SAVANNA FIRE MANAGEMENT AND BUSHFIRE AND NATURAL HAZARD SCENARIO PLANNING FOR NORTH AUSTRALIA

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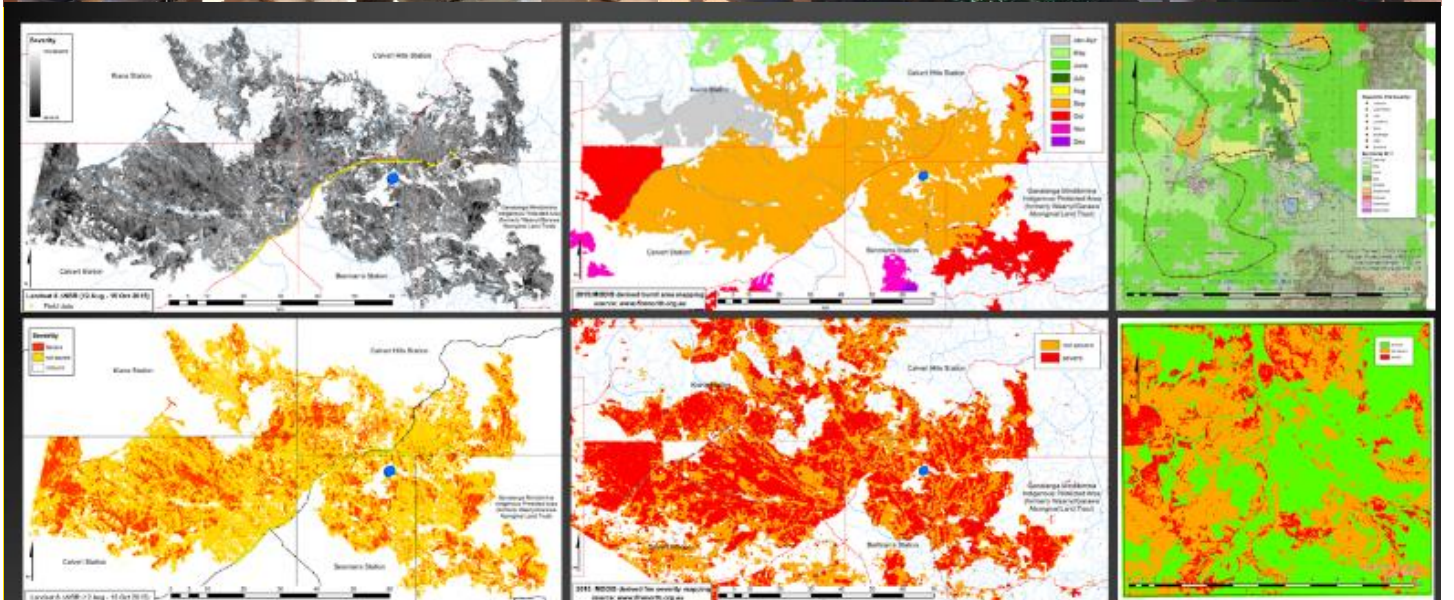
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EXECUTIVE SUMMARY

The 'Scenario planning for remote community risk management in northern Australia' project is part of CDU's northern hub second round suite of projects, which commenced in July 2017. The hub involves collaborations between the Darwin Centre for Bushfire Research (DCBR) at Charles Darwin University (CDU), the North Australia Indigenous Land & Sea Management Alliance Ltd (NAILSMA), the Aboriginal Research Practitioners Network (ARPNet) also based at CDU, and regional stakeholders including north Australian Fire and Emergency Management agencies, Conservation Agencies and remote Indigenous communities. In this report, we provide summaries of the work undertaken to date in the two main components of the Northern hub's scenario planning project.

Firstly, we are developing a framework for the Fire & Emergency Services agencies to engage with remote Indigenous communities to potentially improve Emergency Services delivery. The agencies recognise the need to improve the services provided remotely, but also recognise that in part and in some jurisdictions (particularly the NT) not only are they not funded to achieve this, also that the classic model of volunteering does not suit remote Indigenous community members, who are too busy dealing with unemployment and poverty. However, the expanding Indigenous Ranger program is a potential means to more appropriately engage with local Indigenous people to build resilience and disaster assistance.

The process has involved a suite of case studies where interviews have been undertaken with members of the, now, wide-spread Indigenous Ranger programs to ascertain the aspirations, willingness and capacity of the Indigenous Rangers to engage in EM activities. In this report, we provide summaries of the activities undertaken and information gathered to date at Hermannsberg in Central Australia, Broome in the Kimberley, Galiwinku on Elcho Island off Arnhem Land and Borroloola on the Gulf of Carpentaria.

Secondly, we are continuing the program of service delivery of land management, monitoring and evaluation tools to assist fire managers in remote north Australia to develop "Improved Fire Management Regimes", by providing information with respect to the spatial distribution, and effects of fires on tropical savanna and rangeland habitats through the Savanna Monitoring & Evaluation Reporting Framework (SMERF). In this report, we outline the further development of SMERF, in particular the proofing of the fire metrics collated in the previous year with a Far North Queensland Conservation estate case study in conjunction with partners at Queensland Parks & Wildlife.

END-USER STATEMENT

Ken Boulch, *Director Policy & Planning, Bushfires NT, Department of Environment and Natural Resources, Northern Territory Government*

The scenario planning project is focusing on opportunities for Indigenous Ranger Groups (IRGs). Helping to develop fee-for-service arrangements utilising the capacity that has been developed through their land management activities generally. There are many opportunities within government agencies and shire councils to take over management in mitigation and post-event activities, such as prescribed burning around towns and out-stations, and tree clearing and other activities after big storms and cyclones. As an agency we can foresee many benefits from local, trained individuals for emergency management primarily in mitigation but also in in response to wildfires.

Volunteering is a very worth-while activity, for the community and for the mental and physical health of the people involved. However, there are barriers to involvement for people living in remote areas, such as maintaining car registration and drivers' licenses, especially where there is poverty. The work the DCBR team have been undertaking with the IRGs is crucial to identify these issues and instigate the changes needed to involve local people in local emergency management activities.

The Darwin Centre for Bushfire Researchers have, so far, developed a rough model outlining the development of two very successful IRGs and their involvement in volunteering in Bidyadanga and Beagle Gulf in the Kimberley in Western Australia. The salient points our agency will be able to take away from the DCBR analyses includes: the importance of providing long-term agency support from trained personnel with appropriate cross-cultural training; the provision of regular, flexible and appropriate training and resourcing; respectful collaboration with communities and traditional owners; and to engender fee-for-service arrangements within the shire councils, agencies and other land owners/managers to help support the IRGs.

Over the years, DCBR have developed a number of irreplaceable tools that are used widely and regularly by land managers right across the NT and the rest of northern Australia, such the North Australia Fire Information (NAFI) web portal, the Greenhouse Gas Emissions calculator (SAVBat), Infonet for our reporting needs, and now they are reporting on the development of the Savanna Monitoring & Evaluation Reporting Framework (SMERF) and Fire Severity mapping. SMERF will greatly increase our capacity to analyse past fire regimes to assist with planning. Fire Severity mapping will take this one step forward providing us with more detail regarding the real distribution of hot fires.

This past year, DCBR have performed very well, having published papers of international significance and working towards the development of remote Indigenous community resilience. They have provided insights into the success of Indigenous Ranger Groups volunteering in EM activities, and interviewed Rangers to better understand their aspirations in this space. The upcoming Leadership and Governance training they are about to undertake is new and exciting, I look forward to seeing the results of its completion shortly.

PRODUCT USER TESTIMONIALS

Chris Kinnaird, *Principal Ranger, Technical Support, Northern Region, Queensland Parks & WIldlife Service & Partnerships, Department of Environment and Science, Queensland Government*

Queensland Parks and Wildlife Service (QPWS) actively engages in a wide variety of land management activities across the state of Queensland. Fire management is regarded as one of the highest priorities for the agency and whilst QPWS can lay claim to a significant and successful fire program on an annual basis, how we measure our success has been noted as an area to improve. As a member of the North Australian Fire Managers (NAFM) group (annual forum of land and emergency management authorities and key stakeholders hosted by the Bushfire and Natural Hazards CRC), QPWS was alerted to the work of the Darwin Centre for Bushfire Research (DCBR) in the field of savannah burning monitoring. DCBR's work is varied and extensive and compliments the great work done by all fire managers across the north of Australia. Specifically, QPWS was immediately interested in the Savanna Monitoring and Evaluation Reporting Framework (SMERF) as method of; (a) establishing context around our fire management activities; (b) measuring our effectiveness against key metrics as agreed and (c) reporting on those activities and metrics to enable continual effectiveness, learning and improvement.

The QPWS association with SMERF is still in its infancy however we are already seeing the fruits of consistent, tailored and specific measurement of targeted objectives. Currently there are six parcels of QPWS estate under the SMERF program spanning QPWS Northern and Central Regions with the potential to add to this number as the benefits evolve.

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WORKSHOPS AND INTERVIEWS WITH REMOTE INDIGENOUS RANGERS AND COMMUNITIES

BACKGROUND

The Scenario Planning project has focused on engaging with Indigenous Ranger Groups (IRGs) working in remote communities. The Darwin Centre for Bushfire Research (DCBR) have a long-standing relationship with many of the IRGs, and as the Rangers are skilled land managers, relative to most remote Indigenous community members. We commenced our research by interviewing the Rangers to determine their **willingness** to engage in ES, as well as their **skills and training**. We then determined the **requirements** of the agencies for the Rangers to successfully engage in ES.

This year we worked with three ranger groups (Hermannsberg, Galiwinku and Borroloola). We interviewed the Rangers to ascertain their perspectives on the emergency services (EM) needs in their communities, and their willingness and capacity to fill the EM gaps they identified.

We spoke with NT Emergency Services (NTES), Bushfires NT (BFNT) and the NT Fire & Rescue Service (NTFRS) to determine the potential for the Rangers to work in EM.

NTES have a limited presence in all 3 remote communities, generally represented by the Police and the volunteer Fire and Emergency Response Group (FERG). The main opportunity for the Rangers is to train to become volunteers with the FERG.

IMAGE 1. NT REGIONAL COUNCIL AREAS.

In Borroloola, we invited the Captain of the FERG, Nathan Eames, to visit the Garawa & Waanyi Garawa (G&WG) Rangers, He gave an inspirational talk about his fulfilling life as a F&ES volunteer. There is not only a great deal of personal benefit, also kudos from the community, they will also receive extensive training, have access to personal protective equipment (PPE) and EM equipment. The Northern Land Council (NLC) management agreed to allow the Rangers to "volunteer" with the FERG as part of their ranger duties. There are, however, other barriers to volunteering for the Rangers, with respect to extensive availability, a driver's licence, a criminal check, and a much greater level of responsibility they've not had before. To date, none of the Rangers have submitted the volunteer application forms to NTFRS, due to either a lack of drivers licence or fear of the responsibility. We are trying to remedy this second condition through funding from the Australian Institute of Disaster Resilience.
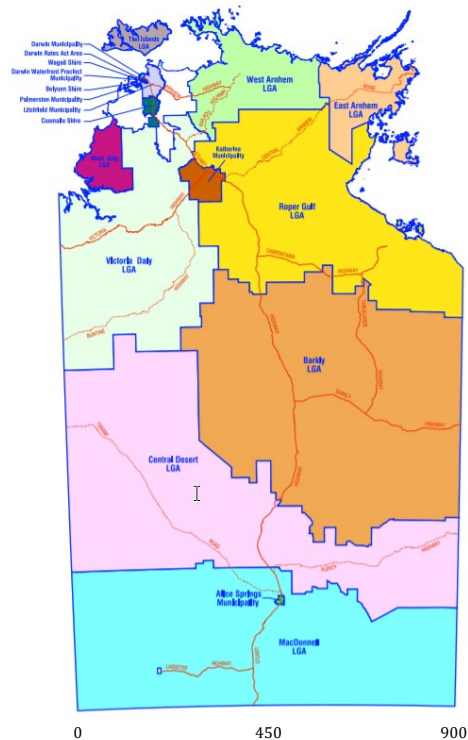
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We spoke to the Regional Council's (Central Desert and Roper Gulf) with a CDEP[1] work force, generally undertaking Council activities (such as rubbish removal, weed removal, and infrastructure maintenance). However, colleagues in BFNT informed us that the Central Desert Regional Council have employed a fire management officer to train and deploy a bushfire mitigation workforce through the CDEP program. Tamara Rolph (BFNT) was involved in the training, and provided us with information to take the program to other jurisdictions. We have spoken to the Roper Gulf Regional Council CDEP program coordinator who is very interested in implementing the program.

In Galiwinku, Cyclone Lam in 2015 was the impetus for the community to make their governance structures, transparent to Government and other non-local agencies, through the establishment of reference groups. The governance structures which existed formally before colonisation and still exist.

GARAWA & WAANYI GARAWA RANGES - BORROLOOLA

In this past quarter, we again attended the Borroloola F&ES meeting with the G&WG Senior Ranger (Donald Shadforth) and Ganalanga Mindibirrina (Nicholson Block) Indigenous Protected Area (IPA) coordinator, Ostianne Massiani. This is the second EM Borroloola town meeting in two years. The first meeting, which we were invited to attend, produced some great outcomes for the G&WG Rangers. The first was to be identified by the CEO of Mubanji for an outstation fire management contract; the second was recognition that the rangers had skills that could be adapted for volunteering in the Fire and Emergency Response Group (FERG).

Summary of the Borroloola Emergency Response Area, Fire & Emergency Services meeting,

Mabunji meeting room, Borroloola, 10.00-11.30 Friday 24th August 2018:

Attendees: Bernie Welsford (FRS), Steve (FRS), Melissa Sanderson (Police), Jamie Seib (Mabunji, FERG volunteer), Ostiane Massiani (NLC), Nathan Morrison (NLC), Donald Shadforth (W&WG Rangers), Rebecca Gentle (MRM), Andrew Urquhart (Clinic, FERG volunteer), Andrew Edwards (Darwin Centre for Bushfire Research, CDU).

The Garawa camp is to be included in town management. There is a hydrant in the camp, in working order, to be maintained.

Nathan Eames has resigned as volunteer captain due to work commitments (i.e. not available enough):

- All notifications for volunteer activities will be notified through the Police.

- When the FERG becomes a bit bigger they will then elect their own captain.

Donald, the new Senior ranger, is at the meeting on behalf of the Waanyi & Waanyi Garawa Rangers (W&WG). The rangers are still keen to be volunteers but reluctant to attend motor vehicle accidents (MVAs). James stated they can be

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[1] CDEP – Community Development Employment Projects program – an initiative by the Australian Government for the employment of Aboriginal and Torres Strait Islander people - https://www.dss.gov.au/about-the-department/publications-articles/corporate-publications/budget-and-additional-estimates-statements/indigenous-affairs-budget-2007-08/community-development-employment-projects-cdep-programme-continuation-of-funding

left out of such activities. "You are volunteers, you can choose what you want to do". Melissa stated that it is unlikely they would be attending alone, as most calls go to the police first, and Police generally attend MVAs. Bernie stated it was okay for the rangers to only attend fire incidents.

A number of members have recently left the FERG. Jamie has spoken to a lot of the businesses around town canvassing for new membership. The Rangers offered to organise a meeting with town folk to broaden the recruitment pool. Andrew had a suggestion regarding CDP.

Jamie said the FERG are planning fortnightly, or even weekly, training. A trainer, or trainers, from Darwin will fly down at different times. Rebecca stated MRM can offer to provide free seats on Air North flight that comes down, and back, Monday, Tuesday, Wednesday and Thursday. Melissa stated the Police have a visiting officer's quarters (VOQ) for free accommodation. Jamie stated Mabunji could provide transport.

Donald stated that he has visited the out-stations on the ALT outside of town. The rangers intend to go and put in some firebreaks in the next week or so.

An NTES trainer delivering rescue boat training, is coming Nov. 17-19. Only the Police and FERG invited.

Ostiane made the comment that it'd be useful to develop some employment pathways for local people in many of these fields. It was stated that the NTG have been advertising for similar sorts of positions but have not had applicants that are good enough to fill the positions.

Bernie described the current legal situation regarding prescribed burning in the ERAs. Only a few senior personnel within FES have the qualifications to supervise such activities, such as Bernie and a handful of others. The acquisition of qualifications is lengthy, requiring a number of steps. Bernie is hoping to get the likes of Jamie qualified.

Bernie said he would email out the Bushfire Mitigation Plan for Borroloola to those of us in attendance.

Andrew described the appointment of a fire Management Officer in the Central Desert Regional Council, who has helped to developed fire plans in each of the communities in the region. They have engaged with Bushfires NT (Tamara Rolph) to train CDP employees in all aspects (e.g. equipment use and maintenance). Andrew is liaising with Roper Gulf Regional Council to perhaps do something similar. This might provide more trained volunteers.

There are a number of disaster packs being destroyed by vermin in the FERG shed. Jamie offered to move them into a less accessible container. Bernie suggested that if they're no good they should go to the tip.

TJUWANPA MEN RANGERS - HERMANNSBERG

After our visit and interview with the Tjuwanpa Women Rangers Group in Hermannsberg we were directed to the Men Rangers Group. The coordinator, Benji Kenny, is a local man, and very keen to advance the standing and capacity of the Rangers. Benji invited us to their biannual Traditional

Owner/Ranger Advisory Committee meeting (TORAC). He was also interviewed with regard to Emergency Services in Hermannsberg and the capacity and willingness of the rangers to be involved.

A summary of the TORAC, Hermannsberg Ranger Office, Hermannsberg NT, 10.00-11.30 Tuesday 17th July 2018:

Attendees: Rangers (Obed Ratara, Fabian Ragget, Colin Joseph, Emron Campbell, Dean Inkamala, Raphael Impu, Christopher Ungwanaka, Malcolm Kenny))and Ranger Coordinator (Benji Kenny); ~10 TOs; CLC staff (Tony Renchan (Regional Manager); Sue Ellison (Regional Land Management Officer) both dealing with the rangers, and Anthony – Aboriginal Benefit Trust Program Coordinator, Vaugh Hampton – Employment Support Officer); Parks & Wildlife NT (Aleisha and Dwayne).

After a good quick start to the meeting at around 10am and some presentations from the CLC staff, AE and KKS talked about the Scenario Planning project. Andrew started with a brief presentation explaining our team's work to date in fire management, such as NAFI and the Savanna Burning program to illustrate our credentials, and finally about the scope of the Scenario Planning project with respect to the agencies understanding that they need to engage with local communities better. Kamal described the common emergency issues in remote communities and informed rangers about our project work plan, that includes 1-2 workshops and a final scenario planning workshop involving all the stakeholders. She described the common emergency management issues in the communities e.g. the location and level of community involvement in the EMP. Some TOs/Rangers asked questions regarding the agencies involved, and what could be done. The rangers also asked about the involvement of the Women Rangers (who had already been consulted by the team, and are also somewhat willing to be involved in EM). The team also shared their Borroloola experience.

After lunch, the Rangers gave an impressive presentation describing their activities over the last 6 months, which included fencing, fire and emergency training with women rangers, computer skills development, organising ranger and family camps, monitoring waterholes etc., and their proposed land management planning for the next 6 months.

The team will follow up with Benji to find out what they decide and when it could be possible to hold our first workshop with the Rangers and TO's. The next TORAC is in December.

A Transcript of the interview with Benji Kenny, Tjuwanpa Men Rangers Coordinator, Hermannsberg Ranger Office, Hermannsberg NT, 14.00-15.00 Monday 16th July 2018:

Attendees: Dr. Andrew Edwards (AE), Dr. Kamaljit K Sangha (KKS) and the Ranger Coordinator Mr. Benjamin (Benji) Kenny.

The team met at the Tjuwanpa Men Rangers' office. AE and KKS informed Benji about the project in detail including what it involves for the rangers to participate in the project.

Benji shared some of his experiences such as occasional flash flooding in the Finke river and how people on the other side of the river get cut off from basic

services such as food, medical supplies etc. Land searches are another important issue in the community. He also suggested that rangers involved in Emergency Management could be provided with more employment opportunities around the community.

GALIWINKU REFERENCE GROUP – ELCHO ISLAND

Here we provide a summary of the meeting with local community members and other workshop particiants, held in the NAILSMA Workshop Room. Galiwinku, Elcho Island, 1st April 2019.

Participants:

Galiwinku community members: James Mawutarri Gumbula; Ted Marrawili Gondarra; James Bayngu Garawirrtja; and Jack Gurrudupunbuy Wanambi.

NAILSMA – Glenn James and Danny Burton.

Red Cross – Andrew Kenyon and Annie Ingram.

ARPNet – Dr. Bev Sithole.

CDU – Prof. Jeremy Russell-Smith, Steve Sutton and Kamaljit Sangha

IMAGE 2: WORKSHOP PARTICIPANTS

Topics discussed included: how to effectively engage and partner with Galiwinku community; what are the local structures and aspirations; and how CRC projects can support or empower the locals.

After introductions the NAILSMA CRC project team member provided an overview of the project and the work that Galiwinku mob is doing to build their governance.

Background

When cyclone Lam hit the Top-End communities, in February 2015, Galiwinku elders started the process of re-inventing their own governance. It was triggered as they were approached by various Emergency Management (EM) agencies for recovery, who picked up individuals from the communities to consult or work with, following their own protocols with little considerations of locals. The locals

felt the need to do something about it, hence started discussion about their own governance with support from the BNHCRC Indigenous Partnerships project led by NAILSMA.

Galiwinku is a relatively large community of about 2000 people (ABS 2016), located in the north of the NT on Elcho Island (Figure 1), comprising of about 96% Aboriginal and 1.2% Torres Strait Islanders, and the rest non-Indigenous people. About 83% of people speak the local Djambarrpuyngu language. Yolngu is a common term for Indigenous people from north-eastern Arnhem Land including Elcho island.
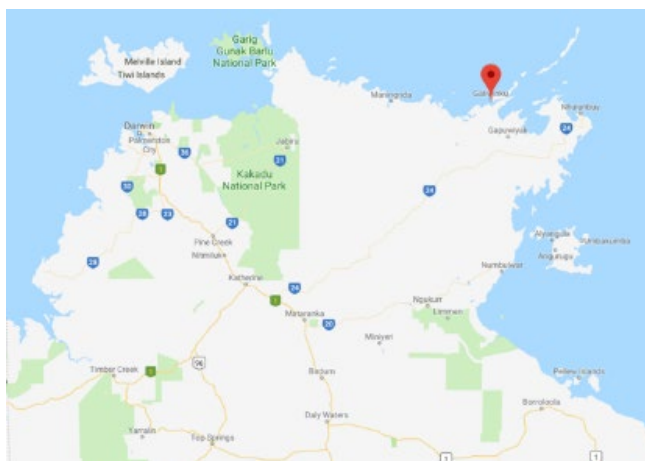
FIGURE 1: LOCATION OF GALIWINKU

Indigenous perspectives on governance

Galiwinku mob shared their views on how outside organisations approached the community and created chaos when recovery and emergency services after cyclone Lam were delivered for the community. The members expressed a lack of visibility of their own governance structure, which they later explained in detail.

As one participant pointed out, '*Galiwinku governance is just invisible, its been there for so many years. There has been no recognistion of Galiwinku governance among the service providers. They are run by their own structure and have sub-committee representation groups which is not right for the Yolngu mob.*'

NAILSMA researchers pointed out that usually the CEOs, who are usually Balanda (white fellows), control the organisation even if the organisation is Yolngu/Indigenous. It was also pointed out that different community-based organisations compete with each other for funds and resources, its like a disaster. The chaos among the outside organisations has lead to disengagement and disempowerment of locals this then results in a big disaster.

Galiwinku Governance

Galiwinku participants presented their local, well-defined, governance (represented in Fig. 2) that includes:

1. Garama (all the community members from various clans) = equates to Public in non-Inidgenous system

2. Dhuni (Tribal leaders/clan leaders) = equates to Parliament

3. Ngarra (final agreement/decisions) = equates to Government
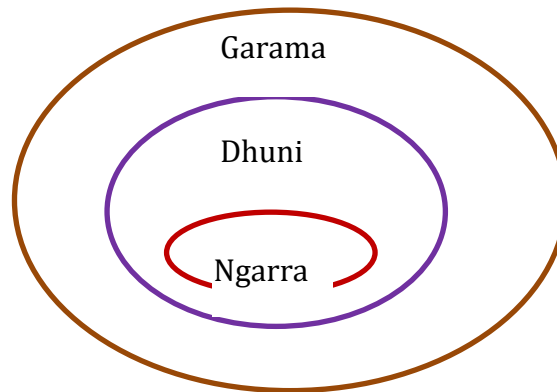
FIGURE 2: GALIWINKU GOVERNANCE WITH THREE LAYERS OF GARAMA, DHUNI AND NGARRA

However, the porposed governance structure is invisible to outsiders and is currently not functional as the elders want to strengthen it through a local authority, DDA, (Dalkarra Djirriray Authority) that will help improve the delivery of EM and other services in the community.

An essential element of this governance is a community interface where various community reference groups can be hosted to serve as the first point of contact for any outside organisations. As one participant pointed out, '*there is no single organisation that is linked to Yolngu structure*'. Another added, '*instead of DDA, the government bodies interact with the comm. ref. groups without approaching DDA. From each department in a project, they choose a person, so they do things in their way.*' He further added, '*we need the service for the community but through a right process so we can benefit. So far it's not been recognised by the Balanda. Dhuni is our foundation*'. Examples were discussed where locals were ignored despite the presence of a community reference group, e.g. School council is a community reference group where some members of the community decide about education without appropriately consulting with the locals.

It was recognised that the community reference group concept requires a lot of support for real community engagement, hence for formalising the DDA. Once DDA is established, it can provide community reference groups some kind of authority, guidelines/principles and laws to comply with, so as to deliver the service in a right way.

In relation to the existing local EM committee, Yolngu don't feel comfortable. The EM plan is there but not digestible for the community/TOs. Another major issue is that there are too many organisations that humbug the community and often cause chaos. Often, outside organisaitons operate within strict time frame with little flexibility.

End-user – Red Cross (for EM in Galiwinku)

In response to Galiwinku Governance, Red Cross representative ageed for a need for the outside organisations to contact the right community reference group to do the right things. It will benefit not only EM agencies but many others

as the outside organisations are there to service the community. Red Cross currently supports Galiwinku mob for offering a venue for their monthly meetings.

Potential for Scenario Planning (SP):

CDU researchers from the SP and other northern hub projects shared stories about their research and offered their help to the Galiwinku elders as and when they need it. It was left up to the Galiwinku participants to discuss this at their own time. However, later talking with the community members, interest was expressed in having SP workshops to work with the agencies and community around two storylines, focusing on business as usual and improved services for the community. However, this requires further discussions with NAILSMA and among the locals themselves.

Future targets

1. How to continue supporting the Galiwinku group

2. How scenario planning workshops with the community representatives and agencies can help deliver the EM services in an effective and culturally appropriate way while empowering the locals.
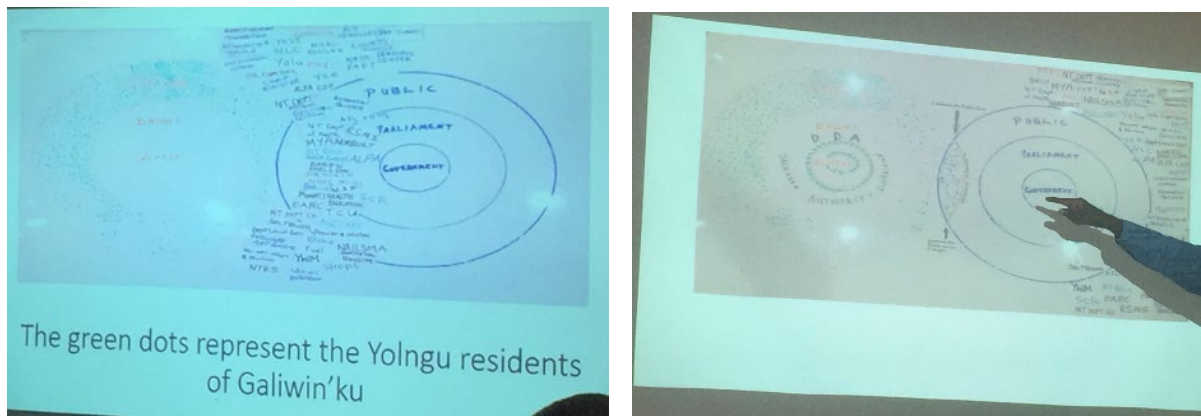

FIGURE 3: GALIWINKU COMMUNITY IN THE LIGHT SHADE ON THE LEFT BEING APPROACHED BY SO MANY ORGANISATIONS, AND LOCAL GOVERNANCE INCLUDING A COMMUNITY INTERFACE WHERE REFERENCE COMMUNITY GROUPS SERVE AS A 'GATE KEEPER' TO CONSULT WITH THE DDA (DALKARRA DJIRRIRAY AUTHORITY)

MEASURING ENVIRONMENTAL LOSSES FROM BUSHFIRE IN THE NT

SUMMMARY

Natural disasters cause sustained losses to the natural environment, yet we largely fail to account for the economic cost mainly due to a lack of marketable measures. This research applies global and national costing methods, and proposes an integrated framework that incorporates both marketable and non-marketable losses including environmental. It further applies that framework to the Northern Territory, Australia for estimating the cost of wild bushfires (events >1km2) using loss of ecosystem services as a surrogate. These wild fire events impact on 20% of the total area annually (based on 18 years average from 2000-2018), costing ~$150 million per annum. Losses were greatest on the Indigenous estate ($113 million yr-1), followed by pastoral ($22 million yr-1) and the conservation estate ($13 million yr-1). We calculated the impacts of wildfires on "loss of well-being" for the remote Indigenous population, conservatively, at $272 million yr-1. This understanding is essential to developing effective natural disaster management policies that aim to enhance the resilience of these communities.

INTRODUCTION

Natural disasters (NDs) present serious concerns not only for people, but also the natural environment that supports people, due to the significant increase in their frequency, intensity and impact on global populations over the past 50 years or so (World Risk Report 2017; Centre for Research on the Epidemiology of Disasters (CRED) and United Nations Office for Disaster Risk Reduction (UNISDR–United Nations International Strategy for Disaster Reduction) 2018). Recently, the UN Secretary General has warned, "if we do not change course by 2020, we risk missing the point where we can avoid runaway climate change, with disastrous consequences for people and all the natural systems that sustain us", (CRED and UNISDR 2018).

Australia is one of the most frequented countries by disasters, particularly, cyclones, floods and bushfires (Guha-Sapir et al. 2013; UN and ECLAC 2014). About 80% of the Australian population is coastal, and therefore directly exposed to cyclones and floods, whilst the rest residing inland is subjected to extensive and frequent bushfires (Ladds et al. 2017). On average, the total cost of disaster-related losses is estimated at AUD 1.75 – AUD 3.26 billion per annum (in 2013 values) by Ladds et al. (2017) or AUD 18.2 billion per annum (in 2016 values) by the Australian Business Roundtable for Disaster Resilience & Safer Communities (ABRDR&SC; 2017). Most of these costs account for marketable losses of both direct and indirect services and goods but exclude the loss of environmental assets and their services to people.

Measuring a true cost of NDs, particularly including appropriate loss of environmental assets and their services which sustain human life, remains a key challenge within the natural disaster sciences. In a recent seminal report, CRED and UNISDR (2018) highlighted that the reported losses only account for part of the story as 63% of the emergency disaster related reports to the EM-DAT (the

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international Emergency Management Database managed by CRED) contains very little account of environment losses, if any. That report stresses for the need to evaluate environmental costs.

Current methods for measuring loss from NDs largely rely on insurance data (e.g. insurance losses of infrastructure or crop/livestock production), with very little account, if any, of environmental assets and their services to the local communities (Ladd et al. 2017; Handmer et al. 2018). These accounting measures need to be updated to include people's well-being related losses which are beyond the customary economy, to fully understand the cost of NDs.

This paper offers an integrated framework to account for environmental (and other tangible) losses applying cost-valuation techniques from the trans-disciplinary field 'Ecological Economics'. We present a costing framework to underpin the environmental losses. Further, we use a case study for costing bushfires at a state/territory level for the Northern Territory (NT) in Australia where currently bushfires are expansive and frequent yet no costs are estimated. Incorporating the loss of environmental values could help evaluate total disaster-related losses to inform ND related management and mitigation policies, and enhance resilience of local communities and EM agencies.

ECONOMIC COSTING FRAMEWORKS

We discuss the key global and national frameworks to assess the disaster losses i.e. UN ECLAC (United Nations Economic Commission for Latin America and the Caribbean 2003; 2014), Australian, and the World Bank (2010).

The UN ECLAC (2003, 2014) framework includes three main domains:

Direct damages (stocks) and losses (flows) (tangible): physical mainly including public infrastructure, public, business and private buildings, crop/farm land, etc.

Indirect losses (occur as a consequence of NDs) (tangible): business disruption, loss of public services including transportation, health, education, etc.

Non-marketable losses (intangible): social (fatalities, injuries), psychological (health impacts), and environmental losses.

Direct damage assessment is usually measured from insurance losses, which are then used to calculate total damage applying factors or 'multipliers' (simple factors for particular types of disasters). The ECLAC approach is focused on estimating the cost of repairing or replacing damaged infrastructure as well as the impact on various social and economic sectors, such as education, health, balance of payments, etc. But, the loss of environmental services to people's well-being is grossly missing. However, the need to include them is well acknowledged (UN ECLAC 2014).

In Australia, a similar framework is followed, as reported in the key state-level assessments recently conducted by Handmer et al. (2018), Ladd et al. (2017), Deloitte Access Economics commissioned by the ABRDR&SC (2017), and earlier by the Bureau of Transport Economics (2001), Gentle et al. (2001), and others. Direct losses are estimated largely using insurance data (depreciated economic value where applicable), indirect losses (e.g. loss of public or private service) from other sources of data and/or applying the factors of Insurance Loss Ratio

(ILR proposed by Joy 1991) or multipliers for death/injury to estimate total costs. For example, the ILR for bushfires and storms is 35%, meaning the insurance losses from bushfires and storms represent 35% of the total losses. Similarly, the ILR for tropical cyclone, floods and earthquake represent 20%, 10% and 25% respectively, of the total costs. In other words, a factor of 3 for bushfires and storms, 5 for cyclones, 10 for floods and 4 for earthquake is typically used to calculate the total costs. Throughout Australia, the ILR is equivalent despite significant variations in how people value resources in different parts of the country.

Both direct damages and indirect losses are considered tangible while social, psychological and environmental losses are considered intangible or non-marketable. The common UN ECLAC (2003) and Australian frameworks amalgamate both direct and indirect intangible losses under intangible. In contrast, the World Bank framework (2010) measures the economic losses of NDs for both direct and indirect costs, each involving marketable and non-marketable losses as below:

1. Direct costs:

    a. Marketable: public infrastructure, public, private and business buildings, crops/livestock/fences

    b. Non-marketable: health, death, loss of ecosystems and their services, and cultural assets

2. Indirect costs (as a consequence of NDs):

    a. Marketable: business disruption, communication and network/computer disruption, loss of work and public services, residential and non-residential clean-up

    b. Non-marketable: poor health, loss of public amenity, loss of water, electricity and gas services, sewerage treatment, and volunteer services

We applied the World Bank (2010) framework for distinguishing marketable and non-marketable losses within direct and indirect categories, Table 1, but we considered how each loss from NDs impacts on people's well-being.

Further, we believe that the total economic cost assessment can contain both monetary and non-monetary values. It can include multiple forms of information to appropriately inform policy. For example, loss of crop/pasture production can be measured in monetary units but loss of human life can be simply reflected in number of deaths to suggest the severity of a situation, rather than assigning a value to loss of human life (contrary to Handmer et al. 2018). Hence, we propose a mixed set of monetary and non-monetary tools, explained in Table 1.

Total ND costs = Direct (marketable ($) + non-marketable losses ($ and non-$ measures)) + Indirect (marketable ($) + non-marketable ($ and non-$ measures)) losses.

CONTEXT

Bushfires are an ecological driver of the mesic savannas and arid lands of central and northern Australia, and have been practised by Indigenous people for millennia (Pyne 1998; Woinarski et al 2004). Traditional fire management involved people burning the land for various reasons as they traversed their estates (Russell-Smith et al 1997; Yibarbuk et al 2001). These fires were set incrementally throughout the seasons particularly during lighter winds and in moist or uncured fuels, they were generally small (<1km2) and patchy in extent and arrayed more or less evenly across the landscape (Garde et al. 2009). This practice of burning led to (1) breaking up of continuous ground layer fuel loads thus restricting the spread of unintended wildfire, and (2) a mosaic of different seral stages of post fire vegetative regeneration, providing a variety of food and habitat resources and enabling the persistence of fire sensitive biota (Letnic et al. 2004, Trauernicht et al. 2016). In the post-colonial era, these practices were largely ceased with the massacre of Indigenous people, and the remaining being pressured to move away from their customary estates to community centres (Ritchie 2009; Latz 1995; Burrows et al. 2006). As a result, contemporary unmanaged fire regimes have become dominant with extensive (>1000km2) severe wildfires occurring during hot dry windy weather (Burrows et al. 2006; Yates et al. 2008). However, traditional fire practices are now being revived particularly in the north with Savanna Burning methodologies (discussed later).

In the NT, of ~246,000 people 27% are indigenous (66,000), of whom > 50% live in remote areas (i.e. 35,414 people) (ABS 2016). Most importantly, those who live in remote areas are spread widely across the entire NT landscape (Fig. 1), some retaining knowledge and skills to manage fire (Russell-Smith et al. 2013). Some regions in the Top End, for example the Arnhem Land Fire Abatement Ltd., are the pioneers in implementing prescribed burning on >90,000 km2 area. They are currently generating about $10M per annum under the Emissions Reduction Fund scheme (ERF— http://www.cleanenergyregulator.gov.au/ERF/; Cooke 2019).

Although the current ERF scheme offers some opportunities to manage fires but these are limited to above 600mm rainfall isohyet, and the damage caused by wildfires to biodiversity and water resources, and various Indigenous cultural and sacred sites is enormous. So far, there is no account of bushfire related losses in the NT, which are assessed here.

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METHODS

Burnt area estimations

In order to quantify the extent of impact of bushfires we considered fires greater than 1km^2 as having a negative effect. This threshold size has been applied in assessment of fire regime change with regard to addressing the needs of fire vulnerable fauna and flora with restricted home ranges and dispersal capacity in northern savannas (Evans and Russel-Smith 2019), and is also commensurate with the mean size (63.9ha) of traditional fires documented from historical aerial photography in an arid setting (Burrows et al. 2006). Utilising a fire history archive from North Australia Fire Information (NAFI) website (https://www.firenorth.org.au/nafi3/) covering the NT from 2000 to 2018, we created layers of individual fires as defined by mapped events atrributed with unique dates, and classified these into four size classes (0>1km^2, >1-10km^2, >10-100km^2, and >100km^2).

Bushfire cost estimations

Recognising that wildfires are a threat not only to the NT but also across the entire northern Australia, we estimate the loss of ecosystem services and benefits (ES) from affected natural landscape. ES are defined as the benefits humans derive from their ecosystems (Millennium Assessment (MA) 2003). For this, we firstly estimated the burnt area extent, as described above.

Applying three scenarios to each of the four fire-size classes, we assessed the loss of ES from wildfires according to land use. A step-wise approach included:

Estimating the fire frequency from 2000-2018 for wildfires varying in size from 1km^2, 10-100km^2, and >100km^2 area;

Categorising the burnt area under three main land tenures i.e. Indigenous (including pastoral and conservation), conservation, and pastoral, using data from the National Native Title Tribunal, Aboriginal Land Rights Act (1976) for Indigenous, Collaborative Australian Protected Areas Database (CAPAD 2016) for conservation, and NT cadastre dataset for pastoral land use;

Dividing the entire NT into low (<600mm) and high (>600mm) rainfall regions because ERF scheme is currently applicable only to the latter but not the former;

Estimating the costs for loss of ES from the burnt area for each land use category, following the rationale that healthy ecosystems deliver ES that contribute towards human well-being (MA 2003 & 2005; de Groot et al. 2012; Costanza et al. 2014 and others).

To estimate the value of loss of ES from wildfires affected landscape, we assessed the cost of managing those ES (following de Groot et al. 2012; MA 2003) from each of the selected land uses i.e. Indigenous, conservation, and pastoral. Following a Top End study of valuing ES from Indigenous land by Sangha et al. (2017), the cost of managing the flow of ES as $780/km2 (in 2018 value; USD 5.6/ha in 2015) was used for the total burnt area. For conservation, the loss of ES was assessed applying a value of $865/km2 derived from the cost of managing national parks across northern Australia (Sangha et al. 2019a). For pastoral lands, loss of pasture production was considered applying a conservative value of $264/km2 for gross income from a large complied dataset from northern Australia (by Russell-Smith and Sangha 2018), using pasture, cattle production and financial income data from Holmes et al. (2017), ABARES (Australian Bureau of Agriculture Resource Economics and Sciences 2017), Bray et al. (2015) and others (details are mentioned in Russell-Smith et al. 2019).

Indigenous specific bushfire costs

Bushfire costs particularly for Indigenous lands were assessed applying a substitute value of welfare expenditure that Australian government spends on Indigenous people in the NT (following Sangha et al. 2017). The Steering Committee for the Government Service Provision (SCGSP 2017) reports on Indigenous Expenditure for six main welfare sectors, each with 3-4 sub-sectors. Out of those, only three relevant welfare sectors, i.e. developing safe and supportive environment; healthy lives with a sub-sector on public and community services; and enhancing economic participation, were selected. The average total welfare expenditure for an Indigenous person in the NT is $68,186 (values in 2015-16), but that amount for the selected sectors/sub-sectors was estimated at $29,544/person/yr (in 2015-16 values or $30,695/person/yr in 2018 values).

The rationale for this approach is that Indigenous people derive their substantial well-being benefits from being connected to country and the selected welfare sectors—economic, health and safe and supportive environment services—directly relate to country. In other words, we assume that wild bushfires affect the well-being of remote Indigenous people by compromising their economic opportunity, health, and safe and supportive environment.

The cost of wild bushfires in the NT was estimated only for the remote Indigenous population of 35,414 applying a substitute value of 25% of welfare expenditure on three sectors/subsectors, i.e. $7,673/person/yr (from a welfare cost of $30,695/person/yr in 2018 values). In doing so, a conservative approach was applied for considering only 25% of loss of benefits for three welfare sectors (out of six), as Indigenous people particularly in remote locations benefit multi-folds for being connected to country (as demonstrated by Burgess et al. 2009; Social Ventures Australia 2016; and others). Details of this methodology are published by Sangha et al. (2017; 2019b). All values are reported in AU$ (in 2018) except stated otherwise.

RESULTS

For the NT, the average (2000-2018) total area burnt by >1km^2 fires was ~250,000 km^2, comprising 20% of the entire landscape (Fig. 2a-d). There was marked contrast between high and low rainfall regions. Under low rainfall, ~83,000km^2 (5% of the region) was impacted compared to 166,000 km2 (15% of the high rainfall regions). Notably, wildfires >1km^2 area occurred on almost 98% of the entire burnt area (Fig. 2, Table 2).

To assess the wildfire costs, three scenarios were applied for the loss of ES from wildfire affected areas, each of size: i. >100km^2; ii. >10km^2; and 3. >1km^2, for each of the dominant land uses i.e. Indigenous, conservation, and pastoral (Table 3).

For extremely large fires of size >100km^2 (using long-term average fire frequency from 2000-2018)—Scenario 1, the total costs of bushfires were estimated at $95million/yr (Table 3). In relation to land use, bushfires on Indigenous lands cost $72.3million/yr, pastoral $16.5million/yr and conservation $6 million/yr. Each value corresponds to the management costs required to maintain the flow of ES from Indigenous and conservation lands, and the loss of pasture production from pastoral lands.

For wildfires >10km^2 size (Scenario 2), the total costs were estimated as $132million/yr (Table 3) where the loss was maximum for Indigenous land ($100million/yr), followed by pastoral ($21million/yr) and conservation ($11million/yr) lands. Assuming all wildfires of size >1km^2 affect ES and hence people's well-being—Scenario 3, the total costs then amount to $148million/yr. The bushfires costs for the loss of ES from Indigenous lands alone were estimated at $113million/yr, followed by loss of production worth $22million/yr from pastoral lands, and loss of ES worth $13million/yr from conservation lands (Table 3).

Out of three scenarios, scenario 1 is the most conservative for considering the costs of extremely large bushfires (>100km^2). Given that Indigenous people reside across the entire remote landscape where these wildfires occur almost every year, it is not inappropriate to consider scenario 3 for fire extent >1km^2, that costs ~$150million/yr.

Indigenous specific bushfire costs:

When costs are assessed for the loss of services and benefits from large bushfires for the Indigenous people living in remote areas, the losses are quite high. There costs were estimated for 35,414 persons who live remotely in the NT and visit their country minimally once a week (ABS census 2016). Applying a substitute value of $7.673/person/yr for loss of well-being benefits from a healthy country due to wildfire, the total cost of bushfires for remote Indigenous populations alone is estimated at $272 million per annum (Table 4).

DISCUSSION AND CONCLUSION

Extensive bushfires burn 20% of the natural landscape in the NT and cost about $150million per year. To date, there has been no accounting of bushfires related losses for the NT just because there are no human or infrastructure losses, unlike in the south, and that no measures are available to account for loss of natural systems or Indigenous well-being. This is the first study to our knowledge assessing the bushfire costs in the NT.

To date, the most well-known sources that report ND costs in the NT accounted only for cyclones (& storms), not for any other disasters. These sources include detailed national level studies by the ABRDR&SC (2017), Handmer et al. (2018), and Ladds et al. (2017). Among these, the most detailed report by the ABRDR&SC (2017) suggested a total cost of $50million/yr (average from 2007-2016) for the NT. Using those costs, together cyclones and bushfires cost about $200million/yr. Conversely, the loss of well-being benefits from wild bushfires for remote Indigenous population alone presents a loss of $272million/yr (Table 4).

This assessment should be considered an underestimate because:

The fire mapping archive used here does not discern fires that burn over multiple dates and so we have not accounted for some large fires (that have instead been classified as multiple abutting fires). While these larger fires are less numerous than relatively small ones, they nonetheless make up a major proportion of the total area impacted.

Only management costs are considered for maintaining the flow of ES from Indigenous and conservation estates, and gross income losses for pastoral estate while there are huge biodiversity and soil erosion losses which we have not accounted for.

The framework presented here is an initial attempt that can be improved in collaboration with ND agencies. However, we strongly suggest a mixed set of values including marketable and non-marketable i.e. $ and non-$ measures where appropriate to inform policies.

Most importantly, underlining wildfires-related loss of benefits for Indigenous people is critical to understand the total economic costs to plan for disaster management and resilience policies. It is well acknowledged that the entire northern landscape is imbued with Indigenous cultural and spiritual values (Archer et al. 2019). When wildfires destroy these indigenous imprints, our current techniques (applied by the Bushfires, Emergency or Fire Services) typically fail to even consider or list the loss of such values just because there is no loss of man-made infrastructure. If we want to develop resilience among Indigenous communities, it is important to understand community values of their natural environment and incorporate them into policy-decision-making. Hence, appropriate accounting of disaster related losses is essential.

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Natural Disaster impacts on human well-being	Economic indicator	Details and sources
Direct Marketable losses: private, business and public buildings, infrastructure, farmland, etc.	Insurance costs or loss of farm production using market value	BTE (2001); Handmer et al. (2018); and Ladd et al. (2017). Example: In Australia, loss of pastoral production is estimated for dry pastures at $30/ha, irrigated $370/ha, and fences 5000/km^2 (BTE 2001)
Direct Non-marketable losses: health injury and/or death	Loss of work opportunity over a person life span estimated by applying 'Value of a Statistical Life concept' (Handmer et al. (2018)	Handmer et al. (2018) Example: $4.2m is applied for loss of a statistical life, $853,000 for serious and $29,600 for minor injuries (Office of Best Practice Regulation 2014 and NRMA 2012)
	Alternatively, because human live is priceless listing the number of deaths is an adequate indicator itself to inform the policies.	We prefer to list the number of deaths without applying any monetary measure. However, serious and minor injuries could be costed as mentioned above.
Loss of ecosystems and their services	Affected area of all ecosystems, and related loss of key Ecosystem Services (ES) that are important for people's well-being (involves evaluating local people's values towards their natural systems applying marketable and non-marketable tools).	TEEB-ESV global database (van der Ploeg and de Groot 2010) offers monetary values for ES from different ecosystems (>1300 services); >600 ES evaluated by de Groot et al. (2012); >100 ES values listed by Costanza et al. (1997); and many others. Example: Loss of wetlands due to hurricanes estimated at US$33,000/ha (in 2007 values) in the US (Costanza et al. 2008).
Loss of cultural assets	Insurance losses or reconstruction costs for man-made structures, otherwise if such an asset is part of a natural landscape then measuring the monetary/non-monetary loss of asset's service.	Replacement methods or reconstruction costs can indicate the loss of natural-cultural assets. For loss of nature-related cultural sites, cost of managing natural-cultural lands or the value of lost services (tourism benefits) from the natural-cultural assets (World Bank Group and GFDRR 2017).
	Number of visitors and related travel costs can also reflect the value of lost asset.	Example: Loss of man-made cultural sites estimated from loss of income from tourism. In Nepal, 2015 earthquake damaged 750 cultural monuments, causing an estimated loss of US$600million over two years (World Bank Group and GFDRR 2017)
Indirect Marketable losses: Disruption of Businesses, communication and network, and public services, etc.	Cost of materials and services to restore businesses/services using surveys/reports, or extra costs incurred to meet the public or private needs.	BTE (2001); Gentle et al. (2001); Joy (1991) for ILR; Handmer et al. (2018). Example:
	Insurance Loss Ratio (ILR) or multipliers to understand the total costs for different kinds of natural disasters.	In Australia, the total average cost of cyclones, storms and bushfires and other ND estimated using ILR is $3.65billion/yr (in 2013 values) by Handmer et al. (2018).
Indirect Non-marketable losses: health, public amenity, electricity/gas/water services, etc.	Cost of restoring health, public amenity, and other services.	ABRDR&SC (2017); Handmer et al. (2018) and others have applied multipliers/ILR to estimate the total cost, and provide no measure of individual non-marketable losses.
	Indirect indicators such as number of people who lose access to, or the cost of re-building public amenities; health costs to recover; or the cost of government services (repayments to the public) during disruption of electricity/gas/water services.	However, these costs can be estimated both in monetary and non-monetary units. Example: Cost of loss of an urban park can be measured from the number of people who visited the park or reconstruction costs.

TABLE 1: FRAMEWORK TO MEASURE THE IMPACT OF ND ON PEOPLE'S WELL-BEING FOR VARIOUS DIRECT AND INDIRECT LOSSES

Average burnt area (km²) from 2000-2018	<600mm rainfall zone				>600mm rainfall zone				Total burnt area (km²) of the entire NT landscape
Land use	Indigenous	Conservation	Grazing	Total burnt area (km²)	Indigenous	Conservation	Grazing	Total burnt area (km²)	
NA/No fires	356,222	3,822	341,586	701,629	130,410	16,928	156,902	304,240	1,005,869
<1km²	598	11	221	830	2,880	444	882	4,206	5,037
1-10km²	2,299	37	946	3,282	13,656	2,171	4,283	20,110	23,392
10-100km²	6,945	91	3,781	10,817	28,888	5,290	13,378	47,556	58,373
>100km²	47,419	387	20,621	68,427	45,363	6,719	41,986	94,067	162,494
% total burnt area of respective land use	9.06	0.76	4.28	4.70%	14.37	21.07	10.14	15.19	20%

TABLE 2: LONG-TERM AVERAGE (2000-2018) BURNT AREA FROM WILDFIRES VARYING IN EXTENT FROM <1KM² TO >100KM².

Regions	>600mm rainfall zone	<600mm rainfall zone	Total loss (millions)
Scenario 1- burnt area >100km²			
Indigenous	$ 36,986,826	$ 35,382,804	$ 72.37
Conservation	$ 334,852	$ 5,811,531	$ 6.15
Grazing	$ 5,443,908	$ 11,084,314	$ 16.53
			$ 95.04
Scenario 2- burnt area >10km²			
Indigenous	$ 42,404,013	$ 57,915,811	$ 100.32
Conservation	$ 413,413	$ 10,387,273	$ 10.80
Grazing	$ 6,442,112	$ 14,616,027	$ 21.06
			$ 132.18
Scenario 3- burnt area >1km²			
Indigenous	$ 44,197,534	$ 68,567,498	$ 112.77
Conservation	$ 445,137	$ 12,264,935	$ 12.71
Grazing	$ 6,691,752	$ 15,746,842	$ 22.44
			$ 147.91

TABLE 3: BUSHFIRE COSTS FOR THE NT FOR >600MM AND <600MM RAINFALL ZONES (VALUES IN AUD 2018) APPLYING 3 SCENARIOS FOR FIRE EXTENT >100KM², >10KM², AND >1KM² USING LONG-TERM AVERAGE FROM 2000-2018.

Indigenous land	Indigenous population	Loss of well-being benefits due to wildfires ($/yr, values in 2018)
631,863 km² in total	Total population 58, 238 (ABS census 2016)	Assuming Indigenous people in remote locations directly benefit from having connections with country (SVA 2016, Sangha et al. 2017, 2019b; and others), there are substantial cost-savings for Indigenous welfare expenditure for the government for keeping Indigenous estate healthy and functional apart from biodiversity, reduced GHG emissions, and other benefits for the wider Australian public.
Bushfires >10km² size burn 128, 615 km² almost every year	35,414 living in remote locations	Applying a substitute value for only 25% of welfare expenditure on three sectors/sub-sectors: 1. A safe and supportive community; 2. Economic participation; 3. Healthy lives–public and community services, i.e. $7,673/person/yr, the total bushfire costs were estimated as $272million/year.

TABLE 4: BUSHFIRE COSTS OF FIRES >10KM² IN SIZE ON INDIGENOUS LANDS FOR INDIGENOUS PEOPLE IN THE NT.

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REMOTE COMMUNITY ENGAGEMENT CASE STUDY

BACKGROUND

This report provides a description of the development of fire management capacity in remote Indigenous communities through Indigenous Ranger Groups (IRGs) supported by the Department of Fire and Emergency Services Western Australia (DFES).

DFES have undertaken an 8-year program to develop community-based "volunteer" bushfire brigades initially mandated for 8 remote Indigenous communities, 3 in the west-Kimberley region. Chosen because their English language skills and education levels were the highest, and they were the most socially stable. This task has been driven by the Broome-based District Fire Officer, Lee Vallance, with support from the Superintendent and other DFES personnel. The main lesson being that simply throwing money and equipment at a community has not worked.

To date, the two communities, Bidyadanga and Nyul Nyul, have reached a phase where the IRGs have working brigades and, at Bidyadanga, this includes local council employees. DFES have provided sheds containing functioning fire units on working vehicles, and associated fire management resources, including a communications room, used to undertake a strategic prescribed burning program, and have provided training to respond to wildfire.

Darwin Centre for Bushfire Research staff based at Charles Darwin University, Kamaljit Sangha and Andrew Edwards, travelled with Lee Vallance in September 2018 on one of his weekly visits, to undertake a series of interviews with key personnel at the two communities. The intention of the research was to document the approaches taken to develop the current fire management capacity in these communities to then communicate a model to implement in remote, predominantly Indigenous, communities in other parts of the country and perhaps elsewhere.

In summary, a model for engagement can be guided through the following salient points:

Long-term agency support is required from trained personnel with the right understanding and consideration for the social, economic and cultural issues.

Agencies need to be patient in their support, and provide regular, flexible and appropriate training and resourcing.

Agency representatives need to seek the permission of traditional owners and other community elders, as it shows respect. Give the proper respect, and it will be returned.

The classic model of volunteerism has limited applicability in remote Indigenous communities for various social, economic and cultural reasons.

Fire management can be undertaken as part of the activities of broader landscape and community management. Some of these activities on some land should be fee-for-service.

INTERVIEW OUTLINE

DCBR researchers, Drs Sangha (Kamal) and Edwards (Andrew), flew from Darwin to Broome. Lee Vallance, District Officer from DFES, drove the group to the community of Bidyadanga, Figure 1. The group arrived as the Broome Shire Council were conducting an open meeting with the community, including the Mayor of Broome, the CEO of Bidyadanga Aboriginal Council, other key Broome Council staff, and members of the Bidyadanga Aboriginal Council. This provided the researchers with some insight into the local council structure, local government issues, a perspective from the nearby Broome (predominantly non-Indigenous) community, and locals who spoke up at the meeting.

FIGURE 2. THE EXTENT OF INDIGENOUS PROTECTED AREAS AND LOCATIONS OF KEY TOWNS AND COMMUNITIES IN THE WEST KIMBERLEY.

The group then went to the Police station and interviewed the Sergeant and Assistant Sergeant. The police are generally the first respondents to most incidents, especially a 000 call. Therefore, the interview was undertaken to ascertain the influence the Brigade might have had on emergency services and social issues, from their over-arching perspective.

The group then met with and interviewed the CEO of Bidyadanga Aboriginal Council (BAC), who is coincidentally the Captain of the Bidyadanga Volunteer Fire & Emergency Services Brigade. Most of the brigade are staff in the Municipal Services branch of the Council. The CEO is in the unique position to provide staff, who are volunteers, with flexible work hours to meet the demands of volunteering, particularly when she herself, as captain, is involved.

The group then met and interviewed the IPA coordinator with the Karajarri rangers, managing the Karajarri IPA, covering 32,000 km2, around Bidyadanga, Figure 1. The coordinator and the rangers are part of the brigade, having solely managed fire in the community until recently.

On Day 2, the group went to Beagle Bay to interview the Nyul Nyul Rangers. The Rangers included the Head Ranger, two Senior Rangers, and another Ranger. The rangers undertake all their own planning, prescribed burning and wildfire suppression. In consultation with the rangers, Lee has transformed a nearby shed for the Brigade. It contains a communications room, personal protection clothing, a truck with a slip-on fire unit and fuel.

INTERVIEW METHODS

Lee Vallance introduced us to each of the interviewees and attended each interview. Although his presence may normally have introduced bias into the responses, the trusting relationships he had with each person or group, his demonstrated capacity to kindly receive criticism, and his additional knowledge from the departmental perspective, lead us to believe that his presence was more valuable to the interview than not.

Interviews were undertaken in the form of a conversation based on the questions in Table 1, however a single line of questioning was often pursued, or allowed to flow, to allow the interviewees to relax and express a broader opinion.

The questions were separately asked by Drs Sangha and Edwards. Both researchers took notes of the conversations, Dr Edwards collated the notes at the end of each day with Dr Sangha.

1	The interviewees were asked about their role in the community, their normal working role, and role within the Brigade.
2	They were asked to describe their organisation, its roles and the number of personnel.
3	They were asked to describe the development of the Brigade, and their role in that process.
4	They were asked to describe the EM issues the brigade dealt with, and any other issues that they felt should/could be addressed aspirationally.
5	They were asked to describe the challenges in joining and continuing the Brigade.
6	They were asked to rate community preparedness.
7	They were asked for suggestions as to how to implement Brigades in other Indigenous communities.

TABLE 1: QUESTIONS FOR THE BIDYADANGA AND BEAGLE BAY INTERVIEWS

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Interviews

Bidyadanga Police – Senior Sergeant and Sergeant

The Senior Sergeant described the fire coordination effort, prior to the establishment of the Karajarri Rangers and, more recently, the Bidyadanga Volunteer Brigade (BVB), as "a loose band of people who, at one point, had attended a house fire with a garden hose."

Since the implementation of the Brigade, their combined ability to protect the community from wildfire has increased 100-fold. Previously, there was no coordination, no one to communicate with. Now, they contact the CEO of the Bidyadanga Aboriginal Council and Volunteer Brigade Captain, and she coordinates the response. The brigade has had the truck and shed for approximately 18 months, supplied by DFES, replacing a small red troopie and a busted radio. The two Ranger groups in the community have mostly undertaken certificate 4 in Land Management, providing them with fire management training. An example was described, however, of a recent category 2 cyclone, where the only initiative for clean-up was made by a bunch of New Zealanders visiting family who worked for the BAC, who had access to a chain saw, some of those people have stayed on in the community.

The community have only relatively recently started to take on their more serious social issues, it was felt that it was a "long step" to being able to undertake an EM response role. Police have applied for a grant for 2 community members to work on domestic violence. The monies would provide training and a salary. This is to work on prevention rather than arrest.

Police hold the incident plans for Land Search and Rescue, and Road Crash, and the guidelines for cyclone/storm arrangements. Police assist through communications and coordination, they feel they are very pro-active in the community in terms of their communication. Police are first response, they contact the clinic for the ambulance, then the Council CEO, as she has the volunteer phone list, then she contacts the volunteers to assist.

Bidyadanga Aboriginal Council – Chief Executive Officer

The CEO of the Council is also Captain of the Volunteer brigade. She has been Captain for a year, coordinating the volunteers. Lee works between the

the Volunteers and the Rangers. The Rangers will respond out of town, otherwise the volunteers will respond in town, although the Rangers undertake much of the town response. There are a total of 15 volunteers from 5 different groups. The CEO described the previous situation as "winging it". Municipal services team would show up to a fire in the little red truck, with assistance from local people with cultural training, then Lee showed up and said "get your act together". Currently they have a non-bespoke shed and one fire unit, and they're soon to acquire a light tanker. The CEO stated that their main limitation is the number of vehicles, which can only carry 4-7 people.

The CEO can provide flexibility to her staff to undertake their volunteer activities. They have all undertaken some Bushfire Fighter training, but she would like them all to do a lot more training, and get more exposure to fires, for experience and to build resilience in the community generally. The CEO felt the volunteer group were ready for some equipment upgrades, she would like a big truck, their activities are limited to the community but she felt they could help other communities around them, and undertake other EM activities such as attending accidents. She felt that unlicensed drivers were a limiting factor, and that perhaps there could be a bit more dispensation for remote community people with criminal records, as there was no need for a licence in town for instance.

The CEO felt that the most valuable aspect was that she and her colleagues were assisting on the front-line, not waiting for others from outside the community to come and help, "I'm part of the community preparing, not reactive. The homes and the community have been, and can be, threatened, you have to do something".

The CEO was grateful to Lee, stating that he has built good relationships with the community and the Council. He's involved the various community groups, not just the rangers, including the Council staff, such as herself.

Karajarri Rangers – IPA Ranger Officer

The Karajarri Rangers have been involved in prescribed burning on the Karajarri Indigenous Protected Area (IPA) for many years. The landscape wide burning program occurs through management of the Indigenous Protected Area and Working on Country funding through the Kimberley Land Council, there is no Savanna Burning project to support them, as the IPA is located south of the 600 mm mean seasonal rainfall boundary.

There is a Cert. 3 (Land Management) module for fire suppression that all the Rangers have studied, "but the best training occurs on the ground". 12 of the 15 Rangers are volunteers, the KLC has encouraged their involvement with the volunteer brigade, however the brigade and the rangers do not work together. The IPA Coordinator sees the value of the volunteer brigade as enhancing the overall capacity of the community, provides, through DFES, access to more equipment, and helps to free up more of Rangers' time. A limitation is the lack of integration between the rangers and other volunteers, they require more collective planning.

Most of their fire management work is out and about on the IPA. They don't feel that the community burning is too much work, they do it "out of necessity". They are seen as role models, appreciated by the community, Council, the Shire Council and even the neighbouring pastoralists. They are now at the fore-front of bushfire response in their region.

Although they don't have enough training now for cyclone response, The IPA Coordinator felt that they were ready to take on a significant recovery role. They have had some experience in Land Search and Rescue, an example was given of a lady lost at the lagoon nearby that they tracked.

The brigade has a fire trailer and 2 x slip-on units, but they're not able to be permanently attached, therefore they are slower to respond to a wildfire, whereas the DFES truck and unit are (sometimes) ready to go. There has been recent instances where they've gone to get the DFES unit and it has had no fuel or water, although they are very appreciative for the access to the truck. The wildfire season has been very busy this year. The rangers plan to set up a late dry season roster, to make sure that the same people aren't being used all the time.

The Rangers would like to have more consultation from the agencies (DFES), especially considering the recent big fire in the north of the IPA, they would have liked to have been consulted more, although Lee suggested that there wasn't enough time, he had to make a very quick decision. Lee also stated he was concerned about the rangers staying out on the fire line overnight.

The Ranger Coordinator felt that anywhere where there is a ranger group it would be possible to set up a volunteer group. Other volunteers tended to be less trained than the Rangers. The rangers care more about country as they're managing it more broadly than town-centric volunteers. The Rangers give 100%, an example was given of local volunteers fighting a fire while the rangers were away but left it before it went out, this they felt was due to a lack of commitment and probably training.

Nyul Nyul Rangers, Beagle Bay - Head Ranger (Volunteer Brigade Captain); Ranger coordinators, volunteers; Ranger, volunteer.

The Ranger Group consists of 9 rangers, 8 are volunteers, there are 8 other volunteers from the community in the brigade.

The Rangers undertook the burning previously. But now they have better resources. They only had 1 slip on unit. Rangers have undertaken training in prescribed burning, and response to, and suppression, of bushfires. The Head Ranger has completed the Sector commander training with KTI.

In the last couple of years, the group have been involved in the Dampier Peninsula fire working group. However, DPAW are an annual problem and won't work well with the other groups, and won't let the other groups do any burning.

A Senior Ranger said they love using the leaf blowers, example of one bloke with a blower can do the work of a crew with backpacks and rake hoes. Blowers can be readily used around houses to move away the leaf litter.

Recently native title has been handed down in the area, but previously the rangers did the burning on those lands. The Jaba Jaba people now want to do their own burning. Nyul Nyul would be prepared to do it or even provide training, but they want their own people to do it now, the Nyul Nyul want to support that, but in 2018, "Country lost out", that is, there were huge fires, as a consequence. DPAW are also supposed to work with Jaba Jaba more they don't.

Although no one was given permission to do prescribed burning, but then when there was a wildfire, permission was given in 1 day. The Rangers were excluded, they felt the fire could have been suppressed but instead the government staff did a huge back burn for safety's sake. "They killed all the Bilby's those bastards". A big easterly was obviously coming and DFES undertook a big roadside burnt hat burnt out a lot of country. This area is important country to local people, this was not considered, it was all about the supposed safety. They mentioned the District Manager from Parks & Wildlife. They're not listening to people who know country"". The road works that were being undertaken were more important than looking after country.

The volunteers are involved as casuals, if rangers are short of staff and they need extra staff for an emergency, then the Head Ranger, as Brigade Captain, will press others in the community to assist by using the Bushfires Act. He will take someone and assess the fire (as there's only one seat in the vehicle). Mostly this kind of thing falls to the Head Ranger or he might pass it on to the Senior Rangers. There have been a few structural fires in town, but they are not allowed to do anything, as they do not have the required level of training. Many have advanced first aid training, but not had a call to a car accident, probably due to the proximity to Broome.

The Rangers would like to put a siren near the brigade shed for cyclone warnings. Rangers are involved in Land SAR, or they assist with bogged vehicles. But if it's not an emergency then they won't respond.

They rated the preparedness of the community to deal with the Bushfires issues as 8/10, but still felt there was room for improvement. They did not feel there were any other, as cyclones never hit the community, and anyway, they said "the old people wouldn't leave".

They suggested improvements could be made with more resources, more capacity for vehicles to carry people like the twin cab trucks, that they could do with a light truck. They would like to train more people up, undertake training and be resourced for structural fire training, however they felt they were capable to deal with structural fire. They said they'd like a washing machine and more leaf blowers.

They felt that the weather criteria for permits to burn were not appropriate. That the council need to change the allowable wind speeds to burn on the ground, currently its's 25 km/hr but that's at 8 m not on the ground where wind speeds are much lower.

Although the group said that in the whole there are no real barriers for people to join the volunteer brigade, they believed that there should be some sort of fitness test.

They felt that belonging to the brigade had provided a stronger relationship between the Rangers and DFES (primarily Lee), it had given them much greater capacity and knowledge, and consequently much more confidence as a group. The Rangers liked the fact that the school kids get really involved in ranger stuff and it provides opportunities to get out on country, as they feel this important, they want to take the kids out to do burning, to teach them traditional knowledge and good fire management.

The Rangers felt that to improve the establishment of volunteer units in other communities that the agency representatives need to speak to the Traditional Owners first, and explain what they want to do. They could then feed off existing nearby Ranger or volunteer groups to assist with mentoring and training, roll the program out along a line. This is important as you are getting the right permissions, and it shows respect. Then you need a reliable and committed Ranger crew. They gave the example of the Head Ranger, who can be called away by DFES elsewhere, he will go even if he doesn't want to, because of his commitment to the brigade.

Department of Fire and Emergency Services – Lee Vallance (District Officer)

Lee visits the communities weekly, checks vehicles, replaces equipment where he can, and provides training during working hours (not after hours like other brigades). Lee believes this regular contact is important to their relationship.

There is expansive, almost uncapped, funding available for suppression. The prescribed burning budget is mostly for mitigation on pastoral properties. They must sign up for Aerial Controlled Burning. This is just policy, not part of the Bushfires Act. It is felt that if this wasn't available most of the pastoralists wouldn't do any mitigation work, they are required to have fire breaks, although this is not very practical and not enforced. Local government is supposed to enforce it. Lee is also required to go around to local councils to make sure they're undertaking mitigation activities around the towns, basically to protect WA government infrastructure.

Each of the groups have planning meetings in November/December, neighbouring pastoralists also come to the meetings. In the plans, importantly, Lee wants to know where not to go, e.g. sacred sites/areas, so as not to offend, and if he needs to enter an area and is not sure, then they will ask the right Traditional Owner. In the planning, they use NAFI burnt area mapping to draw lines for proposed burn lines. A permit to burn around town is required from the Local Council, the groups must submit a plan, including road management and all other risks.

Bidyadanga Aboriginal Council sit within the Broome Shire Council. They provide a lot of local employment, unlike Beagle Bay where they outsource a lot of the municipal services.

Lee is conscious not to ruin programs already in communities by coming in and running over them or rebadging them. Example of kids bush rangers WA program, run through schools, while the Emergency Services cadets are run similarly. There are 3 different groups with different governance and other structures. Lee is key to understanding this about each group, developing the relationships to be able to make the assessments and support the right people.

There is often concern from some of the volunteers in terms of their availability, but Lee assures them that they can only do what they can do, and tries to visit at times when they're around. An example is that many remote people go to town on the weekends and are not available to do training. Lee is not aware that there are any issues to do with gender separation, and actively discourages it.

"We have to be prepared as an organisation to take risks with remote communities and give them equipment and training", Lee gave the example of where sheds have been broken into, mostly, it seems, it is just curiosity by young people to see what is in there".

Lee has always had dealings with Aboriginal communities but it has only been the last 8 years he's been working on developing the brigades. It hasn't been done in this manner before, usually only ever in an emergency. Trying to do things differently by setting up brigades.

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INTERNATIONAL WORKSHOP TO FURTHER DEVELOP FIRE SEVERITY MAPPING

BACKGROUND

Many remote Indigenous communities in the tropical savannas of northern Australia reply upon "Savanna Burning" methods, as payment for ecosystem services, providing employment and supporting their livelihoods. The methods rely upon accurate science to calculate greenhouse gas emissions. The current methods use fire seasonality to discriminate emissions estimates, whereas fire severity, if mapped with adequate accuracy, will provide a greenhouse gas emissions method more appropriate to customary burning, by advantaging low severity fires, that has the added advantage of being of overall benefit to biodiversity.

In November 2018, we brought an international group of remote sensing scientists together to develop a collaborative program to increase the spatial resolution of current burnt area mapping programs and incorporate fire severity within them. This report firstly outlines the requirements for the products and summarises the findings of the workshop.

PARTICIPANTS

The attendees at the workshop included our long-standing collaborators from NASA:

Professors Luigi Boschetti from the University of Idaho and;

Professor David Roy from the University of South Dakota;

colleagues from the European Space Agency:

Professor Jose M.C. Pereira from the Instituto do Agronomia, Lisbon and;

Professor João Neves Silva from the Instituto do Agronomia, Lisbon;

colleagues from the Queensland Department of Science and the Environment:

represented by Dr Leonardo Hardtke;

colleagues from the NT Department of Environment and Natural Resources:

Dr Grant Staben and Mr Sun Jing;

colleagues from the NT's rural fire agency, Bushfires NT:

Dr Mark gardener and Mr Ken Baulch;

colleagues from the Darwin Centre for Bushfire Research:

Dr Rohan Fisher, Mr Cameron Yates, Mr Patrice Weber, and Professor Jeremy Russell-Smith;

and our long-time colleague:

Dr Stefan Maier from Maitec.

Also in attendance to help guide the appropriateness of the science were colleagues from the National Greenhouse Gas Inventory Team, including leading remote sensing scientist Dr Shanti Reddy.

SUMMARY

The mapping of the level of effect of fire on vegetation, referred to as fire severity, has the potential to increase the accuracy of greenhouse gas emissions and carbon sequestration calculations. However, unlike burnt area mapping, it is not readily discernible from a satellite image, meaning that it can not be manual mapped by a human operator. Automated burnt area mapping has yet to demonstrate the accuracy of semi-automated methods, improved by the complex interpretive capabilities of a human mind, with its abilities to discern context, colouration and texture, unlike any automated algorithm available today. Unfortunately, the intervention of a trained human mind is not possible with fire severity mapping as there are few direct optical links available through the bands available in an image derived from a satellite-borne sensor. The challenge for fire severity mapping then is to develop an automated mapping system that can be improved by ground observation in a pure machine learning environment, accounting for seasonal changes such as curing, soil moisture and deciduousness.

The Bushfire and Natural Hazards CRC has funded research into the development of a fire severity mapping system for a number of years. In this workshop, this body of research was examined and expanded through a collaboration from international scientists working in this field from NASA, the European Space Agency and leading Australian agencies.

The outcome of the workshop is further collaboration, and the opportunity to develop meaningful spatially explicit fire severity outputs to improve carbon farming opportunities.

INTRODUCTION

Many remote Indigenous people in north Australia are shifting to payment for ecosystem services (PES) economies, thus moving away from capricious government programs, and reducing risk to communities, empowering people economically, socially and culturally.

Many ecosystem services revolve around active land management, such as in joint management arrangements with national, state and territory conservation agencies; Indigenous Protected Area management through Working on Country funding; pastoral activities of one sort or another through the Indigenous Land Corporation. However, each of these arrangements still leaves people vulnerable to the vagaries of short-term government programs and funding directions. The natural answer to this problem is for them to move into non-government industries, such as "Savanna Burning".

The Savanna Burning program not only grew out of the need to provide better economic opportunities for remote Indigenous people in north Australia, but was initially a response by scientists to the obvious and accelerating demise of biodiversity, seen at the time to be strongly influenced by poor fire management. The advent of satellite based sensors in the 70's, and its free access from NASA in the 90's, provided scientists with real and regular images, deriving data regarding the distribution, occurrence, seasonality and severity of fires. Fires were noticeably far more wide spread and deleterious than in previous national assessments (State of the Environment 1996).

Savanna Burning uses robust scientific methods to describe greenhouse gas emissions abatement and carbon sequestration, but with a strong ecological focus. Management is forced to focus on reducing total area burnt, by implementing strategic EDS burning to mitigate wildfire in the LDS. Habitats that require a fire management regime not compatible with the methods are purposely excluded. For instance, floodplain areas do not dry out until very late in the dry season, when burning is disadvantageous to a carbon project, but, in many places they are burnt for traditional hunting and management, having been burnt in this manner customarily, therefore floodplain habitats are not included to allay any perverse outcome. Similarly, grassland habitats in many northern areas can be readily permeated by Melaleuca spp. (generally M. Viridiflora), converting them into woodlands. There are many species that inhabit these grasslands exclusively (Garnett and Crowley 1995, Russell-Smith et al. 2014). This suggests that customary fire management has maintained these habitats, without it, the reduction in these habitats will move some species to extinction. The grasslands need regular hot fires to eliminate the Melaleuca, again, the Savanna Burning program would be disadvantaged by this regime, and to reduce the possibility of losing this habitat, it is not included in the methodology.

To date, Savanna Burning methodologies have relied on the seasonal occurrence of fires. Emissions are related to the amount of biomass consumed, a high severity fire consumes more biomass, and therefore emits more gas. It is well understood that a certain small proportion of high severity fires occur in the early dry season (EDS), but that the majority of EDS fires are low to moderate (~95% in one study, (Russell-Smith and Edwards 2006)). However, in the late dry season (LDS) the distribution is more even, more like 30/40/30 for low/moderate/high, and sometimes even extreme, with documented evidence of extreme fires covering many hundreds of km2 (Edwards et al. 2018). Therefore, to improve emissions estimates, fire seasonality needs to be replaced by fire severity mapping, forcing fire management programs to restrain fire severity as much as possible in the appropriate habitats, and to assist those regions that feel they need, and can successfully, burn appropriately outside of the EDS constraint, such is a common complaint in north Queensland, although research would suggest otherwise (Crowley and Garnett 2000).

EDS fires are highly patchy and affect less of the vegetation, making them far more difficult to discern from satellite-based imagery (Edwards et al. 2018). The most useful means of reducing these inhibiting factors is through increased spatial resolution, however, it is the case with all available satellite sensors, that an increase in spatial resolution equates to a decrease in image swath width and temporal resolution. Thus, rapid detection is obviously reduced, but most importantly algorithms that rely on a specific window of change detection do not work as efficiently as they do for coarser resolution images with high temporal resolution.

FIGURE 3. EXCERPT FROM THE PRESENTATION BY DR STEFAN MAIER, ILLUSTRATING THE VARIOUS EFFECTS OF FIRE IN NORTH AUSTRALIAN TROPICAL SAVANNA EUCALYPT DOMINATED WOODLANDS

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RESEARCH APPROACH

Study area

The mapping required must cover the extent of the tropical savannas region experiencing > 600 mm mean seasonal rainfall and the main vegetation fuel types included in the "Savanna Burning" methodology, Figure 1. These habitats make up the vast majority of landscape types, including 15% Eucalypt Open Forest, 52% Eucalypt Woodland (both Lowland and Sandstone Woodland), 22% Eucalypt Open Woodland, < 1% Closed Forest (i.e. monsoon jungles), and 11% non-wooded areas (i.e. 0.8% Shrubland, 4.8% Tussock Grassland, 4.5% Hummock Grassland, 0.7% Sedgeland/Samphire etc).
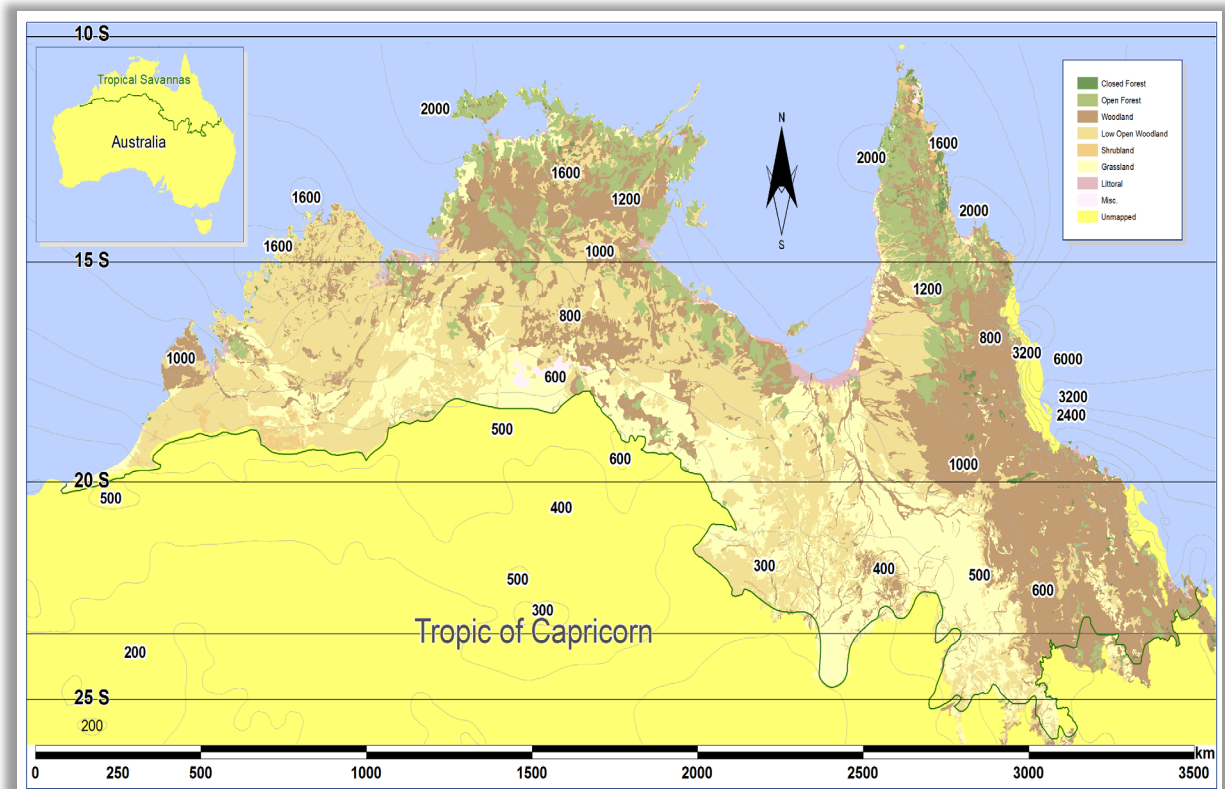

FIGURE 4. THE MAIN VEGETATION STRUCTURE CLASSES AND ISOHYETS OF RAINFALL ACROSS THE TROPICAL SAVANNAS OF NORTHERN AUSTRALIA (AFTER FOX ET AL., 2001).

Classification

Field guides have been developed for Boreal systems (Key and Benson 2006) particularly suited for North American and northern European systems, also for Mediterranean systems (De Santis and Chuvieco 2009) and, most relevant, local habitats (Edwards 2009). The field guide promotes five classes of severity for tropical savannas from a field observation perspective, however, with respect to remote sensing, it is clearer to delineate a severe and a not-severe (binary) fire severity classification, Figure 2.

The proposal for the binary classification system was discussed at length. The trade-off is between the classification accuracy and the accuracy of the classification, that is, having more classes provides for more detailed analyses of fire effects, but fewer classes improves the overall accuracy.
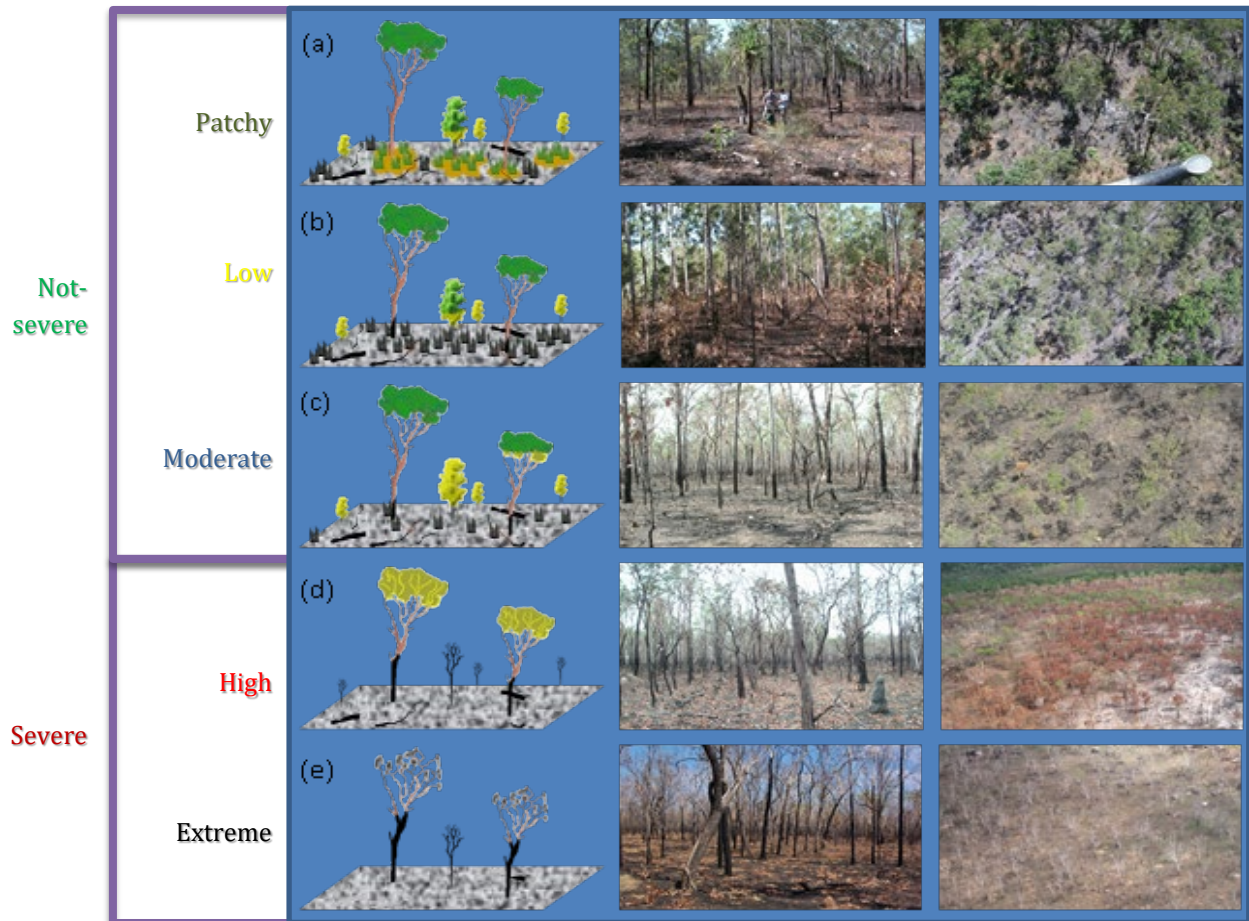

FIGURE 5. THE FIVE GROUND CLASSES OF FIRE SEVERITY, FROM LEFT TO RIGHT, A SCHEMATIC ILLUSTRATING SCORCHED (YELLOW) AND GREEN LEAVES AND BURNT UNDERSTOREY WITH VARIOUS PROPORTIONS OF UNBURNT, BURNT AND SCORCHED PATCHES, NEXT IS A HORIZONTAL IMAGE OF THE VARIOUS FIRE SEVERITY CLASSES, AND LASTLY ON THE RIGHT ARE AERIAL PHOTOS.

Binary classification applicability

The tropical savanna woodlands and open forest, are generally fairly simply constructed, Figure 3, containing very low proportions of biomass in the lower and mid-storeys. The study in the PhD thesis by Dr Andrew Edwards, detailed the measurements at over 30 eucalypt woodland and open forest sites (Edwards 2011). In unburned sites, the upper canopy contained an average of 45% of the biomass of the total upper canopy area, and 94% of the ground layer biomass area, using a point based method.

The Tropical Savanna Fire Severity field guide referred to earlier, was undertaken with a number of land managers, mostly working in conservation land management, and provided the notion, and support for the notion, of the binary classification.
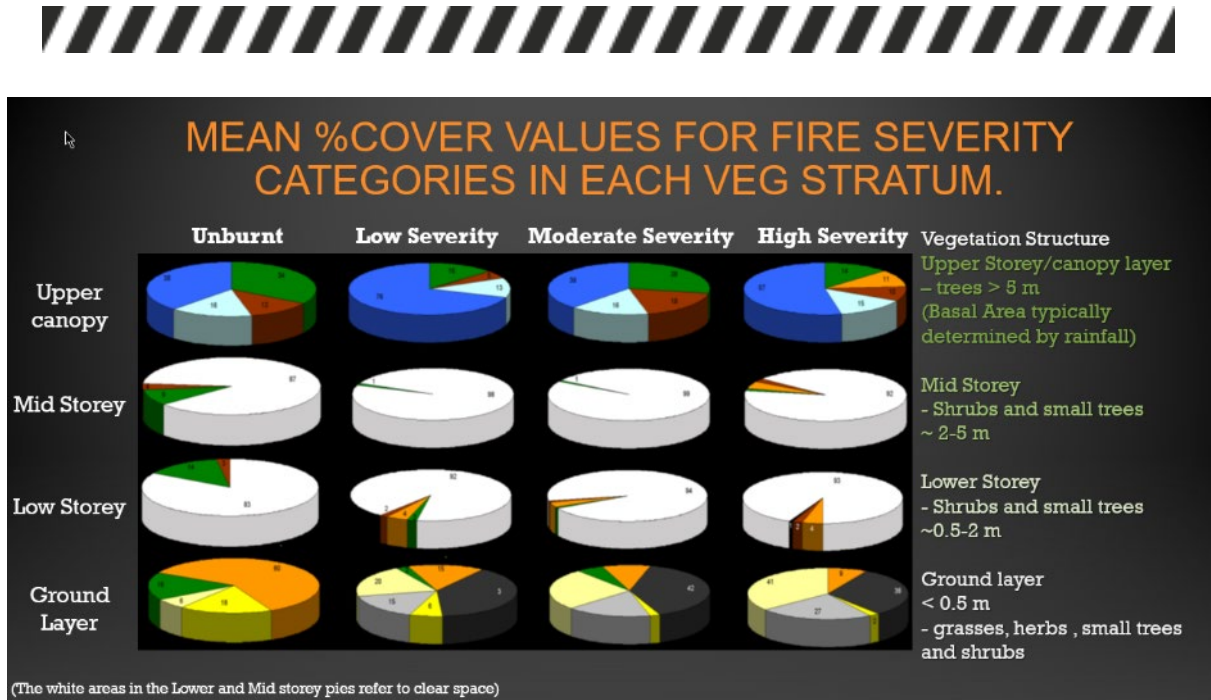
FIGURE 6. ILLUSTRATION OF MEASUREMENTS MADE AT 30 SITES IN TROPICAL SAVANNA WOODLAND AND OPEN FOREST IN THE TOP END OF THE NORTHERN TERRITORY. EACH PIE REPRESENTS A PORTION OF THE CANOPY (NOTED ON THE LEFT) AND THE FIRE EFFECT (NOTED ACROSS THE TOP). EACH PORTION OF EACH PIE REPRESENTS THE PROPORTION OF THAT PHENOMENON: MID-BLUE = OPEN SKY BETWEEN CANOPIES, LIGHT BLUE = OPEN SKY WITHIN CANOPY, BROWN= NON-PHOTOSYNTHETIC VEGETATION (E.G. TWIGS, STEMS, BRANCHES), GREEN = PHOTOSYNTHETIC VEGETATION (I.E. FOLIAGE), WHITE = OPEN AIR IN THE MID AND LOWER STOREYS, ORANGE = SCORCHED/DEAD LEAVES, YELLOW = CURED GRASS, LIGHT YELLOW = BARE GROUND, LIGHT GREY = WHITE MINERAL ASH, DARK GREY = CHARCOAL OR CHARRED LEAVES/STEMS.

Efficacy of fire severity mapping

The group workshopped an assessment of the various parameters of the greenhouse gas emissions calculations of abatement methodology that would be improved by replacing fire seasonality with fire severity, Figure 4.
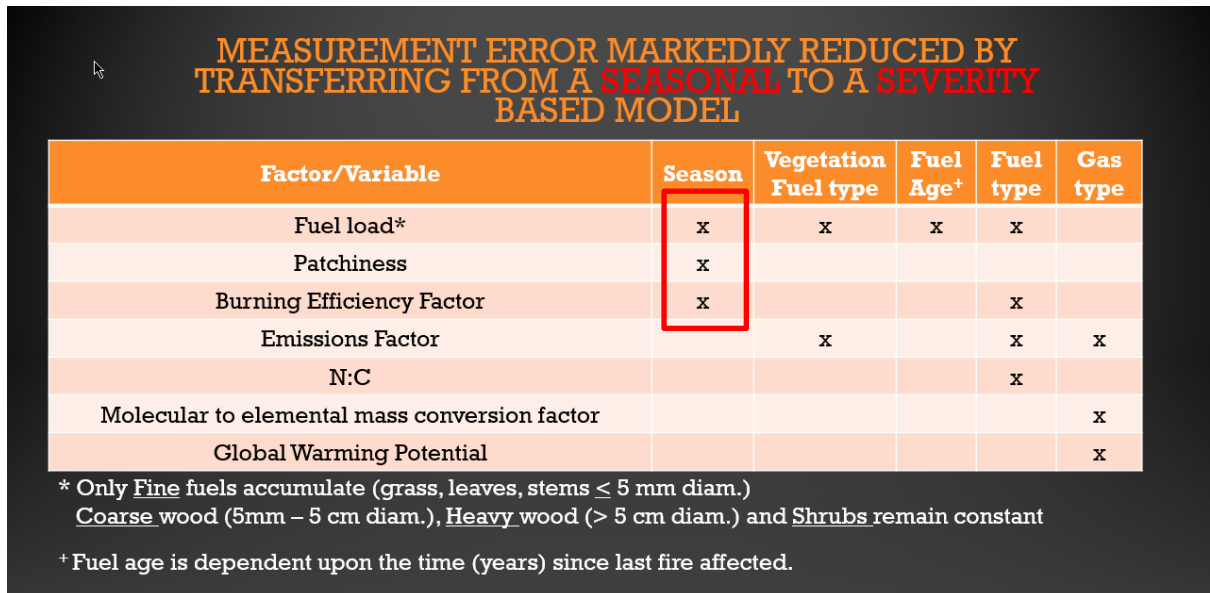

FIGURE 7. ASSESSMENT OF THE PARAMETERS INVOLVED IN GREENHOUSE GAS EMISSIONS CALCULATIONS.

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The latest method, however, attempts to model the accumulation of coarse woody debris and includes this in the summary calculations for greenhouse gas emissions, unlike the former methodologies that could not find significant relationships between coarse woody debris and the time since last burnt in the higher rainfall region and therefore used only a mean value measured at all sites, and although significant relationships were found for coarse woody debris in the lower rainfall region, again averages were used to be consistent with the high rainfall region.

A proportion of the study sites were burnt and biomass re-measured post-fire. Fire severity was scored according to the field guide, (Edwards 2009), but also scorch height (the strongest relative indicator of fire severity according to the findings of the field guide) and the height of all stems (thus providing mean tree height). Therefore, it is possible to determine the relative proportion of the canopy affected by fire, and a quantitative measure of the fire severity. This than can be applied to develop a relationship between fire severity and biomass burnt (fuel load), for different vegetation fuel types, in different seasons under the various climatic conditions. Similarly, for patchiness and, consequently, burning efficiency.

Indices in current usage

Work in northern Australia has focused on the development of a single fire severity algorithm that applies a threshold value of the relatativitism of the normalised burn ratio derived from the near and short wave infrared bands of the electromagnetic spectrum (Edwards et al. 2018):

1. Normalised Burn Ratio

NBR = ((Near Infrared) – (Short-wave Infrared)) / ((Near Infrared) + (Short-wave Infrared))

2. Change in NBR

dNBR = (NBRpre-fire) – (NBRpost-fire)

3. Relativised dNBR =

RdNBR = dNBR / (| NBR$_{pre-fire}$ |)$^{0.5}$

The indices have been applied in two major studies in the region as presented by Dr Edwards, Figure 6, indicating the variation that can be affected by two sensors of very different scale.
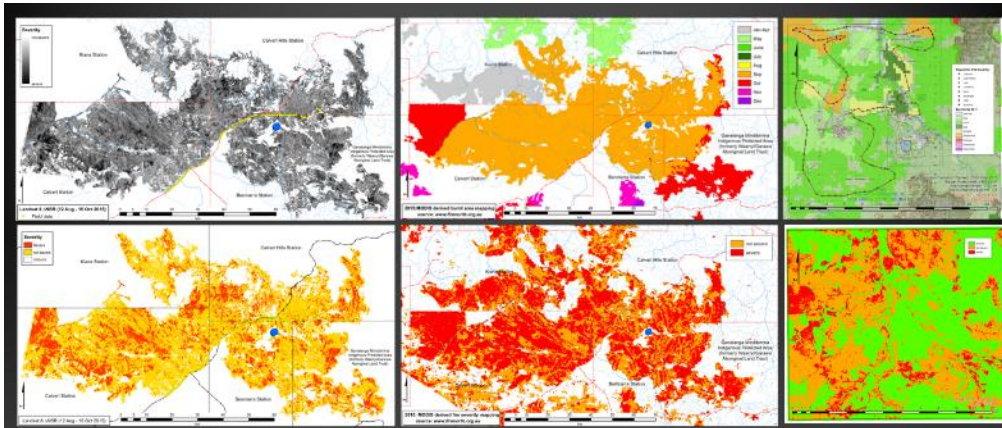
FIGURE 8. FIRE SEVERITY MAPPING RESULTS UNDERTAKEN BY DR ANDREW EDWARDS AND COLLEAGUES AT THE DARWIN CENTRE FOR BUSHFIRE RESEARCH. (A) LANDSAT DNBR SHOWING FULL SPECTRUM OF RESULTS WITH NO CLASSIFICATION, (B)MODIS DERIVED BURNT AREA MAPPING, (C) VALIDATION POINTS COLLECTED AT THE JABIRU STUDY SITE, (D) THE BINARY CLASSIFICATION OF THE DNBR LANDSAT 8-DERIVED MAPPING, (E) FIRE SEVERITY ALGORITHM APPLIED TO MODIS DIFFERENCE IMAGERY AND, (F) LANDSAT 8 DERIVED RDNBR MAPPING IN THE JABIRU AREA.

A different approach

Dr Stefan Maier and Dr David Roy are separately researching the possibilities of a spectral un-mixing approach, in north Australia and Africa, respectively, an example is given in Figure 7 and illustrated in Figure 8. It is neither scale dependent nor sensor specific, instead relying solely on the physical nature of fire severity, not an index, so no field calibration is necessary (nor readily possible, which is the counter argument for its application). To date, the field comparison looks reasonable, but very little validation data have been applied.

The Fractional Pixel Burnt approach allows us to directly measure the patchiness factor and therefore, the combustion completeness of the biomass and therefore negates the use of surrogates including seasonality. The assessment found that the shift of some fire regimes from EDS to LDS dominated patterns has reduced the severity of the LDS fires, possibly because the fires are smaller in size and less likely to progress into periods of adverse climate (e.g. high winds and temperatures).
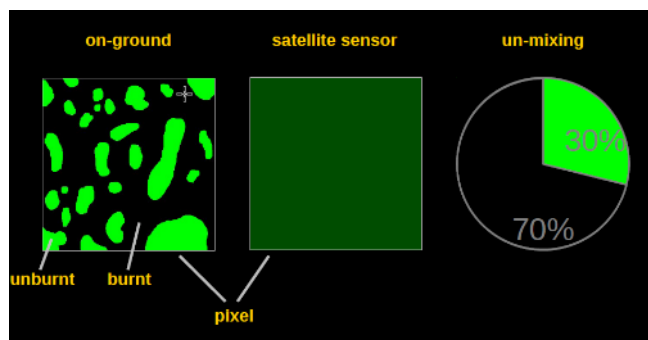

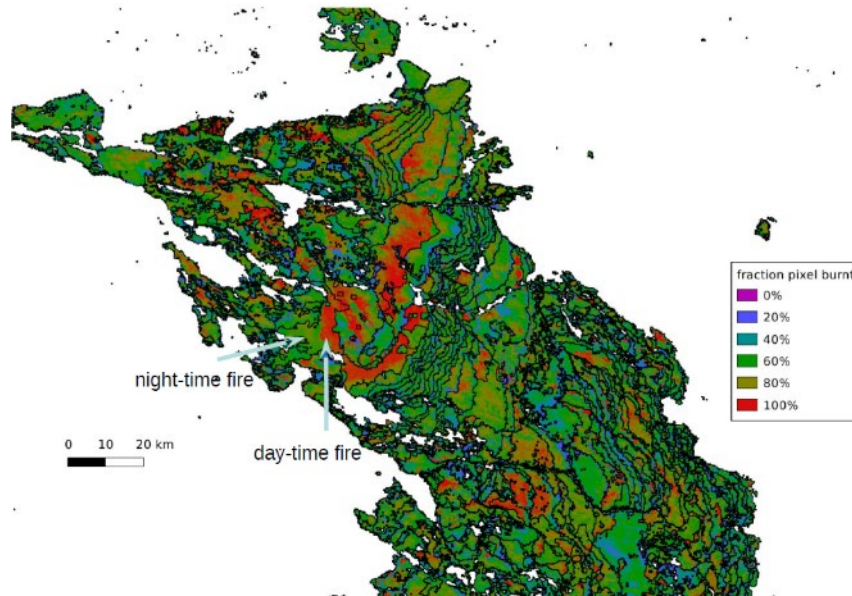FIGURE 9.SPECTRAL UNMIXING OF MODIS PIXELS (FRACTIONAL PIXEL BURNT).

FIGURE 10. EXAMPLE OF FRACTIONAL PIXEL BURNT ALGORITHM APPLIED TO AUTOMATED BURNT AREA MAPPING.

Further applications

At the time of the latest research into the application of fire severity mapping indices, previous studies by the CSIRO in Darwin had found no significant influence of fire regime (that is high versus low severity fires) on tree stem mortality, and living tree biomass overall. Coincident with the research undertaken by Edwards et al. (2018) on fire severity mapping was research into the effect of extreme severity fires on tree stem mortality, Figure 9. The overall proportion of extreme fires is, as yet, unknown but it was identified as a signifncant effect in terms of the proposed methodologies to incorporate Living Tree Biomass calculations into Carbon Sequestration methodologies.
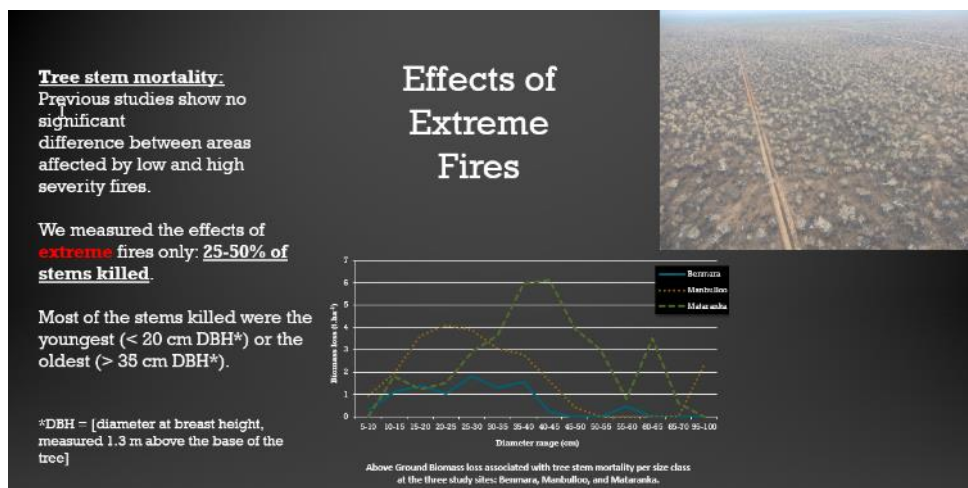

FIGURE 11. EXTRACT FROM THE PRESENTATION BY DR ANDREW EDWARDS, ILLUSTRATING THE MEASURED EFFECTS OF EXTREMELY SEVERE FIRES

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Outcomes

The workshop was very successful in bringing together some of the latest international and Australian research and offered many future opportunities to develop fire severity mapping programs.

Dr Roy from NASA offered to use his Fractional Pixel Burnt mapping program being applied in Africa to areas in north Australia. DCBR have an extensive field dataset describing fire severity across many hundreds of kilometres of helicopter transect that can be readily used to calibrate the classification and assess the accuracy.

Dr Leo Hardtke from the Queensland Department of Science and the Environment, has a machine learning system that will, initially, only map burnt areas, as this is the product that fire managers in Queensland are most interested in having, especially in higher density areas where the scale is of MODIS derived data is too coarse to meet their needs. However, the system Leo is developing leaves it opens to the possibility of readily applying the thresholds developed in the north Australian research.

The Index approach has been tested and provides reasonable results, Figure 10, however relies upon a single threshold to characterise fire severity, it does not account for geographic, topographic, climatic (i.e. seasonal) differences, to most simply calculate fire severity. The data exist to account for these differences and is possibly the most strongly identified future research program for consideration in order to develop an all of north Australia fire severity map product. This would require a machine learning approach where the temporal as well as the location attributes are used to derive the classification. Also, importantly, it needs to use the masking from the NAFI derived fire mapping as it consistently provides far greater mapping accuracy, especially in terms of omission error, Figure 11.
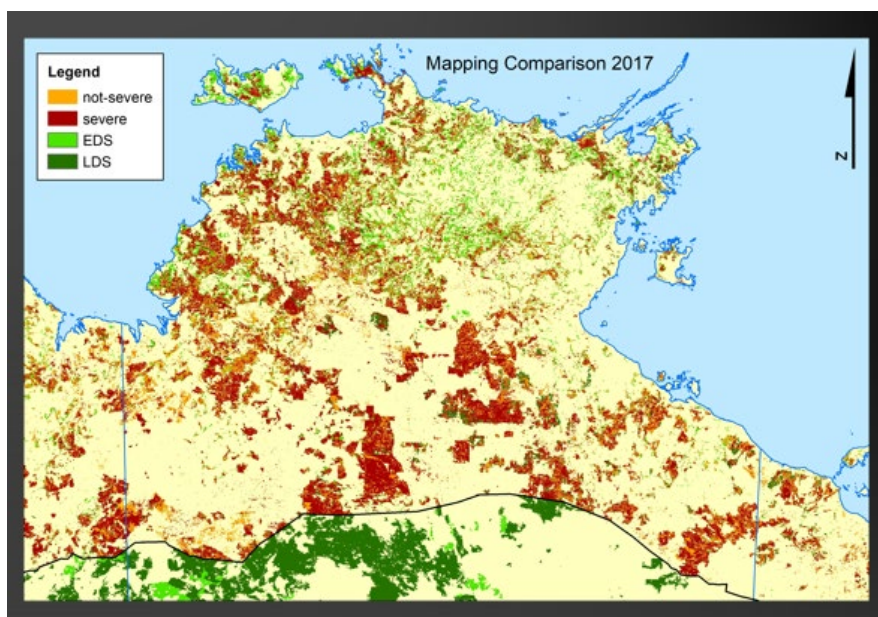

FIGURE 10. A COMPARISON OF THE NAFI BURNT AREA MAPPING CLASSIFIED FOR THE EARLY DR SEASON (EDS AND LATE DRY SEASON (LDS) IN COMPARISON TO THE OUTPUT OF THE AUTOMATED FIRE SEVERITY MAPPING, FOR THE TOP END OF THE NORTHERN TERRITORY, AUSTRALIA.

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Russell-Smith, J. and A. C. Edwards (2006). "Seasonality and fire severity in savanna landscapes of monsoonal northern Australia." International Journal of Wildland Fire **15**(4): 541-550.

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SCENARIO PLANNING: BORROLOOLA

BACKGROUND

We had a whole-day meeting with the Garawa and Waanyi Garawa rangers from Borroloola on the 11th of June 2019. Since September 2018, a few meetings were planned but cancelled at the end due to several unfortunate incidents in the community, the wet season, and a cyclone that hit the region earlier in 2019.

The purpose of this meeting was:

- To learn about, discuss, and help revive the rangers' interest to participate in emergency management at a community level

- To inform and discuss DFES's Broome model of volunteer brigades in the Beagle Bay and Bidydangg communities

- Scenario planning workshop – Business-As-Usual vs Future Directions

- To learn about the rangers' experience befoe and after cyclone Trevor

- To see the rangers' interest and participation in an EM-related mutli-stakeholder workshop to be organised in August, in Darwin.

PARTICIPANTS

Rangers: Donald Shadforth, Peter Green, Robert O'Keefe, Jack Green, John Green, Karen Davey and Josie Green

Ranger Co-coordinator, Ed Slade, and the IPA coordinator, John

CDU researchers: Andrew Edwards and Kamaljit K Sangha

OUTCOMES

Ranger participation in Emergency Management (EM) services

The rangers expressed interest to participate in Em and related community level services. The community experienced the category 3 cyclone "Trevor" that landed in the region hitting Borroloola on the 23rd of March 2019. The lack of involvement before and after the event, yet again, made the rangers rethink the role they can play in EM planning and services. The EM agencies in the NT do not recognise the role these rangers can play in EM unless they are registered as volunteers, having the appropriately certified training.

A senior ranger and others felt that they could do a good job, saying "we should be going and talking to our people…before EM agencies come, and talking to our people…we should be informed beforehand". This instigated thinking among the rangers for how they could be involved and become part of the EM activities that happen in the community. At this stage, the main option is to join the local volunteer brigade. All the rangers agreed that to help their own community, they need to become the members of the brigade.

The CDU researchers have contacted the main station officer in Katherine and the Captain of the Volunteer Brigade in Borroloola. We hope to organise a meeting soon with the rangers and the Captain of the Brigade to understand the obligations of joining a brigade and related paperwork.

Joining a volunteer brigade was also discussed in a workshop last year but due to lengthy and cumbersome procedures, and requirements for photo ID, police checks, and constant availability of a phone number for the members, the rangers withdrew. We hope to discuss some alternatives for those concerns with the Captain this time.

Analysis: Beagle Bay and Bidydanga volunteer brigade models

To help improve emergency management and service delivery in Borroloola where locals (and the rangers) are hardly consulted, the researchers shared their knowledge of DFES's (Department of Fire and Emergency Services, WA) volunteer brigades that are established in the Beagle Bay and Bidyadangg communities in the Kimberley. Those brigades are currently operating quite well in participation with the rangers, locals and other community organisations.

These remote community volunteer brigades were established after 8-9 years of persistent, ongoing and dedicated involvement of a district officer and superintendednt from DFES to work with the community members. Each brigade includes a building (shed), a fire-truck, uniform and regular training for the volunteers, in each of the community. As a result, the local communities are reliable and confident to manage emergency situations, particularly bushfires, in their local regions.

This model provided some ideas and thoguhts for the Garawa and Waanyi Garawa Rangers regarding involvement in emergency management planning and services. However, it is obvious that accessing brigade resources like in Beagle Bay and Bidyadanga is still a long way off for the rangers. In Borroloola, there are some resources such as a boat, a fire truck, etc. managed and housed by the Council and the local Sea Rangers with Mabunji, as discussed in the earlier meetings, with limited access to any outside organisation/person. To access the resources, one has to be a member of the brigade.

Scenario Planning workshop: 'Business as Usual' and 'Future Directions'

We conducted a Scenario Planning workshop with the rangers, utilising their recent experience of cyclone Trevor, and interest to do better in emergency services for their community. For this, we discussed two scenarios, Business as Usual (BAU) and Future Directions (FD).

The BAU scenario was based on emergency planning, management and services are currently being delivered by the NTES/FRS/Police, with no involvement by the Rangers nor access to resources. This top-down approach, is delivered by agency rules. To illustrate the current situation, a senior ranger gave a few examples: "the Council burns the town area but without consulting people in the camp where some Aboriginal families live, and some of them suffer from asthma…who could be taken out to safe places". Currently, there is no community consultation for burning around the town. The BAU Scenario helped to understand that this situation and that frustration will continue.

Alternatively, the FD scenario involved discussions around what the rangers could do to bring a positive change to the community. One key aspect that all the rangers mentioned was the need to involve young people, especially in the ranger program, with a hope to make them responsible. In the future, the rangers are looking for a female ranger coordinator, a ranger-base at Nicholson block, recognition of their work in the community, and taking a lead role in the event of bushfire threats. From an EM perspective, the rangers see themselves burning around the community, contacting and informing the locals to prepare for emergency events, and helping in the clean-up process after the event. However, this may require establishing fee-for-service arrangements for the rangers to be able to do that work.

The Garawa & Waanyi Garawa Rangers demonstrated an interest in the implementation of the FD scenario, particularly in the EM context. The next step is to consult with the other organisations/stakeholders in the town such as the Council, NTES/FRS, Police, via a multi-stakeholder scenario planning workshop which can help to highlight the benefits of involving and working in participation with the rangers and traditional owners in the Borroloola community.
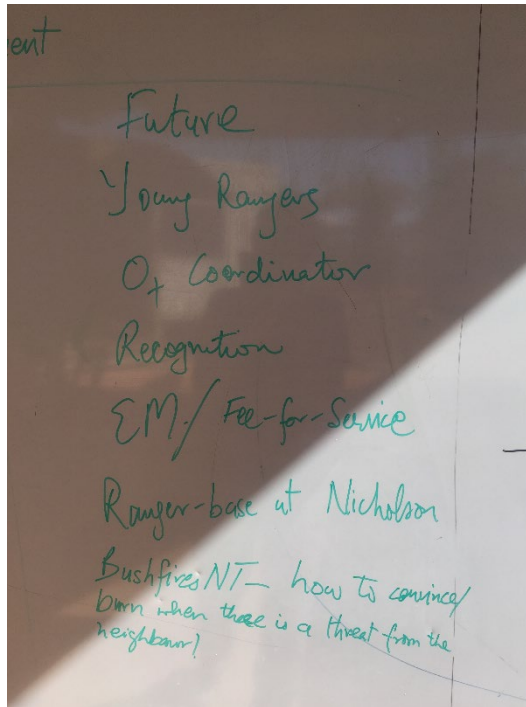
IMAGE 2: SCENARIO PLANNING WORKSHOP – 'FUTURE DIRECTIONS' – SCENARIO DISCUSSIONS WITH THE RANGERS IN BORROLOOLA

Cyclone Trevor: the ranger experience

Cyclone Trevor landed in the Gulf region on the 23rd of March (Saturday) 2019 as category 3 and then was downgraded to a Tropical Low soon after. The Borroloola community was evacuated before the cyclone on Friday, the 22nd of March 2019– some drove in their own cars to Katherine, and others were transported to Darwin via Australian Defence Force planes. Camp sites were set up at Katherine and in the Marrara auditorium in Darwin.

The rangers realised that the EM agencies didn't check the outstations properly. The agencies contacted the ranger coordinator to ask if there is someone at the Nicholson block outstation on the 23nd of March, the day cyclone Trevor landed, while the community was already evacuated. The rangers felt that "we should be going and talking to our people…before EM agencies come and talking to people…", and even "afterwards, we should be utilizing our chain cutting skills, not the contractors from Katherine. We could help them clean-up. We want to be part the team, with support from Mabunji-Sea Rangers." The rangers felt that no body from the EM agencies asked for their help, instead the contractors were brought in from Katherine. During the clean-up, the ranger coordinator and a ranger met with a person who was involved in clean-up, he said they will get back to them…but that never happened. In fact, during recovery contractors cut down trees without consulting the locals (and the rangers). In Robinson river, the contractors cut all the big old tree that upset people. Some junior rangers from Robinson River worked (as a labourer) with the clean-up team but none of the senior rangers were involved in consultation.

The experience before and after cyclone Trevor made the Rangers feel that it's important for them to be involved in emergency management and service delivery around the community, and now want to join the volunteer brigade, although there are issues with the procedure and paperwork required to fill-in the forms to become a volunteer. Along with that, the CDU team will liaise with the NTPFES, the main EM agency in the NT, to express the community concerns. There is a plan to hold a multi-stakeholder workshop, including the rangers and the NT EM agencies, in Darwin from 19-23 August.

A multi-stakeholder EM workshop, Darwin, 19-23 Aug 2019

As a main initiative for improving emergency management in remote communities, a multi-stakeholder workshop is planned for August 19-23, 2019. The workshop participants include Indigenous rangers and traditional owners (~20) from different communities across the Top End, representatives from emergency management related government agencies (e.g. NTES, FRS/Red Cross), researchers, and Indigenous organisations. The main focus will be how to effectively engage the rangers and traditional owners in emergency management related planning and service, what models can work, an understanding of how and why NTES/FRS operate in particular ways, and how emergency situations can be better and effectively managed in remote communities.

As an ongoing part of the project, we are assessing the cost of bushfires for the NT. For that, a preliminary assessment was conducted, and results will be reported at the AFAC 2019 conference. A copy of that paper will be uploaded in the directory.

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KEY MILESTONES

2.1.1: Scenario Planning workshops in selected remote indigenous communities

During this quarter, we visited the Garawa & Waanyi Garawa Rangers in Borroloola, The Tjuwanpa Men Rangers in Hermannsberg and interviewed Benji Kenny, the Tjuwanpa Men Rangers Coordinator. We undertook a series of interviews with each of the groups as part of scenario planning.

2.1.2: Posters and/or Conference Papers for BNHCRC Conference

We supplied the AFAC conference with a paper and posters outlining our work over the past year.

2.1.3: Quarterly Report

The quarterly report summarised the various interviews, meetings and publications we undertook or produced in the period.

2.2.1: Reports distributed to communities on Scenario Planning workshops

In this quarter, we were invited over to Broome by Grant Pipe and Lee Vallance from DFES WA, to undertake interviews with two of the local Indigenous Ranger Groups who have successfully integrated their work programs into the local Volunteer Brigade.

We have since summarised the processes and conditions that have made this program successful.

2.2.2: Report on the assessment of the multi-scaled calibration of high resolution burnt area and fire severity mapping

In this report we collated and distilled all of the available information required to undertake high resolution burnt area and fire severity mapping for the ;savanna regions of Australia.

2.2.3: Quarterly Report

The quarterly report summarised the various interviews, meetings and publications we undertook or produced in the period.

2.3.1: Consultations with remote Indigenous communities and end-users about planning activities to date

In this quarter, we reported on the consultations undertaken with the Galiwinku community on Elcho Island. The Galiwinku community is in the unique position to have been impacted on by two Tropical Cyclones in a short period. Their journey from having little recognised role in the disaster response to now has seen significant change in the way they represent their governance to the government and similar institutions.

2.3.2: Journal articles submitted for BNHCRC approval on "Multi-scaled calibration of burnt area and fire severity mapping" & "Preliminary findings from scenario planning activities in remote Indigenous communities of north Australia".

In this quarter, a paper was developed and submitted for submission to the Australian Journal of Emergency Management. Entitled "Long-term solutions to improve emergency management services in remote communities in northern Australia" this seminal paper sets out a framework for engaging with remote Indigenous Australians to improve emergency management capabilities.

2.3.3: Quarterly Report

The quarterly report summarised the various interviews, meetings and publications we undertook or produced in the period.

2.4.1: Analysis of the feedback provided from the Scenario planning workshops in remote Indigenous communities.

In this period, we continued the development of the scenario planning strategy for the Garawa and Waanyi Garawa Rangers in Borroloola. We have worked with the rangers for a number of years, and seen many set-backs due to inter-family fighting, particularly to do with mustering on the Nicholson Block, with respect to the Section 19 process undertaken by the Northern Land Council. Also, earlier in the year, Borroloola had been impacted by a cyclone.

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UTILISATION AND IMPACT

SUMMARY

Other than the publications, there have been three major outputs in the past year of the project:

1. A summary report of the assessment of Indigenous Rangers in Volunteering in the Broome region

2. A framework developing a joint platform to manage natural disasters in remote locations

3. A report summarising the research undertaken to date to develop appropriately scaled burnt area and fire severity mapping.

INDIGENOUS VOLUNTEERING

The report developed from this preliminary research has provided DFES and DCBR with further funding from the WA NDRP to continue the data gathering aspect of this research. Then the work will also be further developed within a Utilisation Contingency Funded project to collate this and similar data.

JOINT PLATFORM FRAMEWORK

This seminal paper was published in the Australian Journal of Emergency Management, providing a wide audience for further discussion and expansion.

MAPPING

Two papers have thus far been published within the project outlining methods and undertaking a comparison of methods and results for mapping burnt areas and fire severity, at multiple scales across large and small areas. In this past year we convened an international workshop to discuss new methods for burnt area and fire severity mapping, that will be implemented over the next year.

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NEXT STEPS

AIDR WORKSHOP

A consortium of Charles Darwin University researchers from the Aboriginal Research Practitioners Network (ARPNet), the School of Humanitarian Response & Disaster Management Studies, and the Darwin Centre for Bushfire Research have been working together with NT Emergency Services Agencies (Bushfires NT, NT Emergency Services and the NT Fire and Rescue Service) to develop a workshop to enhance remote Indigenous community capacity to work with the agencies by developing leadership skills. The funding has come from the Australian Institute of Disaster Resilience and will provide 20 senior Indigenous community members, mostly senior Rangers, with the opportunity to upskill their engagement with the NT EM agencies.

UTILISATION

The Northern Hub of researchers have applied for three separate projects through the Utilisation Continency Funding that we hope will greatly advance the research we've undertaken to date:

1. A new version of the very popular Savanna Burning Book. First developed by the Tropical Savannas CRC and published in 2001, this volume was developed before any extensive long-term monitoring programs had been developed, and although it provided great ideas for improved fire management, little or no research had been undertaken with respect to Carbon.

2. Many components of all the Northern hub projects have substantial contact working with remote Indigenous Rangers and other community members. The UCF project hopes to bring all of this information together to provide a guide for Indigenous people to engage with emergency management agencies, and vice versa, provide the agencies with principles and guidelines to best work with remote Indigenous Australians.

3. The Savanna Monitoring and Evaluation Reporting Framework (SMERF) has undergone significant development in the past twelve months. A thorough quality assessment process was undertaken with Queensland Parks & Wildlife Service operational personnel from Far North Queensland. Funding obtained through the B&NH CRC Utilization Contingency Fund allowed us to create an automated on-line reporting tool. However, user engagement has identified the need for a more dynamic interface using Javascripted infographics.

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PUBLICATIONS LIST

PEER REVIEWED JOURNAL ARTICLES

Edwards, A. C., J. Russell-Smith and S. W. Maier (2018). "A comparison and validation of satellite-derived fire severity mapping techniques in fire prone north Australian savannas: Extreme fires and tree stem mortality." Remote Sensing of Environment 206: 287-299.

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Russell-Smith, J., Sangha, K.K., (in press) "Beneficial land sector change in far northern Australia is required and possible—a refutation of McLean and Holmes". Rangeland Journal.

Sangha, K.K., Edwards, A.C., Russell-Smith, J., 2019. "Long-term solutions to improve emergency management services in remote communities in northern Australia". Australian Journal of Emergency Management 34 : 62-71.

TEAM MEMBERS

The Scenario Planning project is part of the larger Northern hub group of projects working with remote Indigenous communities in the NT to develop appropriate community-based training, providing economic opportunities to enable community engagement with emergency management and land management agencies, and community engagement.

RESEARCH TEAM

Professor Jeremy Russell-Smith – Project Leadership.

Jeremy is project leader for the suite of Northern Hub projects. Jeremy has long been involved with research to understand, monitor and evaluate the effects of fire in the tropical savannas. This has involved research on Indigenous land and with Indigenous people to meet their aspirations to provide economic opportunities to live back on country and manage it.

Dr Kamaljit K Sangha – Ecosystem/Economic Evaluation.

Kamal uses data derived to value ecosystems and the services they provide to calculate the economic opportunities available. In this project, Kamal is looking at the various fee-for-service and other economic opportunities for remote Indigenous communities to be involved in emergency management.

Dr Andrew Edwards – Spatial Science.

Andrew works with maps and spatial information to illustrate and assess fire effects in the tropical savannas. Deriving burnt area mapping from satellite imagery he has created fire history mapping and collected field data that he has used to develop ecological models. In this project, Andrew is further developing tools to assist with bushfire monitoring and evaluation.

END-USERS

Queensland Parks & Wildlife Service:

Michelle Ibbett, Chris Kinnaird, Marty McLaughlin, Nathan Connor

WA Parks and Wildlife Service:

Phil De Bruyen, Ben Corey, Ian Radford

Bushfires NT:

Mark Gardener, Andrew Turner.

Parks & Wildlife NT:

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Jonathon Vea, Liesl Wilson, Belinda Oliver, Lincoln Wilson, Sarah Kerin

Garawa & Waanyi Garawa Rangers:

Jack Green, Donald Shadforth, Robert O'Keefe

WA Department of Fire and Emergency Services:

Lee Vallance, Grant Pipe.

Jonathon Vea, Liesl Wilson, Belinda Oliver, Lincoln Wilson, Sarah Kerin

Garawa & Waanyi Garawa Rangers: