NSSN Frontiers in Sensing Forum 2020:

Smart Sensing for Bushfire Prevention, Response & Mitigation

Outcomes & Opportunities

On 7 May 2020, the NSW Smart Sensing Network (NSSN) hosted the annual Frontiers in Sensing Forum. This year's theme was *Smart Sensing for Bushfire Prevention, Response & Mitigation* – prompted by the devastating 2019-20 'Black Summer' bushfires that raged across Australia. The aim of the forum was to explore the critical role that smart sensing technology can play in delivering solutions to the complex challenge of bushfire prevention, mitigation and response.

The Forum was opened by The Hon. Matt Kean MP, Minister for Energy & Environment, with the keynote presentation given by Mr Rob Rogers, the incoming NSW Rural Fire Service Commissioner. Following this was an open discussion session chaired by Dr Katherine Woodthorpe AO, Chair of the Bushfire and Natural Hazards CRC, featuring an expert panel consisting of Mr Andrew Gissing, Director at Risk Frontiers; Mr Matt Riley, Director of Climate and Atmospheric Science at NSW Department of Planning, Industry & Environment (DPIE); Mr Adrian Turner, Lead at Minderoo Wildfire and Disaster Resilience Program; and Dr Marta Yebra, Senior Lecturer in Environment & Engineering at The Australian National University.

Enclosed is a summary of the discussions that were sparked at the forum along with **five opportunities** where smart sensing provides innovative and impactful solutions for bushfire prevention, response & mitigation.

The NSSN now invites stakeholder feedback on this document and will pursue partnerships across government, industry academia and frontline agencies. The objective is to develop collaborative projects that address the critical challenge of Australian bushfire seasons of greater intensity and longer duration.

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Background and context

Ahead of the forum, the NSSN scoped the areas where smart sensing could play a role in addressing bushfire related issues. Topics from the forum are incorporated into the map below:

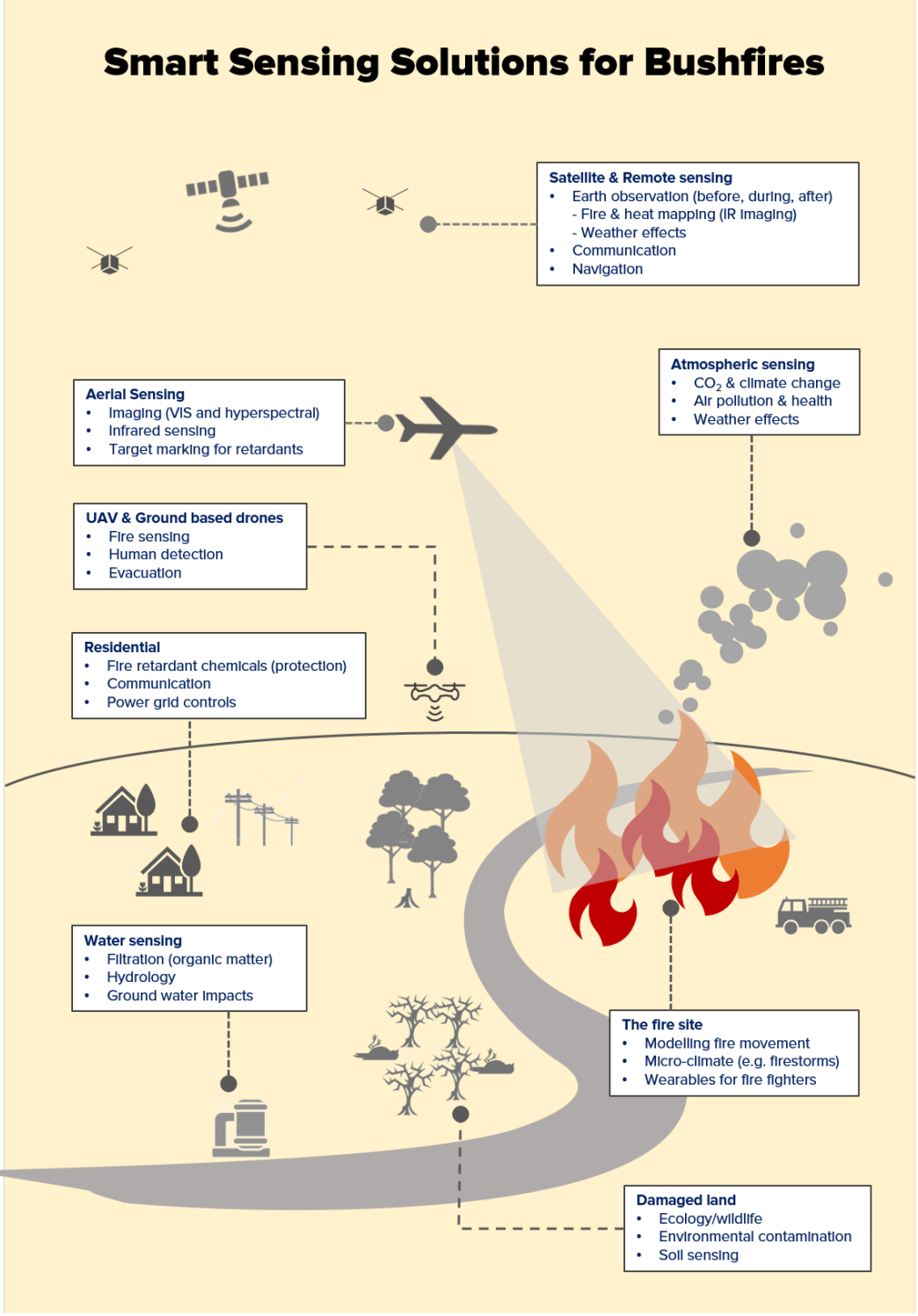

Figure 1: Smart sensing for bushfires at a glance - key areas where the NSSN's wide research network offers expert solutions.

Remote Sensing to inform community warnings during fires

Frontiers in Sensing 2020 opened with a keynote presentation from Rob Rogers, reflecting on the learnings from the previous bushfire season, an introduction to the operations of the RFS, and a look towards what opportunities lie in the future for sensing.

The Commissioner began with some high-level facts about the 2019-20 bushfires stating that;

- More than 11,770 fires occurred between July 2019 → March 2020
- More than 105 fires reached the level of *Emergency Warning*
- 430 *Emergency Alert* campaigns were issued

Warning messages were given out through direct emergency alerts, the *FiresNearMe* app, and social media. Therefore, it was stated that real-time sensing of the fires is essential for RFS to know which fires pose the biggest threat.

RFS operations and remote sensing capability

Decisions and communication made by RFS in response to bushfires are underpinned by sensing. Aircraft were contracted over the summer to perform remote sensing by performing line-scan imaging and heat density maps (4,800 scans in the summer). This data is then sent to fire behaviour tools, such as the Phoenix platform, that interpret which fires have the most potential to cause harm. This analysis then advises how resources are allocated to specific areas, and associated warning messages to be send to the community.

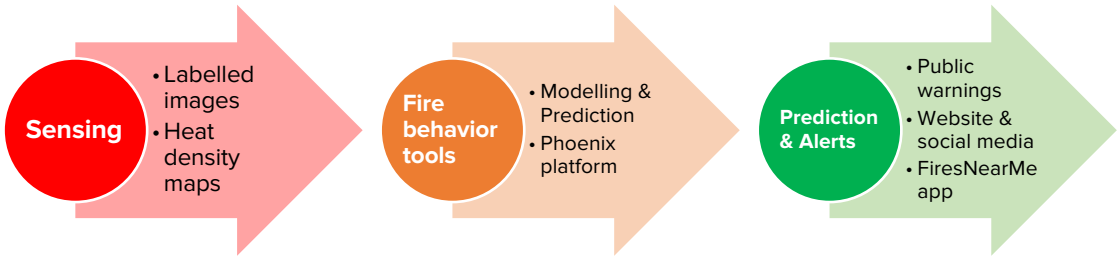

Figure 2: Sensing plays a key role in the RFS in their operations against bushfires. Sensing data feeds into fire behaviour models to predict which are the most dangerous/at risk areas, which then indicates the communication made to the public.

The remote sensing aircraft play two important roles; the first to perform the imaging and mapping, but also to act as a guide to mark targets for the Large Air Tanker Program to drop fire retardant in high risk areas.

A point was made that the data from these lead planes suffered a problem in requiring significant manual handling before putting them into fire modelling and prediction tools. As much as 30 minutes of work was needed on each image (labelling risk zones).

In response to this, the NSW Government has invested in two Cessna aircrafts, which have been fitted with *Overwatch TK-9 Imaging Systems*, able to fly at lower altitudes (currently limited at 20,000 feet), providing:

- Geo-referenced maps
- Automated KML polygon labelling for fire edge mapping
- RGB, LWIR, and NDV images (including 7 band hyper spectral imaging)

The hope is that this new automated system will remove the bottleneck of getting data into the analysis tools.

After the Commissioner's presentation a Q&A discussion was held and some highlights from this were:

- There exists a gap in remote sensing data to understand the fuel load of the land - how much fuel residual remaining (including already burnt areas). Question raised whether there exist methods to do this from currently collected data.

- More research is needed to understand the fire thunderstorms, which are becoming more common – on the scale of every few days during the season. If there are better indicators from sensing based on thermal, smoke column characteristics, and weather data it would be highly valuable for prediction models.

- Satellites are currently being used at a basic level, but getting bushfire specific data is problematic as the satellites are not configured specifically for bushfire mapping. The Himawari satellite is used for broad heat images but lack the spatial and temporal resolution for further usage.

- The use of drones and UAVs is being closely monitored as an emerging technology but are either too expensive or lack the range. Opportunity exists to deploy drones or swarms of drones, equipped with sensors, capable of flying vast distances quickly and at the same time being cost-effective.

Discussion Panel

The panel discussion, chaired by Dr Katherine Woodthorpe AO, invited experts from government, industry and academia to share their insights.

Mr Andrew Gissing, Director at Risk Frontiers, provided a perspective for bushfire risk analysis based on available data. He mentioned that the use of existing population models, climate projections, and societal changes feed into an overall risk profile to Australia from natural hazards. These profiles will identify key areas at risk and those areas where sensor technologies can fill data gaps.

Dr Marta Yebra, Senior Lecturer in Environment & Engineering at The Australian National University, gave in in depth view of the capability of satellite-based remote sensing. She elucidated the need for the integration of various data – merging satellite data with ground-based information to provide holistic situational awareness. She highlighted the limitations with of current satellites in use and recommended technologies like CubeSats for their strong potential to deliver solutions. An argument was made for Australia developing its own capability to put bushfire-specific satellites in orbit.

Mr Matthew Riley, Director of Climate and Atmospheric Science at NSW DPIE, spoke across climate effects and air quality related health impacts from the bushfires. Regarding the use of low-cost air quality sensors, he mentioned the limit comes from the quality of data from these sensors. He points out the importance of machine learning and data analytics to make use of this data but noted that we have not yet reached a critical mass of sensors to fully explore this opportunity. Other ideas were mentioned about sensors for measuring the composition of smoke and monitoring other gases (VOCs) from aircraft based remote sensing measurements.

Mr Adrian Turner, Lead at the Minderoo Foundation's Minderoo Wildfire and Disaster Resilience Program, spoke about the objectives of Minderoo towards building bushfire resilience. The program's focus areas are in enhanced prediction, enhanced response, resilient landscape and resilient communities. He sees a role for machine learning to develop high-fidelity risk models to advise better planning. Much of his work is focused on filling data gaps – enabling ways to allow datasets to be shared across various sectors to feed into machine learning and AI platforms for better decisions to be made today.

Opportunities in the future

Based on the discussions from the forum, the NSSN has synthesised five key opportunities: (in no particular order):

1. **Australian satellite sensing for bushfires**
   A project to launch bushfire-specific satellites, that collect vital information for forecasting, is recommended. Australia makes good use of the available satellite data, however none of these were specifically launched for the purpose of monitoring bushfires. Currently they do not meet the spatio-temporal requirements to do sufficient modelling. The rise of CubeSats allows for faster and cheaper ways to do this. For example, the Canadian Space Agency is deploying the WildFireSat initiative to monitor all active wildfires in Canada on a daily basis. Australia needs to push developments to best prepare for future.

   Key Stakeholder: Australian Space Agency

2. **Advanced airborne sensing for bushfires**
   Recommendation to upgrade the current airborne scanning capability for bushfires, adding new sensor technologies and the latest edge-processing to minimise communication delays. NSW RFS has adopted two Cessna aircraft equipped with the Overwatch Tk-9 System. For these assets to show a return on investment, more sensing capabilities are needed to be added to get more data per flight. These could include infrared gas sensing, hyperspectral imaging, LiDAR, or new techniques like neuromorphic imaging. Such applications could include detection of smaller fires, real-time fuel-load analysis, and even wildlife detection. This also may include the use of UAVs and drones for more localised sensing.

   Key Stakeholder: NSW Rural Fire Service

3. **Unravelling fire thunderstorms**
   The use of advanced weather sensing technologies is recommended for understanding the dynamics of fire thunderstorms. Numerous fires in the last season developed in ways the models did not expect. The dynamics of pyro-convective events ('fire thunderstorms') are not well understood. These create their own weather systems and even took the life of a firefighter during the last season. Sensing technologies, such as LiDAR and Ceilometers, would probe into the inner workings of these to provide data for better predictive capabilities of these events in the future.

   Key Stakeholder: Bushfire CRC

4. **Air quality sensing for citizens**
   A network of air quality sensors, consisting of low cost and existing reference stations, brought together using machine learning and data fusion principles is recommended. Air quality information does not cover the spatial resolution needed to address every citizen's concern. Low cost air quality sensors enable personalised warnings for individuals to act but lack the precision to make accurate measurements. On the other hand, highly calibrated monitoring stations exist around the state that can be used as a reference. Currently there are no methods to integrate these data sets and there is a strong role for machine learning and AI.

   Key Stakeholder: NSW Department of Planning, Industry and Environment

5. **Machine learning & AI for data integration for risk analysis**
   The latest in machine learning & AI algorithms has been called upon to pool together existing data to provide recommendations for future natural hazard responses. This would include datasets on climate prediction, population projections, and infrastructure development. These recommendations would establish a cost-benefit analysis of key risk areas, and identify areas where sensors are needed.

   Key Stakeholder: Minderoo Foundation, Risk Frontiers