the bush or the veld, if it's hot or large enough, a MODIS satellite will record the heat signature. Every six hours, if conditions are right, we can spy where the hotspots are heading and if the fire's burning hotter, colder or not at all. And once the burns are ground-truthed and melded into GIS formulas with "ecognition" software, one can determine high-severity canopy burns from low-severity ground burns, as well as patchiness, which altogether can help to quantify and certify the carbon-added value.

This is MODIS's gift of good will, the freely streamed data that's shaped fire detection and mapping globally. "We would have absolutely nothing without MODIS," Edwards says. "It's our meat and potatoes. Without

MODIS, fire management would take big leaps backward."

What NAFI has accomplished with this NASA-launched and maintained gift of data, though, is to ensure that the data answered the questions that the practitioners on the ground needed answered, serving the lands of a huge country with large, slow-moving burns and few management resources. Without MODIS and NAFI, land managers would be burning days of time in a truck or "thousands of dollars a day of chopper fuel that they didn't have to use" to track their fires.

Now, each morning, they log into the computer and check NAFI. What's burning, where's the fire burning toward, is it burning into older burns (and lighter fuels) or burning toward values that need protecting — all with a low-bandwidth connection and an interface that remembers who you are and what you want to watch.

A NAFI study estimates $2 million in savings each year, for a program cost of one-sixth that amount. It's estimated that regional indigenous communities earn $1 million per year in benefits. The program has just been renewed, with $1.2 million of support for five years, with a new website planned to launch soon as well as added support for Australia's Carbon Farming initiative.

Oddly, though, the NAFI success may be due, in part, to an initial lack of resources. As Jacklyn notes, "There are such limited resources in the Northern Territory that there's a tendency to agree if it meant you could get some more resources. And, we were all facing common problems across the north."

Edwards notes that one component that helped launch NAFA was "the early focus on low bandwidth delivery of a very simplistic map."

Jacklyn agrees: "People wanted something simple. People just wanted to know where fires are and where the burnt country is, in relation to them."

"With NAFI," Edwards adds, "in seconds they'd know what they'd have to do that day. You look out and see smoke on the horizon, and you know, is it smoke I need to worry about?"

The NAFI website offers two kinds of knowledge: on the land management side, the rangers can judge the success of their burning and "use it to iteratively monitor and target areas you need to return to. But then the data from NAFI can be used for the carbon abatement program...it's a legally recognized measurement."

While NAFI, as a model, offers technical, social and economic lessons, its success required hard work and a dedicated sponsor; a network that offered creative and strategic leadership that also listened to what was needed in the field; and, as Andrew noted, "Someone to sell the program."

From its initial pilot in 2003, the NAFI program needed to design a website, invent and manage a GIS system, measure pre-and post-burn sites, both build and offer ongoing support for aerial and ground ignitions and ground-based suppression rangers, and run helicopter transects to correlate burn severity with the satellite data.

Which brings up one of the more challenging questions for NAFI's future, and for all fire mapping: the entire program depends on MODIS data, which is produced by an aging satellite system with a delayed replacement. There is talk of new solutions — the crowd-sourcing of next-generation $50,000 satellites — but for this season (and for how many to come?), we rely on satellites that were expected to fail years ago.

AFTER THE FLAMES

Anywhere a fire burns or has the potential to burn, someone is likely to be monitoring this elemental process. Some fires are observed simply by their carbon exhaust, a measurement that implies future management, just as we now measure though don't yet manage so much of our personal and industrial carbon exhaust. We may measure the acres burned as either resources or homes lost, or rejuvenation, or carbon sequestered or saved or lost. Whatever our rationale for measuring, it is comforting that we have those who've spent a decade (and more) perfecting this craft.

Perhaps this is the take-it-to-the-carbon-bank lesson we can draw from the NAFI mapping program: that real-time mapping can shape the strategies and responses we apply today. By mapping the early burns and fuel breaks, we can manage the later burns.

The maps connect the projects, the funders and on-the-ground managers and the scientists. The maps are knowledge, but they're nothing without the relationships that build the maps — and together, they can be traded — for hard cash that can support community fire-management partnerships, a cadre of rangers, the helicopters trailing aerial firesticks, and data-inspired management protocols — that again, taken together, can help to support a rich culture and biodiversity where both are at risk. All because a satellite's eye can be taught to convert the remotest fire into a pixel.

That was my question: to learn how to burn fires early and cooler, to maintain more carbon in the soil and the unburnt plants, and to map the fuel breaks that these early fires hold against the late fires. This is why I traveled to the Kimberley — to learn to map the hotspots and ash that may conserve a bit of carbon and balance the hot-fires and carbon exhaust that now shape our fire regimes and livelihoods.

CONSERVING CARBON

After a week in the field, I debriefed with Edwards in NAFI's Darwin lab, part of Bushfire CRC and now housed within Charles Darwin University. We clicked through screens of fires burning and burn scars in Arnhem Land and the Kimberley and Cape York and Kakadu National Park, a free-burning land from the height of space. One can click on pre-set zones and instantly collate a PDF report of fire's impact and benefit. The savanna and bush move from green to brown to black and then flushes green again.

This is the power of a system that applies global tools for global solutions while drawing on local feet-on-the-ground skills that offer local solutions.

This is the optimism being crafted in North Australia — where a burn (and its representative pixel) can be both the fire and a potential salvation from our carbon-fires, where fire is both a tool for local development and a bank for global carbon. But optimists must smell the smoke, too. Fire intervals need to lengthen; fire intensities need to drop.

Edwards pulls up the day's hotspots on the map, here in the hot season when more carbon is outgassed than can be sequestered in return. Fires dot the NAFI screen red, like digital measles. "The carbon we're unlocking is ridiculous." W

Ron Steffens works as a long-term fire analyst in the western U.S. and is a Professor of Communications at Green Mountain College, Poultney, VT.

EMS Vehicle Treats Patients Quickly

The MedStat off-road, 6x6 ambulance features a fully enclosed, all-aluminum patient compartment that secures a full-size cot and seating for up to two attendants and a driver. The top speed is 42 mph; ambulance can go into full 6x6 mode from the cab in seconds. Three models range from a basic entry-level product up to a fully loaded high-end version. Models come with a list of options that enable customers to build the unit that best fits their needs. Financing is available for those looking to purchase any vehicle. **ASAP LLC** | ***www.asap911.com***

Use Forest Fire Shelter as a Last Resort

If escape routes or safety zones become inadequate, this tool just might save your life. New generation Forest Fire Shelter provides protection against radiant heat, convective heat and burn-over when trapped in a wildfire. The shelter measures 15-1/2 x 31 x 86 inches long when deployed and protects firefighters as tall as 6 feet, 1 inch; it weighs about 4-1/2 lbs. Standard accessories include nylon duck carrying case, plastic case liner and instructional DVD. **Ben Meadows** | ***www.benmeadows.com***

Goggle is Optimized for Wildland Firefighting

The lightweight, low-profile, ESS FirePro FS Goggle's compact frame is designed for maximum peripheral vision and minimal interference with helmets. The ESS Speed-Clip system allows for rapid strap adjustment, and the full-perimeter ventilation and filtration system minimizes lens fogging while filtering airborne particles. Durable, anti-microbial OpFoam face padding ensures comfort for hours. The extra-thick, 2.8 mm ballistic polycarbonate lenses provide distortion-free optics and 100% UVA/UCB protection. In addition, they feature advanced ClearZone FlowCoat lens treatments, which provide anti-scratch protection on the outside of the lens and fog resistance on the inside. **Forestry Suppliers Inc.** | ***www.forestry-suppliers.com***

Firefighter Boots Built for Comfort

The Lion Marshall design features a 14-inch boot with a breathable Crosstech fabric membrane, wide-fitting toe cap and a protective heel strip to enhance stability. A Lock-Fit Angle Support System ensures the foot is securely positioned within the boot. This anatomical ankle-padding system helps prevent the heel from riding up and down against the back of the boot. The Thermoplastic heel counter is individually molded to every size for custom fit and keeps its shape even in severely wet conditions. 3M Scotchlite Reflective Material (silver) provides added visibility. Vibram Fire & Ice sole offers durability and traction at both temperature extremes. Nomex webbing boot straps with reinforced stitching ensure easy donning and doffing. The boot is made for Lion by STC. **Lion Apparel Inc.** | ***www.lionprotects.com***

Wildland Fire Helmets

Bullard Wildfire helmets are specifically engineered to meet the needs of Wildland/forestry firefighters. Manufactured from heat-resistant thermoplastic for impact and penetration protection, Wildfire helmets meet and exceed the performance specifications of NFPS 1977-2011. They also exceed major state fire codes for Wildland firefighting. The helmets feature Flex-Gear ratchet sizing suspension, thermoplastic shell and reflective lime-yellow stripes. Available in cap or full-brim hat styles, the helmets have three goggle clips, an adjustable chinstrap, absorbent cotton brow pad and Velcro attachments inside the shell. Models are available with an extra-large, full-brim shell. **Bullard** | ***www.bullard.com***

Glove Designed for Wildland Use

The Pro-Tech 8 Wildland Glove features component materials designed to withstand the effects of flame, heat, sharp objects and other hazards that are encountered during wildland firefighting operations. Glove meets or exceeds the NFPA 1977 Standard-2011 edition for Wildland firefighting. Reinforced palm and thumb provide enhanced protection and durability. Extreme flexibility reduces hand fatigue during long missions. Eastic Modacrylic inner cuff band prevents debris from entering and secures fit. One hundred percent Kevlar stitching is used throughout the entire glove. **National Fire Fighter Corp.** | ***www.nationalfirefighter.com***

Wildland Packs

> EQUIPMENT NEWS

NARGEAR's ENGINE-1 Web Gear

The ENGINE-1 is NARGEAR's new modular web gear designed specifically for those performing wildland firefighting tactics via fire engine. This model keeps you lightweight, helping you move efficiently while working in close proximity to your engine. Whether manning nozzles right off your spools in a mobile attack scenario or tending to your hose lay during mop-up, this pack will carry your essentials with comfort. Perfect for initial attack and extended attack fire scenarios. The modular system of the NARGEAR ENGINE-1 allows you to position your fire shelter in a variety of options to accommodate your state, county or federal entity guidelines. The functional NARGEAR design allows you to arrange your pack so that you can enter and exit your engine without having to take off your fire shelter. | ***www.nargear.com***

The Supply Cache Timber Pack

The Timber Pack is essential to both engine and hand crew scenarios. It is designed to bear weight over one's center of gravity and reduce shoulder and back ache from the load of the pack during a long duty day. The line pack is versatile with a 2,045 cubic-inch main bag, zipped top pocket, four 32-oz canteen holders, 16 fusee holder bands, compass pouch, lighter pouch, tool straps, reflective strips and a new-generation fire shelter pouch. The main bag detaches for the web gear, leaving two canteen holders and the fire shelter pouch for a lighter load under working conditions. The pack is made of 100 Denier Cordura. | ***www.supplycache.com***

Initial-Attack Wildland Line Pack

Wildland Line Pack FP123 is designed to U.S. Forest Service dimensional specifications and meets the California Department of Forestry line gear regulations. An adjustable yoke-style harness evenly positions weight on waist for low-riding comfort for all body sizes. Harness includes 1/2-inch, foam-padded Aer Spacer Dri-Lex lined back, lumbar belt and shoulder straps for moisture-reduced comfort. | ***www.initial-attack.coc***

Coaxsher FS-1 Ranger Wildland Fire Pack

When you're fighting wildfires, you need to focus on your job, not your equipment. You need a comfortable, lightweight and durable fire pack like Coaxsher's FS-1 Ranger that can be customized to meet your needs. With its ergonomic harness system, adjustable waist belt and Dual Action Stabilizer, this modular fire pack is ideal for long shifts in rugged conditions, allowing you to carry everything you need without pain or strain. | ***www.coaxsher.com***

Nimrod Initial Attack Pack

The Initial Attack Pack is designed to carry heavy loads. The advanced shoulder and belt support system minimizes fatigue by melding to the body. Each pack is sized to height and weight to ensure a comfortable fit with maximum body flexibility and freedom of movement. The custom design allows access to the pack interior in seconds. In addition, the color-coded interchange system features quick-release buckles for an easy changeover; yet, they are tough enough to stand up to the most demanding conditions and perform diligently. | ***www.nimrodpacks.com***

National Fire Fighter Back-Max Wildland Pack

The Back-Max Wildland Pack features a detachable auxiliary daypack and an integrated smokejumper-style web gear system in one rugged backpack. The detachable daypack includes a padded back with a single top-loading zipper entry. It also has 1-quart bottle pockets on each side as well as outside elastic netting on the rear for aerating wet or soiled clothing. The web gear features a padded "S" harness system that self-adjusts with body movements and an extra wide waist belt that is sewn into a rigid lower lumbar support. This harness system is comfortable to wear all day. The pack also has a specially designed fire shelter pocket located close to and low on the body for comfort. The pocket uses a rip cord and harness system for quick shelter deployment.

The firefighter backpack is constructed of 1000 Denier Cordura nylon for durability. Its capacity is 1.345 cubic inches.
www.national firefighter.com

A Strike Team of Engines

A day in the life of a Southern California strike team. One of many busy days this season.

Left to right: En route into the windmills; Prepping the engines; A slurry paints the line (and the engine); Patrolling for spots. *Photos by Jeff Shelton.*

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