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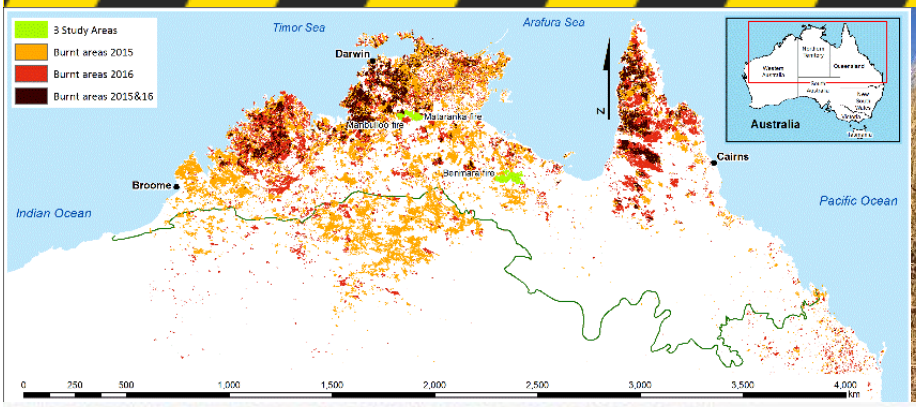
SAVANNA FIRE MANAGEMENT AND BUSHFIRE AND NATURAL HAZARD SCENARIO PLANNING FOR NORTHERN AUSTRALIA

Annual Project Report 2016-17

Professor Jeremy Russell-Smith
Darwin Centre for Bushfire Research



DCBR
Darwin Centre for Bushfire Research
Research Institute for Environment and Livelihoods
Charles Darwin University

Version	Release history	Date
1.0	Initial release of document	13/09/2017

Publisher:
Bushfire and Natural Hazards CRC

July 2017

Citation: Russell-Smith, J. (2017) Savanna fire management and bushfire and natural hazard scenario planning for northern Australia: annual project report 2016-2017. Bushfire and Natural Hazards CRC, Melbourne.

Cover: Clockwise from top left: 1. The three study areas involved in a fire severity tree mortality assessment illustrating Burnt area mapping from the North Australia Fire information (NAFI) data portal. 2. Dense infestation of the high biomass grassy weed, gamba grass, Batchelor, NT. and 3. Waanyi-Garawa women rangers working with PhD candidate Kate Van Wezel.

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ABSTRACT

SAVANNA BURNING IN NORTH AUSTRALIA

Professor Jeremy Russell-Smith
Darwin Centre for Bushfire Research
Charles Darwin University
Northern Territory, Australia

The ***Savanna fire management and BNH scenario planning for northern Australia*** project is part of a larger suite of Bushfire and Natural Hazards CRC projects being undertaken through Charles Darwin University focused broadly on '*Building community resilience in northern Australia*'. Collectively, these projects aim to promote enhanced understanding of the special circumstances concerning resilience issues in remote Indigenous communities, and identify culturally appropriate governance arrangements and enterprise opportunities that can contribute to enhancing community development and resilience.

We report here on activities undertaken in 2016-17 for four sub-projects: ***Savanna fire management***, ***Management of flammable high biomass grassy weeds, Gulf fire management,*** and ***Scenario Planning***.

The ***Savanna fire management*** sub-project (undertaken by Dr Andrew Edwards CDU) commenced late in 2013 and provided its final report through the current reporting year. The sub-project continued with the work on savanna-wide fire severity mapping, and assessing the implications and possibilities of using fire severity to replace seasonality in a revised greenhouse gas emissions abatement methodology. In this component we undertook a much-needed assessment of tree mortality with respect to high severity fires to quantify this phenomenon, and published this information in the international literature. The sub-project is developing a framework for a Savanna-wide Monitoring and Evaluation Reporting tool.

The ***Management of flammable high biomass grassy weeds, Gulf fire management*** sub-project (undertaken by Associate Professor Samantha Seterrfield of the University of Western Australia, and Dr Natalie Rossiter-Rachor CDU) commenced in the current reporting year and is due to be completed in 2017-2018. The project focuses on a range of invasive grasses that have spread rapidly in tropical Australia over the past two decades, substantially altering regional ecosystems. The ecological, economic and social consequences of these grasses are so significant that many are now declared at the Territory and State level, have been listed as Weeds of National Significance, and listed as a Key Threatening Process under the EPBC Act. The project is assessing the fire risk of these species and the social, environmental and economic consequences associated with high biomass grasses.

The ***Gulf fire management*** sub-project principally involves PhD studies (undertaken by Kate van Wezel CDU) exploring Indigenous women's engagement and employment opportunities with fire management and emissions abatement projects being established in the remote NT / QLD Gulf region. In 2015 the Waanyi-Garawa Indigenous Ranger group based at Borroloola commenced a partnership with the BNHCRC in a participatory action research project aimed at assessing the challenges and opportunities associated with the development of a women's caring for country program focused on Waanyi and Garawa country. This research provides a case study of successful collaborative land management in remote Indigenous Australia, and a gendered analysis of the caring for country movement as a strategy towards community resilience.

Preparatory activities for the ***Scenario Planning*** sub-project, looking at how EM agencies and remote communities across northern Australia could better engage and develop effective partnerships, commenced in early 2017. Currently the project is focused on implementing scenario planning activities at two NT general locales—the Borroloola / Gulf region, the broader central Australian region focused on Alice Springs. Ongoing discussions are being held with QLD and WA agencies concerning the extension of project activities into those jurisdictions. This project component will now continue over the next three years as part of the new round of BNHCRC projects.

Notably, activities from the first three sub-projects listed above, as well as from other projects addressing the broader research theme of '*Building community resilience in northern Australia'*, are due to be incorporated in a book (with the current title, '*2Way Country—transition to a resilient North Australia land sector economy*', due to be published by Magabala Press late this year.

END USER STATEMENT

Naomi Stephens & Felipe Aires
National Parks & Wildlife Service
Office of Environment & Heritage, NSW

At the end of three years, the subprojects of the **Savanna fire management and BNH scenario planning for northern Australia** project have skillfully demonstrated capacity to understand and work with under-resourced fire management agencies and groups in an extremely fire-prone landscape. Projects like this are critical not only to support improved fire management, providing landscape-wide mapping, and developing strategic decision making processes but also to empower local communities, create opportunities and promote resilience through evidence-based knowledge, facilitating the self-empowerment and sustainability of communities.

The **Savanna fire management** sub-project has created an important network of fire managers and stakeholders across northern Australia and provided them with mapping tools to assess risks to various environmental and community values. The fire severity maps have important implications in landscape risk assessment, on the future analyses of greenhouse gas emissions and carbon sequestration, particularly to inform models of the effects of severe fires on tree mortality, which it seems, although well understood was previously poorly applied. The project modelled the effects of fire across all savanna landscapes and developed new metrics to interpret the effects of fire management. The knowledge and data produced by this project has helped identify research gaps, and directed the future research agenda with respect to wildfire monitoring and evaluation and, importantly, reporting.

The introduction of high biomass grassy weeds has had a disastrous and costly impact on fire management, particularly Gamba grass in the peri-urban zone of the Greater Darwin region. The **managing flammable high biomass grassy weeds** project is undertaking research to provide answers to key fire management issues to end-users and stakeholders. The project team successfully engaged with the community to inform them of the deleterious effects of the increase in fuel loads to natural vegetation and to assist with information for fire management planning.

The **Gulf fire management** sub-project has an important role in promoting Aboriginal women's inclusion in fire management and identifying impediments, opportunities and challenges. Empowering women to participate in fire management, re-building fragmented cultural knowledge and women's capability will add essential value to the fire management strategies on Waanyi-Garawa country. This project has the potential to have a positive long-term impact in the local community and on sustainable indigenous fire management.

The preliminary steps undertaken to develop the future **BNH scenario planning** project assist in extending the fire research previously undertaken over many years in north Australia. Adaptive research is evident in the projects' new focus on engagement between EM agencies and remote indigenous communities. The growth of the Indigenous Ranger movement has been well publicised in

recent years. There is great potential in the notion of adapting the skills of well-trained and qualified local people and Indigenous Rangers into emergency management planning through a scenario planning framework to potentially root out obviously systemic hurdles that have hindered this adaptation before. We foresee a positive effect from the broad range of EM agencies and groups that have been consulted in the development of this program, and grateful for their reception to the key concepts.

The sub-projects have helped connect an important network of fire managers, local community and other stakeholders. The detailed research results contribute important contemporary insights into different aspects of fire management in the savanna region of northern Australia.

INTRODUCTION

The ***Savanna fire management and bushfire & natural hazards scenario planning for northern Australia*** project has four sub-project components:

1. Savanna fire management;
2. Management of flammable high biomass grassy weeds;
3. Gulf Savanna Fire Management and;
4. Major disaster scenarios planning.

The ***Savanna fire management*** component builds on the substantial work previously undertaken within the Bushfire CRC's North Australian Fire Mapping project. The sub-project continued with the work on savanna-wide fire severity mapping, and assessing the implications and possibilities of using fire severity to replace seasonality in a greenhouse gas emissions abatement methodology. In this component we undertook a much-needed assessment of tree mortality with respect to high severity fires, to quantify this phenomenon, and published this information in the international literature. The sub-project is developing a framework for a Savanna-wide Monitoring and Evaluation Reporting tool.

Managing flammable high biomass grassy weeds: is a joint activity between University of Western Australia and Charles Darwin University, led by Associate Professor Samantha Setterfield. It focuses on a range of invasive grasses that have spread rapidly in tropical Australia over the past two decades, substantially altering the tropical ecosystems. The ecological, economic and social consequences of these grasses are so significant that many are now declared at the Territory and State level, have been listed as Weeds of National Significance, and listed as a Key Threatening Process under the EPBC Act. This sub-project will assess the fire risk of these species and the social, environmental and economic consequences associated with high biomass grasses.

The ***Gulf savanna fire management:*** With a third of Australia under some form of Indigenous landownership it is imperative for emergency and land management agencies to collaborate with Indigenous communities. However, Australian government organisations typically impose western management agendas upon Indigenous peoples in these so-called 'collaborations'. In addition, many agencies remain oblivious to the highly gendered nature of Indigenous knowledge and practice, and may (unwittingly) deny Indigenous women the opportunity to fulfil their specific cultural responsibilities towards country. These top-down approaches are increasingly recognised as ineffective at empowering Indigenous peoples to manage their vast homelands. In 2015 the Waanyi-Garawa rangers partnered with the BNHCRC in this participatory action research project towards women caring for Waanyi and Garawa country. For the Waanyi and Garawa people this was an opportunity to finally develop their women ranger program. For the BNHCRC, this research provides a case study of successful collaborative land management in remote Indigenous Australia, and a gendered analysis of the caring for country movement as a strategy towards community resilience.

The ***scenario planning*** component commenced in early 2017. Previously, this sub-project was to focus on scenario planning for major disasters occurring in

the north Australian region, and potentially include neighbouring countries to the north. Following a re-appraisal of the broader suite of BNHCRC projects being undertaken by CDU and partners focused on "Building community resilience in northern Australia", agreement was reached that this project component will use materials developed as part of that broader project to better inform and engage with select community groups and associated stakeholders (including EM agencies) across northern Australia through the undertaking of targeted scenario planning exercises. This community identification phase is underway, we have been working with emergency services agencies in the NT, Western Australia and Queensland.

BACKGROUND

Australia's tropical savannas constitute the most fire-prone landscapes of a fire-prone continent—where ~20% of the 1.9 km^2 savanna region (a quarter of the Australian land mass) is currently burnt each year. Annual fire incidence is particularly frequent across higher rainfall (>1000 mm) far northern regions, where over half the landscape is burnt each year, mostly under relatively severe late dry season fire-weather conditions.

The current patterning of late dry season fires impacts on a broad range of issues, including community safety and health, production (e.g. pastoral enterprise) and environmental values (e.g. soil erosion, stream health, biodiversity, greenhouse gas emissions).

As part of a suite of complementary projects being undertaken by the 'northern hub' of the BNH CRC, this project focuses on a number of issues broadly relating to identifying the extent and magnitude of risks to community, production and environmental values. The project currently has four sub-project components (the fourth component, dealing with scenario planning, only commenced 2017 and leads us into the new phase of the research program):

- Describing environmental risks across the north and providing mapping tools for remote community planning purposes in trial locations
- Quantifying the risks posed by large flammable exotic grasses (e,g, gamba and mission grasses)
- Exploring fire management risks and challenges in the NT / QLD Gulf region
- Preliminary scenario planning development in key regions identified by emergency services agencies in north Australia

A second suite of northern hub projects explores related issues pertaining to remote community resilience and governance, and the potential for environmental services projects to provide enhanced economic and community resilience.

1. SAVANNA FIRE MANAGEMENT

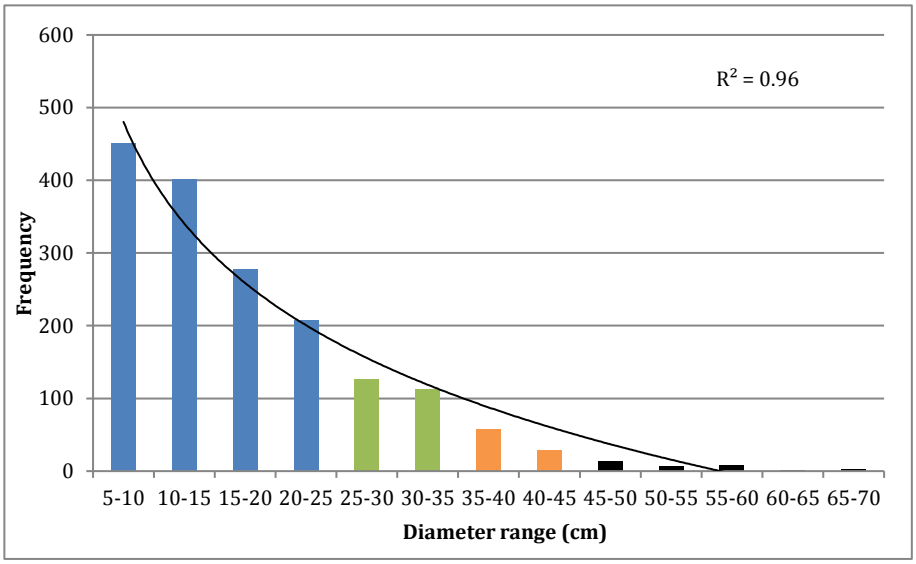
Dr Andrew Edwards
Darwin Centre for Bushfire Research
Charles Darwin University
Northern Territory, Australia

Fire Severity Mapping and tree mortality

Severe fires in tropical savanna systems are recognised as incurring significant impacts on a variety of ecological attributes, including woody vegetation structure and greenhouse gas emissions. However, knowledge of the frequency and extent of severe fires is restricted given challenges associated with the development of reliable remotely sensed mapping procedures. This study takes advantage of three very severe fires, 900 – 5300 km^2 in extent, occurring in semi-evergreen, eucalypt-dominated, tropical Australian savanna, and which resulted in complete canopy scorch, very significant tree stem mortality (24-55%), and associated loss of living above ground biomass (47- 69%) at respective sites. Although increased map scale is generally considered to improve the reliability of fire severity mapping, our analysis found > 90% agreement between Landsat and MODIS-derived burnt area mapping, and >80% for binary (severe—>90% canopy scorch vs. non-severe) fire severity mapping products. Mapping of internal fire (unburnt) patchiness was enhanced with finer resolution Landsat imagery, but the much longer orbital return cycle precluded its use at two sites given extended cloudy conditions. Application of an automated MODIS-derived fire severity mapping algorithm (overall reliability in 2015 = 75%) calibrated for generalised north Australian savanna conditions, suggests that 15% and 12% of Australia's 1.3 M km^2 northern savannas region were burnt by severe fires in 2015 and 2016, respectively. The study illustrates the potential for MODIS-derived fire severity mapping, as well as the current extent of severe fire impacts, in Australian savanna systems.

Tree Mortality information

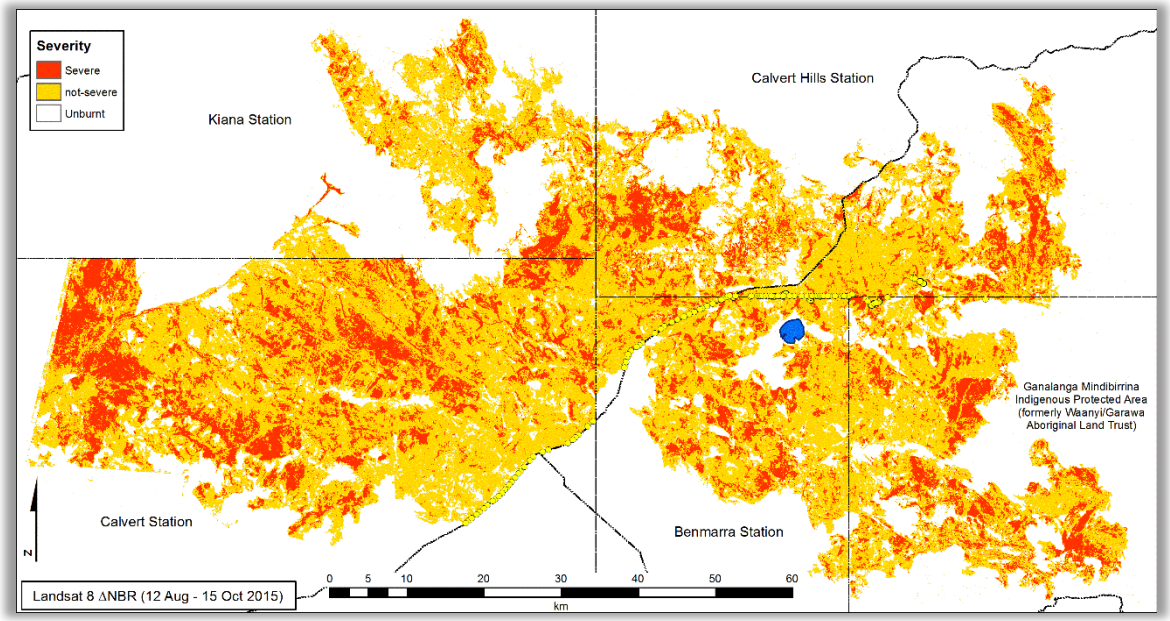
A total of 2,445 stems were sampled in an area of 14.2 ha in 142, 100 m x 10 m transects. The pre-fire size-class distribution of tree stems observed over all sites was effectively described as a negative exponential function (R^2 = 0.96) where stems >25 cm DBH contributed 75% of above ground biomass (AGB). The post-fire stem-class mortality distribution varied between sites, but largest stem sizes were particularly affected at all sites. Overall mortality at sample transects was 42%, comprising 37% of eucalypt and 50% of non-eucalypt stems. Complete post-fire tree stem sampling observations from respective sites are given in Appendix Table A1. Based on allometry for dominant tree species [1], loss of above ground biomass (AGB) attributable to severe fires at respective sites was 9.3 $t.ha^{-1}$ (-47%) at Benmara, 9.6 $t.ha^{-1}$ (-23%) at Manbulloo, and 35.2 $t.ha^{-1}$ (-55%) at Mataranka. Most (>75%) loss of living AGB was associated with 21% of stems > 25 cm DBH. Stem mortality in severe fires increased significantly with fuel age (Fig. 5). Notably, severe fire effects were observed at sites even with only one year of fuel accumulation.



PRE-FIRE FREQUENCY DISTRIBUTION OF ALL 2,444 STEMS SAMPLED AT BENMARA, MANBULLOO AND MATARANKA SITES. LINE IS A LOG OF BEST FIT (R^2 = 0.96). THE VARIOUS COLOURS REPRESENT QUARTILES OF THE TOTAL PROPORTION OF ABOVE GROUND BIOMASS ($T.HA^{-1}$) WITH RESPECT TO STEM DIAMETER RANGES, THAT IS, 5-25 CM, 25-35 CM, 35-45 CM AND 45-70 CM DBH RANGES.

Fire severity Information

The size of the Benmara fire was estimated as 5,300 km^2 based on mapping derived from Landsat imagery, and 890 km^2 and 2,657 km^2 for Manbulloo and Mataranka fires, respectively, derived from MODIS imagery. Using the same image sources, we estimate that internal unburnt patchiness in respective fires was ~20% at Benmara, <1% at Manbulloo, and 3% at Mataranka. For the Benmara fire, there was strong agreement (91%) between fire extent mapping derived from MODIS and Landsat.



THE MAPPED EXTENT OF BURNT AREA AND BINARY FIRE SEVERITY CLASSIFICATION DERIVED FROM A LANDSAT 8 IMAGE DIFFERENCE PAIR. THE FIRE COMMENCED ON BENMARA STATION 30 AUGUST 2015. TOTAL BURNT PATCH ~ 5,300 KM^2,

Fire severity and biomass result

Based on the Landsat-derived RdNBR model, 33% of the Benmara fire area was mapped as high severity. Given fire size, stem mortality and density data, we estimate that ~78,000 adult tree stems were killed by the high severity component of the Benmara fire. However, the MODIS FSM resulted in high fire severity affecting 2,353 km^2 (44%) which equates to ~163,000 dead stems. Applying the observed size-class distribution of fire-killed stems at respective sites, the estimated total loss of living AGB associated with high severity fires at the three fire events is given in Table 6. The estimated total tree stem AGB (expressed as carbon) killed in the three fires applying the MODIS algorithm was ~3.6 $\pm$ 1.5 Mt, or 7.7 $\pm$ 3.3 t $C.ha^{-1}$.

Regional implications

The extent of severe fire has significant ecological, greenhouse emissions and associated carbon sequestration implications for Australia's fire-prone northern savannas (Edwards et al. 2015a). Application of the same MODIS FSM algorithm utilised in this study implies that severe fires affected 10% of north Australian regional savannas both in 2015 and 2016 [2, 3]. Even allowing for significant levels of internal unburnt and less severely burnt patchiness (e.g. the Benmara fire), it is widely observed in regional studies that there is a strong correlation between extensive fires and fire high severity, particularly in the LDS [4, 5]. Application of a robust fire severity mapping procedure would allow for enhanced understanding and assessment of the regional impacts of contemporary fire regimes.

Application of a generally reliable (75% accuracy overall) savanna-wide MODIS fire severity mapping algorithm shows promise as a robust, remotely sensed, automated method for directly accounting for fire severity effects in Australia's national 'savanna burning' methodology [6]. Currently, fire severity effects on fuel consumption (and resultant emissions, and carbon sequestration) in the national methodology are given as default EDS and LDS values based on decadal observations of fire severity from long-term monitoring plots in two contiguous conservation reserves (Russell-Smith and Edwards 2006). Application of an automated, annual, *post-hoc*, savanna-wide assessment procedure would allow for direct accounting of severe fires wherever and whenever they occurred over the seasonal fire cycle.

While this study investigated the ecological impact of severe fires, further studies should investigate fire effects on flora and fauna at the lower end of the severity spectrum. Burning completeness in the lateral direction, i.e. fine scale patchiness [7] has a marked impact on small mammals [8] and birds [9]. A promising remote sensing method developed by Maier [10] estimates sub-pixel patchiness using MODIS data. However, this method requires further validation to assess the accuracy of the derived fine scale patchiness maps.

In summary, remote sensing methods to estimate fire severity provide essential information to better understand fire regimes, their impact on savanna vegetation and to calculate carbon stocks.

Publications

Freeman, J., A. C. Edwards and J. Russell-Smith (in press) *Fire regimes can outweigh other global change drivers in savanna systems: decline of Allosyncarpia monsoon forests in northern Australia* **Diversity and Distributions.**

Sangha, K. K., J. Russell-Smith, S. C. Morrison, R. Costanza and A. Edwards (2017) *Challenges for valuing ecosystem services from an Indigenous estate in northern Australia* **Ecosystem Services** 25: 167-178.

Edwards, A, J. Russell-Smith and S. W. Maier (in press) *Severe fires, tree stem mortality, and fire severity mapping in fire prone north Australian savannas* **Remote Sensing of Environment**

Savanna monitoring and evaluation reporting (SMERF)

Background

Northern Australia is an extensive area with meagre population and infrastructure. There is considerable summer rain (in the "wet") and very little in winter (the "dry"). In the "wet", grass and trees grow verdantly, producing abundant fine fuel. Temperature is relatively high all year, so that when the rain stops at the end of the "wet" the fine fuels dry quickly and are extremely fire prone, large tracts of the region burn annually. One simple ignition in the latter half of the "dry" can create a wildfire that will burn for months, often even if the area burnt last season. However, prescribed burning is very effective at halting wildfire.

Our group have provided dynamic up-to-date web-based fire mapping to inform people of the occurrence of fire since 2002. In recent years, through CRC funded research, we have created more sophisticated mapping and modelling. The information is used for fire management operations, planning, and suppression, and is analysed to describe past and present fire regimes. In this Hazard Note we describe the application of these information and our development of the Savanna Monitoring and Evaluation Reporting Framework (SMERF), being set up to provide a standardised assessment report on fire regimes, for all Australia's savannas and rangelands.

Monitoring and Evaluation of fire regimes is undertaken at a very rudimentary level in most organisations, with simple calculations of the area burnt, the seasonality and the frequency of fire, if they report at all.

Some groups such as the Kimberley Land Council, Kakadu National Park and the West Arnhem Land Fire Abatement project provide information to stakeholders regarding the efficacy of their fire management in sophisticated reports that assess the effects of the past year's fire against previous years; and a set of Key Performance Indicators related to ecosystems and biodiversity.

Many other groups in north Australia aspire to this level of sophistication in their own Monitoring and Evaluation, however, it is analytically demanding, requiring an experienced spatial scientist to derive the various fire layers; create and collate the underlying vegetation or habitat information; and undertake the spatial calculations.

Through an extensive consultation process with many stakeholders, a suite of metrics were identified. A basic set was used to provide a simple standard summary report. The more extensive suite of metrics will be made available for users to choose from to meet differing user reporting requirements.

Preliminary scoping

Workshops to ascertain the need and requirements of SMERF have been undertaken to date in Cairns, Broome and Darwin, Alice Springs, and Kununurra. After explanation of the tool, user engagement has been high. The best way to user-enable SMERF is to have as much user input as possible. Therefore, it is beholden upon us to get out and find out what monitoring and evaluation reporting needs other stakeholders have, and incorporate any

further thoughts from those involved in previous workshops. Reporting in some areas is sophisticated and informs management of the efficacy of their fire management, especially where projects are on Indigenous land with a high expectation from Commonwealth funding agencies to monitor and report on fire management in those projects. However, in most areas, particularly those run by the state and Territory agencies there is little or no reporting on fire management efficacy.

Knowledge Based Metrics

Traditional Indigenous knowledge and contemporary experience with fire management has provided a suite of metrics to inform management, stakeholders and funding bodies about the efficacy of the effects of fire management particularly with respect to conservation land management. At a higher level, basic metrics describe the amount of area affected by fire in comparison to other fire seasons; other jurisdictions; the fire weather; and the cost and effort of fire management either through prescribed burning or wildfire suppression.

Future Research

SMERF will be integral to the next iteration of the Northern Hub's Savanna Management research agenda. The main lesson we have learnt is that although there are a number of basic metrics such as the proportion burnt, the seasonality and severity of fire, there are many more metrics required to determine the efficacy of fire management that are slowly but surely coming to light.

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2. MANAGEMENT OF FLAMMABLE HIGH BIOMASS GRASSY WEEDS IN THE NORTHERN SAVANNAS

Associate Professor Samantha Setterfield
School of Biological Science
University of Western Australia
Western Australia, Australia

Dr Natalie Rossiter-Rachor
Research Institute for the
Environment & Livelihoods
Charles Darwin University
Northern Territory, Australia

Project Background

Managing flammable high biomass grassy weeds: This is a joint activity between UWA and CDU, led by Associate Professor Samantha Setterfield. It focuses on a range of invasive grasses that have spread rapidly in tropical Australia over the past two decades, substantially altering the tropical ecosystems. The ecological, economic and social consequences of these grasses are so significant that many are now declared at the Territory and State level, have been listed as Weeds of National Significance, and listed as a Key Threatening Process under the EPBC Act. This sub-project will assess the fire risk of these species and the social, environmental and economic consequences associated with high biomass grasses.

Research Progress with flammable grassy weeds, July 2016-June 2017.

The project team firstly determined the priority high biomass grassy weeds by: (1) reviewing State/Territory declared weeds lists, and (2) discussing the broad range of high biomass savanna grasses with research end users in NT, QLD and WA (e.g Bushfires NT, QLD parks and Wildlife, and WA DFES), particularly those grasses that are likely to alter fire behavior and risk management. Based on these consultations, priority grass species were determined. Maps of current distribution and potential distribution were developed to allow us to extrapolate site-based data on fire behavior.

FIG 1 DENSE INFESTATION OF THE HIGH BIOMASS GRASSY WEED, GAMBA GRASS, BATCHELOR, NT. PHOTO CREDIT: NATALIE ROSSITER-RACHOR

Samples of priority species were taken for **flammability analysis** (See Table 1). These were grass species that either potentially increase or decrease flammability. Fieldwork was completed in May 2017 in both the NT and QLD to sample native and invasive grass fuel parameters. These grass samples were prepared and are currently being analysed for a range of range of fuel

chemical traits that may impact flammability, including Caloric energy values, terpene, tannin, lignin, fatty acid methyl esters and crude fat content.

FIG 2 KATHY JOHNSON (BIOSECURITY OFFICER, COOK SHIRE COUNCIL) AND SAMANTHA SETTERFIELD (UWA) INSPECT GAMBA GRASS INFESTATIONS NEAR COOKTOWN. PHOTO CREDIT: NATALIE ROSSITER-RACHOR

TABLE 1: NATIVE AND INVASIVE SAVANNA GRASS SPECIES SAMPLED FOR FLAMMABILITY CHARACTERISTICS

Species	Common name	Samples from
(A) Native grass		
Sorghum intrans	Spear grass	NT & QLD
Heteropogon fallax	Black spear grass	NT & QLD
Alloteropsis semilata	Cockatoo grass	NT
(B) Invasive grass		
Andropogon gayanus	Gamba grass	NT
Cenchrus ciliaris	Buffel grass	NT
Cenchrus pedicellatus	Mission grass (annual)	NT
Cenchrus polystachios	Mission grass (Perennial)	NT
Hyphyrrenhia rufa	Thatch grass	NT & QLD
Melinis minutiflora	Molasses grass	QLD
Panicum maximum	Guinea grass	NT & QLD
Pennisetum purpureum	Elephant grass	NT & QLD
Themeda quadrivalvis	Grader grass	NT & QLD

Fuel curing and fuel moisture

Additional grass flammability measurements have been collected from sites in the Batchelor region by CDU Honours student Daisy Lippiatt (See figure 1). Detailed **Grass fuel loads and fuel moisture** samples have been collected fortnightly throughout the fire season (six times- 9 May, 22 May, 5 June, and 21 June 2017, 4th July, 19th July). **Grass curing samples** have been collected monthly throughout the fire season (22 May, 21 June, 20 July). Sampling will continue until the native and invasive grasses have fully cured this fire season, or the sites are burnt by wildfire. However, to date the fire breaks that the team put in have held.

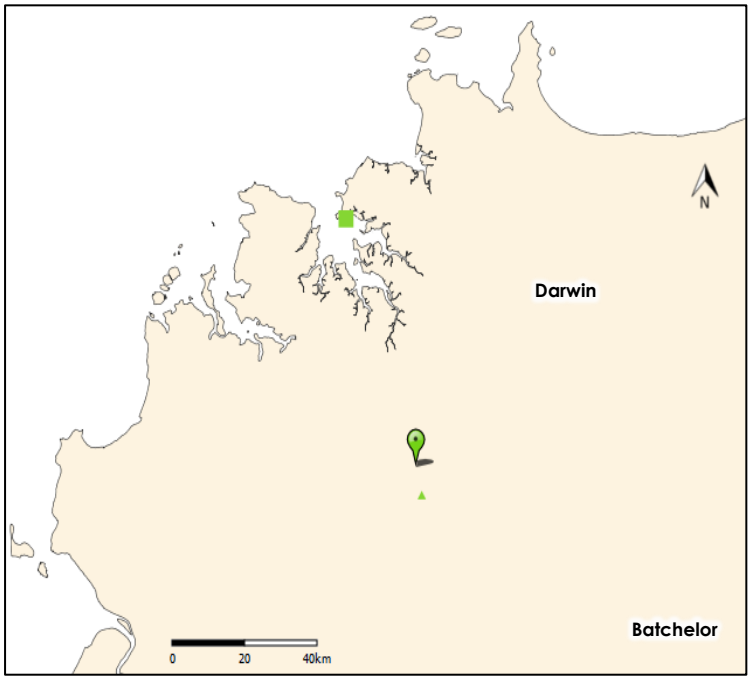

FIG 3: GRASS FUEL MOISTURE AND CURING STUDY SITE IN THE BATCHELOR REGION, NT (MAP SOURCE: NATURAL RESOURCES MAPS, NT DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES)

FIG 4. FIELD TEAM HARVESTING GRASS FOR MOISTURE AND LOAD MEASUREMENT (PHOTO CREDIT: LIPPIATT)

The fuel samples are

so large that they can't be dried in standard lab ovens. Instead, we are using the NT DPI walk-in ovens. This has slowed the processing of samples as we need to be accommodated in with their research activities. At the beginning of the dry season the grass fuel moisture was 55% higher in gamba grass fuel. This was reflected in the much lower curing (ratio of live to dead fuel) (Figure 2).

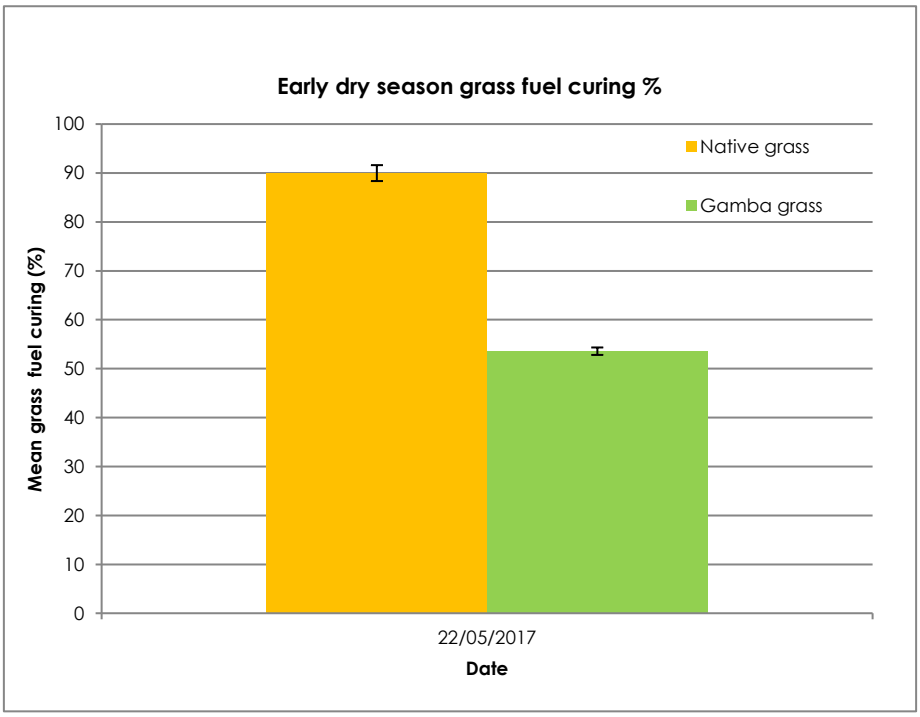

FIG 5: EARLY DRY SEASON GRASS FUEL CURING, BATCHELOR, NT.

Fire Behaviour Models

We have commenced the assessment of the impact of the changes in grass flammability on fire behavior models. We completed an initial review of suitability of a range of fire spread models used in Australia. We collected fuel data to test the models, and collated our previous fire behavior data (rate of spread, intensity etc..) to further help test the models. This data will allow us to test the suitability of fire behavior models.

We have commenced the collation of environmental and socio-economic information for spatially-explicit case studies of flammable grass spread in the NT and Queensland. Both areas include protected areas and surrounding peri-urban communities. Long-term records of the cost and effectiveness of weed control have been collated. Currently the focus is on methods of spatial and temporal extrapolation of the case study data.

End-user and stakeholder engagement

The research is undertaken in collaboration with end-users who have great interest in the outcomes. Therefore, we have been invited to give a range of presentations at informal meetings, formal meetings, and conferences. Examples are:

- Invited presentation on flammable grassy weeds to **Mimal rangers and NT Bureau of Meteorology** severe weather forecasting staff, **Bachelor**, NT (Rossiter-Rachor, Sept 2016)
- Invited presentation on flammable grassy weeds to **Pew Trust annual national meeting**, in **Bachelor**, NT (Rossiter-Rachor, Sept 2016)
- Presentation on flammable grassy weeds project at **BNHCRC Research Advisory Forum** (RAF), **Canberra** (Rossiter-Rachor, Oct 2016)
- Invited presentation on gamba grass & flammable grassy weeds **NQ Dry Tropics Pest Regional Pest Management workshop, Townsville** (Setterfield and Rossiter-Rachor Dec 2016
- Invited presentation on gamba grass & flammable grassy weeds, **Land for Wildlife/Territory Wildlife Park, Berry Springs**, NT (Rossiter-Rachor, April 2016)
- Invited presentation on gamba grass & flammable grassy weeds, **Poison Creek Rural Fire Brigade**, **Cooktown** (Setterfield and Rossiter-Rachor May 2017)
- Invited presentation on gamba grass & flammable grassy weeds **Far North Queensland Regional Organisation for Council** (which represents 13 councils in FNQ). **Cook Shire Council chambers, Cooktown** (Setterfield and Rossiter-Rachor, May 2017)
- Honours proposal seminar on fuel characteristics of grassy weeds and the impact on fire behavior, **Charles Darwin University, Darwin** NT (Lippiatt, June 2017)
- Participation in B&NH CRC **Risk Mitigation project** workshops and follow-up interviews (Timothy Neale, University of Western Sydney)
- Presentation at **Australian Weeds Conference, Perth,** September 2016
- Participation in **Northern Australian Fire Managers** (NAFI) **meeting** - July 2016, **Alice Springs**

FIG 6. SAMANTHA SETTERFIELD (UWA) DISCUSSING THE IMPACTS OF GAMBA GRASS ON FIRE REGIMES AND THE ENVIRIONMENT WITH MEMBERS OF THE **COOK SHIRE INVASIVE PLANTS AND ANIMALS ADVISORY COMMITTEE**, FROM LEFT, ANDY HARTWIG (LANDCARE), RUSSELL JACK (DEPT NATURAL RESOURCES AND MINES), JASON CARROLL (SOUTH CAPE YORK CATCHMENTS), TRAVIS SYDES (FAR NORTH QUEENSLAND REGIONAL ORGANISATION OF COUNCILS), SAMANTHA SETTERFIELD, CATHY JOHNSON (COOK SHIRE COUNCIL) AND KYLIE GOODALL (QLD PARKS AND WILDLIF SERVICES), REPRESENTATIVES, MAY 2017. PHOTO CREDIT: NATALIE ROSSITER-RACHOR

FIG 7. CATHY JOHNSON AND DARREN HIGGINS (BIOSECURITY OFFICERS, COOK SHIRE COUNCIL) AND SAMANTHA SETTERFIELD (UWA) WITH QLD RURAL FIRE SERVICE BRIGADE OFFICERS AT POISON CREEK RURAL FIRE SERVICE. PHOTO CREDIT: NATALIE ROSSITER-RACHOR

FIG 8. NATALIE ROSSITER-RACHOR (CDU) DISCUSSES GAMBA GRASS IMPACTS WITH LOCAL LAND OWNERS, COOKTOWN SHIRE STAFF, AND POISON CREEK VOLUNTEER FIRE BRIGADE MEMBERS. PHOTO CREDIT: SAMANTHA SETTERFIELD

FIG 9. NATALIE ROSSITER-RACHOR DISCUSSES THE ISSUE OF GRASSY WEEDS ON THE VIDEO BY:
MIMAL LAND MANAGEMENT (2017). GAMBA GRASS: A BALANDA GRASS THAT'S KILLING COUNTRY.
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Publications

Book sections

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Unpublished reports

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3. GULF SAVANNA FIRE MANAGEMENT: WOMEN CARING FOR WAANYI AND GARAWA COUNTRY

Kate Van Wezel (PhD Candidate)
Darwin Centre for Bushfire Research
Charles Darwin University
Northern Territory, Australia

Background and research aims

With a third of Australia under some form of Indigenous landownership (Altman and Jackson 2014) it is imperative for emergency and land management agencies to collaborate with Indigenous communities (Palmer 2006; Altman *et al.* 2007; Altman *et al.* 2009). However, Australian government organisations typically impose western management agendas upon Indigenous peoples in these so-called 'collaborations' (Sithole 2007; Muller 2012; Eriksen and Hankins 2014). In addition, many agencies remain oblivious to the highly gendered nature of Indigenous knowledge and practice (Rose 1996), and may (unwittingly) deny Indigenous women the opportunity to fulfil their specific cultural responsibilities towards country (Eriksen and Hankins 2014). These top-down approaches are increasingly recognised as ineffective at empowering Indigenous peoples to manage their vast homelands (Smyth 2011).

The caring for country movement offers a radically different paradigm to emergency and land management models based on western modernist values (Kerins 2012). 'Caring for country' is an Aboriginal English expression, that describes more than just looking after a place and its natural resources (Kerins 2012). It is founded on deep spiritual connections and responsibilities between people – men and women, past and present - and their kin, culture, sacred places, and ancestral beings (Kerins 2012). Although Aboriginal Australians have always been caring for country, this concept emerged as an Indigenous development movement in the 1990s, in the wake of land rights being returned to Indigenous peoples in parts of remote Australia (Taylor 1995). It grew into a cooperative network of Indigenous ranger groups that helped communities adapt and transform in the face of ongoing impacts of settler-colonialism and environmental destruction (Kerins 2012; Rostron *et al.* 2012), building the resilience of remote Indigenous Australia.

The Waanyi and Garawa people of the remote southwest Gulf of Carpentaria have been running their own successful caring for country project since 2005 (Green and Morrison 2012). With federal funding to combat the wildfires that were devastating the region, they employed a small ranger group who now care for their 11.000 km² land trust (Green and Morrison 2012). Many Waanyi and Garawa women helped establish this project, and many women and men alike have been disappointed and frustrated that lack of long-term funding and control over expenditures has delayed the formation of a dedicated woman ranger program (Green and Morrison 2012).

In 2015 the Waanyi-Garawa rangers partnered with the BNHCRC in this participatory action research project towards women caring for Waanyi and Garawa country. For the Waanyi and Garawa people this was an opportunity to finally develop their women ranger program. For the BNHCRC, this research

provides a case study of successful collaborative land management in remote Indigenous Australia, and a gendered analysis of the caring for country movement as a strategy towards community resilience. By employing resilience theory as a framework for analysis, this project contributes to the broader parent BNHCRC project *"Enhancing remote north Australian community resilience"*.

Work to date

Building relationships

Upon completing milestones such as ethical clearance, a literature review, and confirmation of candidature, I based myself in Robinson River community on the Garawa land trust to commence field work at the end of the 2015 dry season. This was an opportunity to build relationships with the Garawa community, and with the rangers. Spending a wet season in Robinson River also made me more aware of the major challenges faced by my collaborators, such as conflicts in in land use, lack of governance, and restricted land access.

Unstructured interviews

Some elders, both men and women, have requested that their life stories are documented and included in the research. Interviews were recorded opportunistically. They often detailed their experiences growing up in stock camps and missions, and how they managed to maintain their connections and rights to country.

On-country workshops

Topsy Green, Kathleen O'Keefe, Kate van Wezel, Iris Hogan, Margaret Cutta, Katie Seccin, and Maxine Wallace plan fieldwork at Kalligum as they enter Waanyi country from the west on Creswell Downs station. Photo: Harry MacDermott, May, 2016

Faralisa Dick, Cherie Dick, Charmaine Aplin, Mary Anne Koorabubba, Ada Walden, and Josephine Foster at Nadjaburra on the IPA. They are about to head home after spending days working on country. July 2016

Lorraine Walden, Geraldine Johnny, Topsy Green, and Harry MacDermott (volunteer woman ranger) talk about caring for country over some tasty brim at Jilundarina on the IPA. September, 2016

In 2016, funding was released for the rangers to manage their Waanyi-Garawa land trust as part of the National Reserve System. This allowed for a more

structured approach to the research, as the rangers were now able to employ women on a casual basis to participate in the project. I moved to Borroloola, a larger community from which the rangers are based, and with operational funding from BNHCRC we were able to organise a series of land-use planning workshops throughout 2016. Here, elders took young women back out to their own country, and effectively designed their own woman ranger program. These field trips were the first time for several young women to visit their country, which in itself was possibly the most empowering aspect of the workshops.

Throughout different stages of this consultation process, the rangers employed over 30 women, spread across all four clan groups and based out of Borroloola, Corrella Creek, Robinson River, as well as Doomadgee on the Queensland side of the border, to visit outstations throughout the Waanyi-Garawa land trust. Organising and documenting this work for them allowed me to learn how people's connections to country and kin have helped them survive settler-colonialism, what role women see for themselves in caring for country, and the challenges they face today. Throughout this process I also developed a close working relationship with the Northern Land Council (NLC), the administrative host organisation of the rangers, as well as other land management collaborators. This gave additional insight into the administrative and institutional challenges to caring for country.

Participating in the ranger program and everyday community life

By continuing to work from Borroloola I was able to participate in the implementation of the ranger program women had designed. 2017 saw Waanyi-Garawa woman rangers participate with men in fire management, wild life surveys, a culture camp, as well as a suite of agency-based training through the NLC. Participating in the ranger program and everyday community life allowed me to supplement insights form workshops with participant observation that revealed other challenges to women caring for country. This has also been a chance to document solutions being championed by the broader Waanyi and Garawa community, as well as emerging opportunities to expand their caring for country program and enhance community resilience.

Insights

There is a vast range of interpretations of the term 'resilience', many of which are inappropriate in the Indigenous community context (reviewed by NAILSMA 2016). Particularly in emergency management, resilience discourse has focused on a community's ability to return to its state of equilibrium prior to a natural disaster (NAILSMA 2016). Indeed, many people are not living in Indigenous communities in a state of equilibrium, but rather in a constant state of emergency (Howitt *et al.* 2012; reviewed in NAILSMA 2016). Coping with the current settler-colonial crisis is understandably prioritised over preparing for future natural disasters (NAILSMA 2016). For insights on resilience amongst Waanyi and Garawa people to be meaningful, they therefore need to be understood in the context of the community's colonial history (Howitt *et al.* 2015) as well as the imposition of centralised and unjust policy making today (Maru *et al.* 2014; reviewed in NAILSMA 2016).

Without question the peoples of the Gulf of Carpentaria were subjected to horrific systematic genocide (Roberts 2005). After frontier wars terrorised the Gulf country, many Aboriginal peoples entered stock camps and missions. Some collaborators remember this transition not as passive subjugation or a sell-out, but rather as a strategic move made by Aboriginal peoples to survive and maintain connections to family. In the case of stock work this was also a way to retain access to their country (see also McGrath 1987).

Although this was a period of social upheaval for everyone, women have their own experiences from this time. For instance, women were not allowed to leave the mission in Doomadgee – where they were forbidden to practice language and culture – until they were married. Upon marriage women often needed to follow their husbands in their travels in search of work, and were therefore disproportionally affected by widespread displacement. Although women did partake in stock work, their chores were mostly centered around stock camps and homesteads, so they had fewer opportunities to travel to their country. However, all women I have worked with insist that their connections to their country have survived these tough times, and that this bond was actually what helped them survive as Aboriginal people.

Caring for country was born out of these connections to country, as a way to cope with their colonial history and combat continuing attacks on their culture. However, many women's experiences of colonisation have denied them confidence to look after country, and have left them with big challenges to participate in caring for country efforts. Still today there are few women with access to a vehicle or driver license. The closure of schools and health services to outstations on the Waanyi-Garawa land trust in the 1990s made it near impossible for women to live on their country, as most are responsible to care for their children and elders.

Neglecting to facilitate more opportunities to participate in caring for country projects does not only leave women more vulnerable to structural violence inflicted by assimilation policies and town life, it also undermines Waanyi and Garawa community resilience as a whole. Women have specific cultural responsibilities towards country. These are complementary to roles men hold. For instance, some country and knowledge is specifically for women and they are responsible to care for it. Women today also feel responsible for passing on valuable knowledge about 'bush tucker' and 'bush medicine' that helped Waanyi and Garawa people survive in stock camps when food was scarce. One of the most important roles Waanyi and Garawa people see for women in caring for country is teaching children about their foundational connections and obligations to family, culture, country, and the dreamings contained within.

Women's specific role in caring for country and growing community resilience means that rebuilding women's confidence and capacity to care for their own country is a necessary investment. This case study demonstrates that this can be a practicable goal. Some of the required skills to manage country in today's world – such as operating fire trucks, aerial fire management tools, chemical handling, and weed identification - were achieved through agency-based training arranged by the NLC. However, western training alone was not enough. The ranger program needed to provide cultural guidance for women seeking to get back out on to country. Elders needed to lead the way and

introduced younger women to country. The Waanyi-Garawa men also provided regular cultural advice, opportunities to participate activities together, as well as assistance in operating unfamiliar equipment.

This case study also provides insights into institutional barriers to women building community resilience through caring for country. The most obvious restricting policy is children not being allowed to travel in work vehicles. This policy is maintained by the bureaucracy of their administrative host organisation for liability reasons. It clearly counteracts some of the core values of Waanyi and Garawa caring for country, and unfairly disadvantages women trying to participate in ranger work.

A more subtle barrier emerged when exploring women's options for permanent working arrangements. The rangers need to report on federal funding expenditure against federal development targets. Here, flexible or part-time fixed-term jobs (that would be more suitable to many of the rangers' transient lifestyle, but especially to women balancing a myriad of family obligations) are considered a less legitimate form of employment, and are difficult to justify. When women later learnt that in order for them to gain a permanent job it would have to come at the cost of a man's employment, they were incredulous. Elders have warned that if women need to compete against men for the same jobs this is likely to cause terrible conflict within the community.

Waanyi and Garawa people have their own strategies to manage how gender-dynamics play out on the ground. For instance, when given the opportunity to allocate expenditure on casual wages themselves, the board of representative Waanyi and Garawa elders decided to budget an equal amount for employing women as men, so that women and men were not competing against each other.

Evidently, Waanyi and Garawa people are highly capable of carrying out caring for country programs that respond to power-relations within their community. In contrast, centralised gender-blind policy-making poses a major threat to the success of the woman ranger program. For women to fulfill the role they see for themselves in caring for country and building resilience, they need to be accountable to a governance entity that advocates for their unique role and recognises the specific challenges to them in caring for country. An investment into building local governance structures is therefore imperative for marginalised groups to be a part of building resilience through caring for country.

Future work

Building local governance is imperative to the continuity of caring for country projects in the Gulf region. This would allow for new investment in and expansion of their caring for country program though markets such as Payment for Ecosystem Services (PES) and the emergency services sector. Diversifying funding sources should leave the community more resilient to policy changes, by reducing their dependence on government funding.

However, transitioning towards a commercial caring for country program is not without risk, and will require the local governance arrangement to uphold the broader Indigenous development agenda based on cultural values.

Opportunities such as PES and joining the emergency services delivery framework are long awaited by the Waanyi and Garawa community, and should be a part of this broader caring for country agenda, but not supplant it. How can people deliver these services to remote areas on their terms, and not at the whims of their commercial partners and clients? How do you ensure equitable outcomes from this commercialisation for marginalised groups within community, such as women?

Clearly, having a local entity to host caring for country projects is not enough. It needs to be nested within a regional network of landholders to which it is held accountable. Much work with landholders has already been done in this space (Gambold and Kerins 2015) and it is these issues that demand urgent attention. Negotiations around building a local governance structure to host a carbon abatement project for Waanyi and Garawa people are already underway. It is therefore an opportune time to investigate the institutional design requirements for this entity to host other PES projects as well as emergency service delivery in a way that is equitable for all landholders, including women. Only then does regional development stand to greatly enhance community resilience.

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4. SAVANNA FIRE MANAGEMENT AND SCENARIO PLANNING FOR NORTHERN AUSTRALIA

Professor Jeremy Russell-Smith
Darwin Centre for Bushfire Research
Charles Darwin University
Northern Territory, Australia

Status of scenario planning project component

In order to extend the applied research of CDU's 'northern hub' suite of projects addressing the broad theme, *Building community resilience in northern Australia*, a sub-project addressing 'scenario planning' was included as part of the present project with a projected stating date in early 2017. Originally, it was envisaged that the scenario planning component would address a mock scenario involving a major regional natural hazards incident (e.g. tsunami) to explore the preparedness of north Australian EM institutions in dealing with such an event.

Over time, however, it became apparent that there was an equally urgent need to look at how EM agencies and remote communities across northern Australia could better engage and develop effective partnerships—and, in particular, how we could better utilize the resources of remote Indigenous Ranger Groups (IRGs) to help mitigate natural hazards risks in and around remote communities (e.g. through undertaking prescribed fire management) and act as front-line EM respondents. Such opportunities are recognised, for example, in the latest national *Keeping Our Mob Safe* (Draft 2017) assessment, where the growth and development of IRGs are identified as providing an emerging opportunity to better assist with managing natural hazards in remote locations. Experience in north QLD shows the importance of developing effective partnerships between emergency management (EM) agencies and IRGs with PPRR generally in the QLD Gulf region, including assistance with post-cyclone operations (e.g. Cyclone Yassi).

To these ends, development of the scenario planning component has been ongoing since the end of 2016 in preparation for the start of the new / ongoing BNHCRC project, *Scenario planning for remote community risk management in northern Australia*. Key project development components have comprised:

- Discussions hosted by WA Dept Fire & Emergency Services (DFES) in Perth, late 2016, to canvas development of the project with north Australian EM agency stakeholders
- Discussions with Prof Douglas Paton (Dept Psychology, CDU) to directly involve his Disaster Risk Reduction scenario planning expertise as co-project leader in the new project
- Ongoing discussions with EM agency personnel in the NT (Dept Chief Minister, NT Fire & Rescue Service, NT Emergency Services, Bushfires NT), WA (DFES), and QLD (Inspector-General of Emergency Management, QLD Recovery Agency), particularly in relation to issues and activities to be addressed by the new project, and their location.

- On the basis of agreement reached with NT EM agencies concerning the desirable locations of project activities in the NT, recent discussions have been held with IRGs operating in the greater Borroloola (NT Gulf) and Alice Springs regions about their potential involvement. The Northern Land Council's Waanyi Garawa Rangers (based at Borroloola), and the Central Land Council IRG coordinators, have both given provisional support to their involvement.
- Follow-up discussions with QLD and WA agencies will be following shortly.
- Contractual arrangements between the BNHCRC and CDU have now been finalised.

From the above it will be evident that the implementation of this project has required careful engagement and negotiation both with EM agencies and prospective target communities. Given this, it is likely that the project will still take some time (e.g. at least some months) to continue to build effective engagement with community and EM agency partners before being able to commence more formal scenario planning research activities.