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Introduction

In just one decade, building on a heritage dating back to 1949, Charles Darwin University (CDU), has developed into an exemplary research-intensive, dual-sector university, ranked highly relative to size and scale in Australia’s Excellence in Research in Australia (ERA) assessment and in international university rankings, including the Times Higher Education (top 2 per cent and top 100 universities in the world under 50 years old) and QS World University Rankings (top 500).

Although Charles Darwin University is small by Australian standards, and located in the remote far north of Australia, research is central to the purpose of the University, and closely tied to the needs of the Northern Territory and the Territory’s immediate region: Timor-Leste, Eastern Indonesia and the Arafura Sea.

To achieve focus, and align research with the changing economic profile of Northern Australia, the University has identified two broad fields of research, critical to our region, to be maintained at world class standard: Environment and Livelihoods, and Human Health and Wellbeing. A limited number of research fields that are strategically important to the Northern Territory, with the potential to develop into world class fields of research, also have been identified including: Social and Public Policy, Education at the interface with Health, and Energy. In addition, Indigenous knowledges is a cross-cutting research focus that is integral to the areas identified above.

The adoption of a strong research focus and promotion of cross-disciplinary research teams has been a successful institutional strategy to build world-class research capability. Research capacity and capability have also been built through key partnerships with the Menzies School of Health Research, with other universities, particularly the Australian National University (ANU) and the Innovative Research Universities group (IRU), as well as with government, industry and Indigenous organisations such as the North Australian Indigenous Land and Sea Management Alliance (NAILSMA). Increasingly, these research partnerships extend internationally, particularly throughout the Asia-Pacific region.

Recognition for CDU’s research has occurred nationally and internationally. The Commonwealth Government’s Excellence in Research for Australia (ERA) 2012 showed that there has been an improvement in research quality across Australia since the last assessment in 2010. In this context it is an endorsement of CDU’s research strength that the University was ranked at or above world average on 71 per cent (10 of 14) of the research disciplines for which it was assessed in the broad fields of: Environmental Sciences, Biological Sciences, Agricultural and Veterinary Sciences, Information
and Computing Sciences, Economics, and Medical and Health Sciences. The pinnacle of achievement was CDU’s research in Clinical Science, conducted primarily through the Menzies School of Health Research, which received the highest possible score of five, ranking the discipline’s performance as outstanding, and well above world standard.

Research by both staff and postgraduate students is largely applied and targeted at significant real-world problems in Northern Australia and Asia. Research results provide input to public policy formulation, private sector decision-making, the work of non-government organisations and communities. The University has identified the need to develop strategies to enhance its social contribution through focus, quality, sustainability and capacity relevant to the distinctive and challenging context in which it operates.

In 2012, CDU participated in a national trial, the Excellence in Innovation in Australia (EIA) trial, aimed at demonstrating the economic, social and environmental benefits of research undertaken by Australian universities. The EIA trial aimed to show that there is direct evidence that research is bringing tangible benefits to the nation. The trial used case studies of research in contrast to the traditional research metrics that focus on publications and citations. This enabled the provenance of research to be traced and the impact documented in more appropriate timeframes.

Led by the Group of 8 and Australian Technology Network universities and including Charles Darwin University, the University of Newcastle and the University of Tasmania, the trial involved seven assessment panels of 75 volunteers, 70 per cent of whom were external industry, community and business sector leaders and experts.

One hundred and sixty-two case studies were submitted for assessment by the participating universities. Of these case studies, 87 per cent were found to have considerable, very considerable or outstanding impact. CDU submitted 10 case studies to the trial, nine of which were assessed, some by multiple panels. All nine of these case studies were found to have considerable, very considerable or outstanding impact.

In addition, two of CDU’s case studies appeared in the ‘20 of the best’ list contained in the EIA report. These relate to our work focused on the emerging carbon economy in Northern Australia (with NAILSMA, Bushfires NT and CSIRO) and to the work of our colleagues at Menzies School of Health Research on better treatments for malaria.

In this publication we present 10 compelling case studies of research with impact at CDU and the Menzies School of Health Research. CDU is extremely proud of these exemplars of our research and the impact this research is generating. This research exemplifies the profile of a research-intensive university committed to addressing the needs of its region through engaged, place-based research. The research ranges from the adaptation of an ancient Chinese biological pest control technique through to the monitoring and mapping of fire, natural resource management and health service delivery in Eastern Indonesia. Many of the case studies focus on issues that are critical to our North Australian Indigenous communities in the fields of health, land management, governance and planning. These case studies document sophisticated models of engagement and inclusion of Indigenous researchers and recognition of Indigenous Knowledges – hallmarks of CDU and Menzies School of Health Research.

This is research undertaken by committed, dedicated researchers and research teams that have access to extra-ordinary opportunities but not necessarily extensive resources. Yet the researchers achieve outstanding results. We hope the case studies provide insight and inspiration – they are just a small window into the evolving world of high quality research at Charles Darwin University and Menzies School of Health Research.

Professor Sharon Bell
Deputy Vice-Chancellor
November 2013
In 2011 National Geographic described the Australian species of weaver ants, better known as green ants, as ‘the oldest known form of bio-control’. The magazine noted that 1700 years ago, Chinese orchardists had observed that the ants were so zealous in consuming most invertebrates in the areas around their nests that orchard pests found it almost impossible to survive.

Scientists at Charles Darwin University (CDU) headed by researchers Dr Renkang Peng, Professor Keith Christian and Professor Karen Gibb have modified this ancient Chinese biological pest control technique to help establish profitable, new insecticide-free crops in parts of Northern Australia, South-East Asia and Africa.

Tropical tree crops are susceptible to damage by pests, such as sap-sucking bugs, caterpillars and beetles, potentially ruining crops and threatening the livelihoods of farmers. When farmers use insecticides to combat these pests, the chemicals eventually impact the soil and water and may leave residue on the fruit that is then passed on to consumers.

Many of the pests that wreak havoc on tropical crops are small and difficult to detect so, by the time farmers realise they have a problem, the damage is done. To prevent this, farmers tend to overuse insecticides by spraying to a set schedule, regardless of need.

With the overuse of insecticides, farmers and their families may experience a range of health problems, particularly in less developed countries where the regulation of chemicals is lax, and there is often a lack of understanding of how best to use them.

Using experimental trials and observations of weaver ant behaviour, Dr Peng’s team has
developed techniques to manage the fierce territorial behaviour of these ants, so that the ants will attack or repel most insect pests.

“We explored the social organisation, foraging behaviour and territorial behaviour of weaver ants in relation to the basic biology of numerous pests and the tree-crop physiology and phenology to ensure the ants can be effectively managed as a biological control agent,” Dr Peng said.

The costs of this biological control technique are lower than conventional insecticides, and the quality of a crop such as cashews is higher because the weaver ants also continuously clean the developing nut.

Field testing of the new CDU ant technology in Northern Australia has increased the annual profits for cashews by at least $1500 per hectare, and by 73 per cent for mango growers who previously had been reliant on insecticides. Vietnamese cashew growers have increased their net profits by 13 per cent and the nut quality is higher as a result of the trees being protected by the ants. Even greater profits are likely in the future if the nuts can be sold as organically grown.

Although weaver ants have been used to control pests in southern China and Vietnam for centuries, the ants had to be reintroduced regularly into the orchards, which limited their more effective use. Now through Dr Peng’s research this has been overcome through better understanding of the social and colony structure of the ants. The CDU research team has developed techniques to identify different colonies, locate the queens and transplant entire colonies into mango and cashew orchards, and even timber tree species.

“To ensure that weaver ant populations remain high and effective as biological control agents, we have studied the colonies closely and developed techniques to manage the ants at the level of the colony so that they spend

OPPOSITE: African weaver ants (*Oecophylla longinoda*) control sap-sucking bugs (*Riptortus dentipes*) which are one of the main insect pests in cashew plantations in Benin.

Australian weaver ants (*Oecophylla smaragdina*) (local people call them green ants) control fruit spotting bugs (*Amblypelta lutescens*) which are one of the main insect pests in cashew, mango and African mahogany trees in Australia.

Weaver ants (*Oecophylla smaragdina*) in East Timor control leaf weevils (unidentified species) which are one of the main insect pests in cashew orchards.
more time protecting the trees and less time fighting different weaver ant colonies and other ant species,” Dr Peng said.

This breakthrough in understanding key weaver ant behaviour gives small farm holders the freedom to abandon harmful insecticides. In a survey of 197 cashew farmers in Vietnam, 92 per cent reported that insecticides had caused adverse effects to their farm environment, such as deaths of fish grown in nearby channels. Additionally, 80 per cent reported that their health had been affected by the insecticides they used.

The use of ants as biocontrol agents has since passed the toughest test: the adoption by previously sceptical farmers.

Vietnam is one of the biggest cashew producers in the world, with annual exports valued at more than $US 1 billion. The research team has worked closely with the Vietnamese Government to train 113 of its employees, who in turn have passed on the techniques to almost 2500 cashew farmers across nine provinces through almost 100 farmer field schools. Of these farmers, 95 per cent said they believed their health would benefit from adopting the biocontrol techniques, and 89 per cent believed there would be an improvement in their farm environments with the adoption of the ants.

After working with the ants and seeing the results in demonstration plots with and without ants, 93 per cent of the farmers were convinced the ant technology was effective. Crucially, after the farmer field schools were completed in 2008, nearly one-quarter of the farmers moved from insecticides to using weaver ants to control insect pests.

Following the success of the work in Northern Australia and Vietnam, CDU is now developing similar tailored techniques and instructional resources to help establish an organic cashew industry in East Timor and an organic mango industry in the African nations of Benin and Tanzania.

**Funding Sources**

This work has been funded by the Rural Industries Research and Development Corporation, the Australian Centre for International Agricultural Research, the Ministry for Agriculture and Forestry (East Timor), and Charles Darwin University.
Counter-forces mounting against fire-prone Gamba threat

Australia’s tropical savannas are recognised internationally for their outstanding natural and cultural values. The vast area of healthy savanna woodlands and forests attract hundreds of thousands of tourists each year. Unfortunately, in the past decade, large areas have been invaded by the weed Gamba grass (*Andropogon gayanus*) and damaged by intense fires that sweep through the invaded areas.

A team of CDU researchers, led by Associate Professor Samantha Setterfield and Professor Michael Douglas, recognised the urgent need to manage this situation and have spent more than a decade completing one of the most comprehensive studies ever undertaken on an invasive species. Professor Douglas said: “The aim of our team was to investigate this quite unusual situation where one species was invading a relatively undisturbed ecosystem, often free of any other weeds, and fundamentally changing it. We wanted to determine factors that contributed to the weed’s success and to measure its devastating impacts. We wanted to do research that would underpin management of this weed and other invasive grasses.”

Introduced into Australia to increase pastoral productivity, Gamba grass has spread across parts of the Northern Territory, Queensland’s Cape York Peninsula and the Atherton Tablelands, as well as

ABOVE: A Gamba fire (photo Samantha Setterfield).
parts of Western Australia’s Kimberley. Originally introduced from Africa, this weed grows up to 4.5 metres tall and invades tropical savanna, from the river edges to the rocky hilltops, outcompeting the native flora. Infestations already total 10,000–15,000 km² and this represents just two per cent of its potential range in Australia.

In the mid-1980s, Gamba grass was deliberately released for planting and was promoted by agricultural departments across Northern Australia and embraced by the cattle industry. But CDU ecologists soon warned of its potential to escape from grazing lands and invade savannas and the need to implement a strong management plan. These initial concerns were met by strong opposition and calls to substantiate these claims from the proponents of Gamba grass.

CDU’s early studies focussed on demonstrating that Gamba grass could invade undisturbed areas and posed a threat to vast areas of the savanna. This had been strongly denied previously by the cattle industry and therefore was a critical piece of knowledge to demonstrate the risk that the weed posed to natural ecosystems. Further demonstration of the risk posed by Gamba grass was provided by Dr Natalie Rossiter-Rachor, who showed that Gamba grass can alter soil nitrogen supplies to ensure its growth and spread over the long-term. Dr Rossiter-Rachor’s world-class PhD research revealed a key that helped explain the apparent paradox of how this highly productive grass was able to thrive in the nitrogen-poor soils of Australia’s savannas.

Dr Rossiter-Rachor, now a lecturer at CDU, explained that the worst impact of Gamba grass invasion was the change in fire regimes. “Compared with native grasses, Gamba forms very tall, dense fuel loads. We measured fuel loads typically three to eight times higher than native grasses,” Dr Rossiter-Rachor said. “We measured the amount of fuel and the fire behavior at many sites and were able to show that the change in fuel resulted in fires far hotter and these are devastating to the local biodiversity.”

The CDU team, working with collaborators in the NT Government, went on to show that the changes in fuel load are so significant that the Bureau of Meteorology and Bushfires NT created two special fire zones in which fire risk is calculated daily to account for the fuel created by Gamba grass and other invasive grasses. The team quantified the massive increase in the costs to the NT Government that were needed to battle Gamba fires. Costs have risen due to the need to bring in major equipment, such as fire-fighting aircraft, much more regularly to fight the much hotter Gamba grass fires.

Gamba grass is continuing to spread but the CDU team is now using innovative models to predict future spread and to identify the priority areas for weed control work. The new research will give land managers the best chance of finding new outbreaks and containing Gamba
The impact of CDU’s research on Gamba grass and other invasive grasses has supported:

- a NT Government policy to assess plants for their weed risk;
- the declaration of Gamba grass as a weed in the NT (2008), Queensland (2008) and Western Australia (2008);
- position Statements and Policies of the Australasian Fire and Emergency Services Authorities Council (2008) and National Farmers Federation (2008);
- creation and implementation of two fire primary response zones by the Bureau of Meteorology (2009);
- listing of Gamba grass (and three other grass species researched by the CDU team) as a Key Threatening Process under the EPBC Act (2009);
- development of the NT Government Gamba grass Weed Management Plan (2010);
- development of a Draft Threat Abatement Plan by the Federal Environment Department to address ecosystem degradation, habitat loss and species decline due to invasion of northern Australia by invasive grasses (2011); and
- listing of Gamba grass as one of only 32 Weeds of National Significance in 2012.

Useful links
http://riel.cdu.edu.au/blog/2012/05/gamba-adds-to-bush-fire-concerns/
http://riel.cdu.edu.au/people/profile/samantha-setterfield

Dr Setterfield said: “Throughout this research program, we have focused on a risk-management approach in which we have demonstrated the risk posed by invasion of Gamba grass, quantified the cost of its impacts as well as the cost of effective management. We will continue to work with stakeholders to ensure that the best information is available to manage this invasive weed.”

RESEARCH COLLABORATORS

Charles Darwin University
S. Setterfield
M. Douglas
L. Hutley
A. Drucker
N. Rossiter-Rachor
V. Adams
A. Petty
M. Welch
J. Barratt
E. Ens

Students
N. Rossiter-Rachor (PhD Student)
K. Brooks (PhD Student)
P. Clifton (Honours student)
B. Ryan (Honours student)
T. Flores (Honours student)

Other Research Organisations
G. Cook (CSIRO)
R.J. Williams (CSIRO)
K. Parr (CSIRO)
S. Schmidt (UQ)
L. Wainger (University of Maryland)

NT Department of Land Resource Management
K. Ferdinands
P. Barrow
A. Hendry
S. Whatley
J. Whatley
C. Platell
S. Davies
A. Turner
S. Sutton

NT Bureau of Meteorology
I. Shepherd
W. Lynch

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Australian Weeds Research Centre
Rural Industries Research and Development Corporation
CDU
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The east Indonesian province of Nusa Tenggara Timur (NTT) is the driest and one of the poorest in the country. It includes the Spice Islands of Sumba, Flores and the western half of Timor. Most of the NTT population live in remote communities where poverty, poor health and reliance on subsistence agriculture are common. Ten years ago, in partnership with Indonesian government and non-government agencies and universities, CDU set up a suite of projects to address a number of problems facing these remote communities.

Each project was developed in direct response to needs described by CDU’s Indonesian partners, especially the NTT provincial government departments, district government departments and non-government organisations. Training using local data and technologies was aimed at low resourced developing areas to maximise the impact of the research.

One of the projects was to assist villagers to manage the fire-prone nature of the savanna landscape, which has become more of a problem for the villagers since the Indonesian Government introduced national fire laws that were at odds with local needs. Ten years ago villagers, when questioned by CDU researchers, said they felt powerless to protect their homes and plots from wildfires. This was despite a long tradition of using fire to prepare fields, stimulate grass growth and to support hunting.

Familiarity with savanna ecology and Indonesian culture and language, along with a commitment to long-term engagement, has enabled the CDU researchers to build relationships of trust and cooperation in NTT. This has resulted in the foundation of local
capacity-building that has seen more controlled use of fire to protect lives and assets, the rise of agroforestry and improved natural resource management.

Another project worked towards poverty alleviation and better health for mothers and children. Access to health care – especially maternal and neonatal services – is impeded in NTT by topography, road quality, availability of transport and seasonal flooded rivers and landslides.

To ensure that all the projects remained effective, CDU researchers developed and implemented monitoring and mapping to evaluate the impact and to assess how resource management and service delivery could be further developed and improved.

Through the introduction of strategic community fire management practices into the NTT study villages by the CDU researchers from 2002 to 2005, communities became aware that by gaining skills in planning and carrying out strategic burning they could protect their agroforestry plots, homes and gardens. Even years after the project has finished, villagers still continue to create and maintain fire breaks in almost all the study villages and every year new villages adopt the practices.

By 2012, 17 villages in East Sumba and 14 villages in the Ngada/Nagekeo area in Flores were implementing community burning. Most of these villages had also established agroforestry. By working with local NGOs, the villagers in the study villages had gained skills in establishing and maintaining agroforestry plots. The community of Dorameli in Flores went on to win a national forestry rehabilitation award in 2006.

Since the fire project began, no large blazes have caused significant damage to the agroforestry plots at the study sites except in 2011 when the plots at Dhereaia village in Flores were not maintained and were burnt by wildfire.

There is also evidence from satellite imagery of reductions in the proportion of land burnt each year within the study villages, compared with that of the surrounding savanna-dominated landscape.

Similarly, health mapping is now used to target programs for improving health facilities, especially improved access to maternal health care. As a direct result of the health mapping project from 2008 to the present, health officers in nine of the 21 districts of NTT province now have health mapping skills. These district health staff create timely maps of disease outbreaks using free, open source Open Jump software, and maps of health infrastructure using free Cybertracker software and handheld PDA units with GPS.

The maps of health facilities, population distribution and estimated travel time are being used...
by the district health departments to develop appropriate health services, especially in maternal and neonatal care.

The head of the NTT provincial health department has given the program and technology a ringing endorsement, saying public health mapping will continue to support the NTT program to improve maternal and infant health.

The CDU researchers are confident that the technology and knowledge transfer originally built into the action research, and maintained over the past decade, will embed the new practices over the longer term.

Indonesian officers trained in mapping now provide training in NTT. Flores planning officers have been employed by other district government and external agencies to provide mapping training. UNICEF employed an Indonesian university lecturer and clinic staff member to deliver health mapping in Sumba in 2011.

A collaboration of universities promises to support capacity building in the region in the long term. Four universities – CDU, Universitas Nusa Cendana, Universitas Kristen Satya Wacana and Universitas Gadjah Mada – have jointly developed and now jointly offer the Eastern Indonesian Field Intensive. Students and staff from the four universities work together to investigate development issues in NTT, enjoying the challenges of working across cultures and using three languages – Indonesian, English and the local language Dawan.

Based on evaluations of the impacts of the work, researchers expect that this new culture of research-based project engagement will continually improve aid delivery across the region, and will in turn improve prospects for international aid delivery and cooperation.
Melioidosis is a disease caused by bacteria that live in soil and appear to have a symbiotic relationship with various plants. It causes local and generalised infection in its victims, often pneumonia, and in some cases septic shock and death. ‘Melio’ or the ‘soil disease’, as it is often called, came on to the Australian radar in the late 1940s when sheep became infected in outback Queensland. The first human case emerged in the Northern Territory in 1960. In 2011–12, the Top End had a record number of 97 cases including nine deaths, with most cases occurring in the wet season.

Professor Bart Currie, the team leader of Tropical and Emerging Infectious Diseases at the Menzies School of Health Research, along with colleagues from Menzies and the Royal Darwin Hospital (RDH), have been researching melioidosis for more than two decades. The Darwin Prospective Melioidosis Study, a collaboration that also includes colleagues from CDU and various other Australian and overseas universities, is now in its 24th year. It aims to understand the epidemiological, clinical and microbiological aspects of melioidosis in the Darwin region, and to use this information to lessen the burden of the disease. It also seeks to improve diagnosis and treatment of cases and provide health promotion messages in
conjunction with the Centre for Disease Control at the Northern Territory Department of Health.

The bacteria, according to Professor Currie, are understood to ‘switch on’ and multiply in the wet season. He explains: “These bacteria are then probably brought to the surface by drenching rains recharging the subterranean aquifers, which are underground layers of permeable rock or materials such as soil or silt.

*Burkholderia pseudomallei* lives below the soil’s surface during the dry season, but after heavy rainfall, it can be found in surface water and mud and potentially become airborne. It usually enters the body via cuts and sores in the skin or via inhalation of splashes, dust or droplets and, in very rare cases, by ingesting contaminated water.

In Australia, cases typically occur in the tropical north, including in the Top End of the Northern Territory, far north Queensland and the Kimberley region of Western Australia.

Bacteria causing melioidosis have been found in various environments in and around Darwin including, for example, rural bore waters where 33 per cent were tested positive. The levels are usually low and are generally of no public-health concern, but on rare occasions, the bacteria have been directly linked to cases of melioidosis in people living in rural areas.

It has also been revealed that the bacteria grow in NT grasses, especially introduced grasses. Also it is not uncommon to find the bacteria in the soil of Darwin’s sporting ovals. Fortunately, cases of melioidosis in healthy sports people are very rare. Finally, the team’s recent work has shown that the melioidosis bacteria potentially can be spread by birds.

Symptoms depend on where the infection establishes itself, which is often in the chest. Other initial presentations include fever with abdominal pain progressing to difficulty passing urine, or fever with headaches and confusion, or just persistent fevers. People who have no specific risk factors for melioidosis may present with only a non-healing skin sore that does not respond to standard antibiotics.

Patients usually fall ill within one to 21 days after being infected, and symptoms may be sudden or gradual. In rare cases, the disease only becomes apparent many years after the initial infection. Although the person has been carrying the bacteria for many years, it is only when the person’s immune system is weakened that it becomes active. The longest documented time between infection and disease activation has been 62 years. The person was a World War II veteran who had served in South-East Asia.

The Top End’s wet seasons of 2009, 2010 and 2011 produced an unprecedented high number of cases. Ongoing studies are assessing the impact of rainfall patterns on these high rates of infection, as well as the impacts of population change in Darwin and of environmental disturbances, which have been occurring as a result of the many construction projects taking place.

The key to decreasing mortality from melioidosis is early diagnosis, so that treatment can be started quickly using powerful antibiotics and state-of-the-art management of the critically ill patient with sepsis. Through the work of the research team and the highly skilled and experienced staff of the Microbiology Laboratory, Emergency, Infectious Diseases and Intensive Care Departments at the Royal Darwin Hospital, the current mortality rate at the hospital from melioidosis is the lowest in the world.

“The RDH staff is truly the world leaders and experts at saving lives when it comes to melioidosis,” Professor Currie said.

**Funding Bodies**

The Menzies melioidosis program is funded by the National Health and Medical Research Council, the Australian Research Council, the Northern Territory Research and Innovation Fund, the Department of Foreign Affairs and Trade, the Department of Prime Minister and Cabinet, and the US National Institutes of Health, Department of Defense and Department of Homeland Security.
Over the past three decades, scientists and traditional owners, led by artist Lofty Bardayal Nadjamerrek, have warned of the effects of fire on the cultural and natural values of two of Australia’s most significant biodiversity hotspots, the Arnhem Land Plateau and Kakadu National Park.

Collaborative research undertaken by CDU, Bushfires NT and the CSIRO (under the umbrella of the CDU-hosted Tropical Savannas Cooperative Research Centre), has underpinned a groundswell for better fire management. This groundswell has been driven by strong Indigenous leadership from Traditional Owners supported by the Northern Land Council (NLC) and the North Australian Indigenous Land and Sea Management Alliance (NAILSMA).

As a direct result of this leadership, land management practices have been developed, including skilled use of fire based on a combination of traditional knowledge and western science. These practices have a clear objective: to restore Indigenous management regimes and minimise destructive fires in the late dry season.

In Australia, 300,000 to 700,000 square kilometres of land are consumed by fire each year. Continental mapping of large fire-affected areas from 1997 to 2004 revealed three-quarters of this burning – more than 500,000 square kilometres annually – swept through the northern savannas.

**ABOVE:** Indigenous fire management has shown that destructive wildfires can be radically reduced (photo Shutterstock).
Apart from threatening lives and destroying assets, these unchecked fire regimes have significant effects on biodiversity and erosion, and are a major source of greenhouse gas emissions.

The contribution to greenhouse gases from the burning of Australian savanna is very significant, typically ranking second or third after Africa.

In 2005, the first major program aimed at substantially reducing greenhouse gas pollution from savanna burning in Northern Australia began with 24,000 square kilometres of Arnhem Land, under the Western Arnhem Land Fire Abatement (WALFA) project.

Although supported by both Australian and Northern Territory Governments, the project has long been a ‘voluntary’ offset until Australia shifted to a market mechanism with the introduction of the Gillard Government’s carbon price signal in July 2012. At the time of going to print, however, there is uncertainty as to whether this will continue.

Scientific research has shown that traditional Indigenous fire management has been effective in reducing wildfires across the vast and exceptional West Arnhem Land Plateau, which lies immediately east of Kakadu National Park. Apart from helping to cut greenhouses gases from unchecked burning, Indigenous fire management has also provided meaningful employment to Indigenous people.

Global exploration and production company ConocoPhillips has invested $1 million a year over 17 years to purchase carbon offsets generated by the project, with payments meeting operational costs, including additional employment for Indigenous ranger groups.

The fire management has involved more than 100 part-time jobs for Indigenous rangers and others, and promoted collaboration among many different ranger groups and communities, according to the Tropical Savannas Cooperative Research Centre (CRC).

Working with Bushfires NT and the NLC, rangers perform the on-ground, strategically planned, early dry-season burning regime.

The impact of the Western Arnhem Land project in reducing wildfires can be seen in satellite images of fire scars.

The map in Figure 1 shows the fires in 2004 – the year before the project started – when the region was swept by large wildfires entering from all sides. The map – based on satellite images – shows in orange the extent of these typically intense, late dry-season fires.

Only a limited number of early, cooler firebreaks (shown in green) were implemented in 2004, which did little to stem the large wildfires. Fires in the late dry season from September to December are shown in orange.

By 2007 (see Figure 2) and 2008 (see Figure 3), however, WALFA funding allowed extensive firebreaks and patch burns to be implemented (green patches), resulting in fewer late season fires (orange) penetrating into the plateau.

In the first six years of WALFA operations, the equivalent to 600,000 tonnes of CO₂ have been abated relative to the baseline average emissions of 1995–2004.

Pivotal work led by CDU Adjunct Dr Jeremy Russell-Smith of Bushfires NT informed the development of Australia’s greenhouse gas inventory reports on savanna burning emissions, especially...
regional values for fuel loads and burning efficiencies.

This work has subsequently been refined and an approved savanna burning methodology has been developed by a team including Dr Russell-Smith and another CDU adjunct, Peter Whitehead as well as collaborators from CSIRO and the Department of Climate Change and Energy Efficiency (DCCEE). In 2011, the Domestic Offsets Integrity Committee approved the savanna burning methodology under Australia’s Carbon Credits Carbon Farming Initiative (CFI) Act 2011.

At the heart of the success of the WALFA project is the insight that greenhouse emissions in the late dry season are higher than those of the early dry season. On average, these late fires emit 52 per cent more emissions than the early fires. This is because early fires typically extinguish overnight. Whereas fires ignited in the late dry season – where strategic, prescribed burning has not been effectively undertaken – regularly burn unchecked over tracts of country greater than 1000 square kilometres.

The role of the collaborative research described here was to set up the scientific basis for better fire management that reduces greenhouse gas emissions. More broadly the collaboration has allowed researchers, Indigenous fire managers and other practitioners to work together to develop practical tools and processes for this new era in fire management. These tools have included a website that displays satellite maps of fires (www.firenorth.org.au) and refined techniques for on-ground and aerial fire management in remote and rugged country. Another key to the success to date of the savanna burning program has been the role of NAILSMA in supporting Indigenous fire managers and advising policy makers. It is this wide-ranging collaboration that has helped to create an economic base for fire management in Australia’s tropical savanna and to provide for Indigenous social and economic development.

Major reductions in unchecked wildfires have resulted in a raft of positive outcomes, which include: reduced impacts on biodiversity through greater habitat protection, especially ‘increased landscape connectivity’ and the maintenance of ‘unburnt refugia’; better protection of significant Indigenous rock art, improved health of country and enhanced bush tucker resources; increased opportunities to ‘work on country’ and implement Indigenous practice, which helps to strengthen cultural connections to country and boost inter-generational transfer of knowledge.
Indigenous ranger program increases esteem and hope

Pioneering research by CDU scientists over a period of 15 years has led to the successful Federal Government ‘Working on Country’ program that employs 680 Indigenous rangers in 91 teams across Australia.

Independent and CDU evaluations of the main Indigenous land and sea management programs show Indigenous rangers are tackling many of the country’s most important environmental challenges. At the same time they are reducing welfare dependency, countering chronic health issues, being role models and, most importantly, increasing self-esteem and hope.

The researchers described the increased self-esteem and hope ‘as perhaps the greatest benefit of the land and sea management ranger programs’.

Using a fusion of Western science and training, and Indigenous ecological knowledge, the Indigenous ranger teams manage more than 1.5 million square kilometres of land and sea. Nearly all the work involves what are officially considered matters of national environmental significance, such as work on threatened species and communities, and wetlands of international importance. More than half involves management of threatening processes, such as feral pigs, cats and invasive grasses. At the same time, the work allows the transfer of Indigenous ecological knowledge to younger generations and it enables people to maintain sites of cultural significance.

CDU’s predecessor, the Northern Territory University (NTU), was among the first to recognise the potential of Indigenous land and sea management. Two key research centres were founded at the NTU in the late 1990s, which produced the underpinning collaborative research needed to drive the change to bring the Indigenous ranger program into being.

CDU traces this historic Australian environmental and cultural reform back to former CDU researcher, Professor Marcia Langton, and her keystone 1998 paper, ‘Burning Questions: Emerging Environmental Issues for Indigenous Peoples in Northern Australia’. In the paper Professor Langton showed that Indigenous people have managed Northern Australia’s landscapes successfully for thousands of years. Indigenous people were also responsive to the concept of sustainable environmental management that integrates tradition and science.

Recognising the need to respond to Indigenous community priorities and to help ensure the dissemination of research outcomes, a partnership was formed between the NTU, Batchelor Institute of Indigenous Tertiary Education, the Dhimurru Land Management Aboriginal Corporation, the Kimberley Land Council, the Northern Land Council, the North Australian Research Unit of the Australian National University, and the Yothu Yindi Garma Cultural Studies Institute.

A year later, the Bawinanga Aboriginal Corporation, based at Maningrida in Central Arnhem Land, and the Katherine-based Jawoyn Association joined the partnership.

Collaborative research undertaken by Australian Research Council Postdoctoral Fellow Dr Rod Kennett, in partnership with the Dhimurru Land Management Aboriginal Corporation and the Parks and Wildlife Commission of the Northern Territory, was among the first to document the effectiveness of Indigenous ranger groups in natural resource management.

Similarly, the inadequacy of research and teaching in dealing effectively with critical issues
for sustainable use and conservation of wildlife in Northern Australia led to the establishment of the Australian Research Council Key Centre for Tropical Wildlife Management (KCTWM) in 1998.

Based at NTU, and led by Principal Research Fellow Dr Peter Whitehead, KCTWM was a partnership between the Centre for Aboriginal Economic Policy Research and North Australian Research Unit at Australian National University, the Balkanu Cape York Aboriginal Land and Development Corporation, the Northern Land Council, the Parks and Wildlife Commission of the Northern Territory and Wildlife Management International Pty Ltd.

The collaborative research of the KCTWM was pivotal to the broader acceptance of the potential benefits arising from Indigenous land management. For example, the researchers worked with the Bawinanga Aboriginal Corporation (BAC) at Maningrida, resulting in BAC obtaining funds to support the regular engagement of the Djelk Rangers and other traditional owners in studies of the sustainability of subsistence use of wildlife under changing circumstances, including local initiatives to use wildlife commercially.

Better understanding of the role of Aboriginal people in management of natural systems and improved application of their knowledge and skills to existing and emerging problems were seen as pivotal issues by the KCTWM.

Charles Darwin University traces the success of Indigenous ranger groups to the strength and coherence of Indigenous leadership, especially from the North Australian Indigenous Land and Sea Management Alliance (NAILSMA). Hosted by CDU and the Cooperative Research Centre for Tropical Savannas Management from its inception in 2003 through to incorporation in 2012, NAILSMA is still located at CDU.

Led by CEO Joe Morrison, NAILSMA is instrumental in expanding the opportunities for Indigenous people in land and sea management. The alliance has created opportunities for Indigenous people to benefit from increased participation in water allocation and management, and more recently, the participation of Indigenous north Australians in the carbon market through their fire management.

University researchers have found the ‘Working on Country’ program provides real employment and training opportunities for some of the most remote and economically marginalised Indigenous communities in the country. The program aims to contract 730 Indigenous positions by 2016. Of these, 60 full-time equivalent positions are dedicated to flexible or casual employment arrangements that have increased opportunities for elders and women to care for country.

A 2011 Allen Consulting Group assessment of ‘Working on Country’ for the Australian Government showed significant cost savings to the Commonwealth from reduced welfare payments, increased tax revenue and increases in income attributable to labour of up to $27.4 million. Service sectors in regional and remote communities saw benefits of more than $12 million.

The benefits of research are often difficult to predict and may take decades to fulfil their potential. Certainly the university researchers from 20 years ago could never have foreseen the extent of the benefits accruing to Indigenous people today from those early efforts to recognise the importance of Indigenous land management.
Aboriginal ways of knowing crucial to collaborations

Improving the health, education and well-being of Indigenous people, and the cultural and intellectual resources of the Australian community, relies on Aboriginal ways of knowing and being in the world, say researchers at CDU led by Professor Michael Christie.

Based at The Northern Institute and the School of Australian Indigenous Knowledge Systems, the researchers have collaborated with Aboriginal knowledge authorities on projects and consultancies for almost 20 years. The research explores Aboriginal knowledge and governance practices, and their applications in policy development and implementation.

Of particular importance is the work of the Yolŋu Aboriginal Consultancy Initiative that grew from a 40-year history of collaborations between CDU academics and Yolŋu north-eastern Arnhem Land Aboriginal knowledge authorities. The partnership began with curriculum collaboration in remote Yolŋu schools and later with teaching Yolŋu languages and culture at CDU.

The researchers say collaboration with Aboriginal elder co-researchers improved professionalism among Aboriginal knowledge authorities as they have become part of the university’s teaching, research and community outreach schemes. As well, it has led to improved ways of engagement and better policy and practice in fields such as health and medical interpretation, local government in remote communities, housing negotiations, Aboriginal knowledge practices in the school curriculum, gambling and gambling-related harm, financial literacy, community gardening, and the lives of itinerants in the long grass of Darwin.

Collaborating with Aboriginal elders and co-researchers is pivotal to the integrity of the research projects, which have explored the ethics of intercultural knowledge and its effect on university-Indigenous community engagement, the relationship of intercultural knowledge to key sociological constructs such as ‘social capital’, and the implications for policy and practice.

There have been three main impacts as a result of this collaboration:

The first is that the primary impact since 2007 has been the growing professionalism of a group of 15 senior bilingual, bicultural Aboriginal knowledge authorities from seven communities in the Top End. For their biographies view: www.cdu.edu.au/centres/yaci/consultants.html.
They previously had worked as teachers in bilingual schools, translators and interpreters in medical and legal contexts, and as community council members. During the research, they have explained their clan perspectives on key traditional and contemporary issues including water management, child development and education, mathematics, finance and traditional values in contemporary life, traditional laws of intellectual property, and knowledge production and research methodology. (See: www.cdu.edu.au/centres/yaci/resources.html.) Their work is so well regarded that they are paid on par with knowledge authorities from the wider Australian community, such as anthropologists, lawyers and environmental scientists.

The second impact, ongoing since 1995, is that Aboriginal knowledge authorities have become part of CDU’s teaching, research and community engagement. (See: www.cdu.edu.au/tfc.) Special modes and rates of payment have been applied and the consultants were recognised through numerous national awards, including the Business-Higher Education Round Table Award for Outstanding Achievement in Collaborative Research and Development, and Education and Training, and the Prime Minister’s Award, both awarded in 2005; Elder of the Year award for Yolŋu lecturer Waymamba Gaykamaŋu in 2010; and acknowledgement from key national bodies such as the Productivity Commission in 2009.

The third impact has been an actual change to government and industry practices of engagement, policy development and implementation. Examples include improved processes for negotiation over water resources in the remote island communities of Milingimbi and Galiwin’ku in 2009. There, local elders, the Power and Water Corporation, and the Aboriginal community have shared and documented their various perspectives on water values and management, and devised workable protocols for involving key people in the ongoing management of water resources.

As well, nine community development officers and nine local Aboriginal Community Development Employment Project supervisors were employed by the Laynha Homelands Aboriginal Corporation in 2012 to develop separate community profiles and action plans for 25 remote homeland centres in the Laynha region of Arnhem Land.

Local Aboriginal researchers were also engaged by the Department of Families, Housing, Community Services and Indigenous Affairs in 2011 to consult with community elders and health service consumers and plan for the community-controlled regionalisation of health services in East Arnhem Land.

Aboriginal knowledge authorities have worked as co-researchers on an Australian Research Council Linkage project entitled ‘Building Community Capacity in Mathematics Education’. This has led to fundamental changes to the mathematics curriculum at Shepherdson College on Elcho Island, using collaborative research processes and working through maths ideas in Yolŋu languages.

The project resulted in ‘Talking Namba’, a Northern Territory Department of Education and Training website that has become a Territory-wide professional development program, view: http://ourcourses.ntschools.net/course/view.php?id=271. The key to the success of the research program is the implementation of ancestral Yolŋu and other Aboriginal practices of agreement-making, conflict resolution and collective planning.
Increasing evidence shows that a significant proportion of lung disease in adults has its roots in childhood, and that the excess burden of disease in Indigenous children is greatest in remote areas. Yet the disease is potentially remediable if detected early and appropriate clinically based interventions are undertaken.

With a string of extraordinary world firsts to her name, Professor Anne Chang is a pioneering medical researcher into the lung diseases affecting Aboriginal children.

An internationally recognised paediatrician and respiratory physician with a passion for Indigenous health and evidence-based clinical practice, Professor Chang was the first person in the world to regulate inspiratory flow for clinical studies on cough sensitivity tests. She also led the first randomised controlled trial on cough using state of the art outcomes; helped develop the world’s first children’s cough-specific quality of life measure; and with others, produced the first guidelines on the management of paediatric cough that have been adopted around the globe.

Professor Chang also ran the first randomised trial to examine how involving Indigenous health workers could improve management of chronic illness in Aboriginal communities. Respiratory disease is the second most common reason for the hospitalisation of Indigenous Australians while one in every 68 Aboriginal children has chronic suppurative lung disease.

Professor Chang, a leading researcher in the Menzies School of Health Research at CDU, undertakes research at the Queensland Children’s Medical Research Institute in Brisbane. She provides clinical services at the Royal Darwin Hospital and the Royal Children’s Hospital in Brisbane, as well as to remote communities in

Tackling Indigenous lung disease
Central Australia and the Torres Strait Islands. Her research aims to reduce the burden of chronic respiratory illness and her focus is on children.

Frequent coughing is an early symptom of chronic lung disease and is linked to high death rates and significant economic costs in terms of diagnosis and treatment. In collaboration with others, Professor Chang has developed several methodologies for measuring cough outcomes, described a new entity called protracted bacterial bronchitis or PBB (with Dr Marchant), and prepared the world’s first guidelines for management of chronic cough in children as well as for bronchiectasis, a disease causing an irreversible dilation of part of the bronchial tubes arising from the destruction of muscle and elastic tissue.

As a result of this research, new sections on respiratory disease have been incorporated into standard treatment manuals here and in America and Europe. Locally, the research has provided a platform for Indigenous research leadership and mentoring, with training opportunities, capacity building and career development for Indigenous researchers.

Professor Chang has undertaken many clinical studies whose key findings include the world’s first description of protracted bacterial bronchitis; that bronchiectasis is particularly common in Indigenous children and poorly managed, but when diagnosed early and adequately managed, children can have stable lung function – as opposed to Indigenous adults with the disease who may die in their 30s and 40s.

Protracted bacterial bronchitis has been incorporated into national and international cough guidelines and there has been a ‘paradigm shift’ in the way paediatric cough is managed. The body of work from Professor Chang’s original research papers is reflected in the many systematic reviews on interventions for chronic cough, as well as contributions to national and international guidelines. This has impacted significantly on clinical practice.

With others, Professor Chang initiated Australia’s first guidelines on bronchiectasis in children in 2006 and this was later expanded to adults in 2008. More recently, the guidelines have been included in national management practices in Australia and New Zealand. The data she collected on improving the treatment of bronchiectasis in Indigenous children arose from her clinical practice and research in Central Australia. This data has been incorporated into the standard treatment manual for primary health care practitioners whereas earlier editions contained no reference to the disease.

The manual is used widely in the Northern Territory and remote areas of other Australian states while data also has been included in a primary care textbook on Indigenous health used nationwide: Aboriginal Primary Health Care: An Evidence-Based Approach, 2008. Previous editions of the textbook did not contain any respiratory chapters and both updated publications have led to improved detection and treatment of bronchiectasis.

Professor Chang also helped initiate Lung InfoNet – a web-based repository for clinicians and the lay community of respiratory resources for Indigenous Australians. Her studies have shown a high prevalence of asthma in Aboriginal children and that improved recognition was the first step towards better management.

Previous asthma guidelines utilised cough as a sole marker of its severity. Subsequent guidelines, including the latest Australian National Asthma Guidelines, have been altered to reflect Professor Chang’s research findings. Current British Guidelines have incorporated her research data in the paediatric section while her work resulted in an invitation from the British Medical Journal to write the Evidence Based Medicine Paediatric Asthma Guidelines for the internet.

Professor Chang has also led, designed and recurrently delivered two different types of three-day training workshops for more than 100 Indigenous health workers. Both workshops were developed in conjunction with local Indigenous stakeholders.

In 2010, Professor Chang received the Charles Darwin University’s Vice-Chancellor’s Award for Exceptional Performance in Research.
In the remote communities and homeland centres including Birritjimi, Gäwa, Mäpuru, Ramingining, and Milingimbi in East Arnhem Land, Aboriginal elders are experimenting with new technology as they use their computer video and Internet connections to teach their languages and culture nationally and internationally.

The elders have given 20 international teaching sessions a year for the past four years to Japan’s Tokyo Institute of Foreign Studies and to the Santa Clara University in California. More than 2600 students have participated in the sessions while the clan elders have earned $16,000 for their teaching work.

This is one remarkable example of a project initiated by researchers at CDU called Internetworking Communities. The project, led by Professor Michael Christie, has enhanced the viability and sustainability of remote Aboriginal communities through the development of a highly functional range of software and hardware configurations.

Since the inception of a Yolŋu studies program in 1994, researchers at the university have been involved in collaborative investigations with Yolŋu knowledge authorities. The aim was to find out how information and communications technology or ICT could contribute to the sustainability of Aboriginal life on country.
Indigenous knowledge authorities are partners in the research and it is from them that the researchers have learnt more about the impact of various digitising technologies on traditional governance practices, communication, knowledge work, environmental management and services, tourism, and the contemporary economy.

The Internet-working Communities Project has facilitated the transmission of traditional knowledge on country between older and younger generations; tailored complex configurations of ICT for local micro-businesses, including Internet banking and cultural tourism; supported traditional knowledge authorities in teaching traditional languages and cultures in very remote homeland centres; and taught basic computer literacy and English literacy to adult Aborigines in remote locations.

The elders involved have helped the researchers evaluate the suitability and impact of various digitising technologies for people living a contemporary Aboriginal lifestyle in very remote places. The researchers have explored the limits and possibilities of digital technologies in the intergenerational transmission of traditional knowledge.

By evaluating the emerging everyday uses of digital technologies in clan and family knowledge work, distinctive configurations of software and hardware have evolved that cover access, privacy, collaboration and accountability. As well, proofs of concepts for a range of software solutions have been developed collaboratively.

Funding for the project enabled the purchase and evaluation of laptops for five communities across East Arnhem Land: Anmatyerr (Ti-tree), Djurrnalpi, Milingimbi, Yirrkala and Gapuwiyak. As well, private computers were bought for the remote homelands of Mäpuru and Gäwa where Aboriginal elders have taken up the use of computers in their own ways and for their own purposes, including remote teaching.

The researchers also developed and configured a ‘stand alone solar powered wireless Internet system’ called SASPWIS, which is still going strong at the Mäpuru community even after seven years.

The Australian Flexible Learning Framework scheme funded a project called ‘Homeland micro e-business: e-learning for family-level businesses’ at the very remote Indigenous communities of Mäpuru, Donydji and Gäwa homeland centres, and at the Ramingining community. Internet banking has now spread around most of the East Arnhem Land communities, obviating the need for expensive plane travel to banks and government-approved shops.

One example is Mäpuru, which is many hours drive from the nearest shops and only accessible by road during the dry season, otherwise only by an expensive charter plane flight. Since the installation of the SASPWIS, the Mäpuru community

‘The aim was to find out how information and communications technology or ICT could contribute to the sustainability of Aboriginal life on country.’
Charles Darwin University has built their own shop which now has a turnover of $150,000 a year. The shop depends on Internet connectivity for payment of orders.

Internet banking at places such as Mäpuru has spread and today, in a community of around 150, the six privately owned computers support 30 per cent of the population’s banking needs. The community has also developed its own website to advertise an ongoing series of weaving workshops, survivalist camps, and basket and mat sales, as well as documenting their ancestral connections to country.

This Internet connectivity is making a real difference to the community. Since 2007, more than 500 visits have been made to Mäpuru by cultural tourists, weavers and ‘living on country’ enthusiasts. This figure, however, does not represent 500 different people because the Mäpuru residents give preference to applicants who have already been to a previous session, a deliberate policy because the community wants to maintain manageable numbers and is aiming at ongoing deeper family-based relationships and reconciliation.

Another example is how elders and young people from the Gupapuygu tribe have worked together with a postgraduate student to develop a website displaying their ancestral history, language, genealogy, ancestral songs and art for both English-speaking and Japanese audiences.

The CDU researchers believe these and other astonishing projects that link the world’s most ancient and continuing culture with 21st Century technology are just the start.

Cultural tourists are able to make ongoing connections with communities via the Internet, enhancing both income prospects for residents and intercultural relationships.

CONTRIBUTORS

CDU Staff
Professor Michael Christie (1994–present)
Ruth Wallace (2002–present)
Bryce King (2003–2008)

CDU students
Hayashi Yasunori (Masters 2008–2010)
Dr Anthea Nicholls (PhD 2006–2009)

Other contributors
Trevor van Weeren

KEY FUNDING SOURCES

Australian Government
Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS)
Australian Learning and Teaching Council
Open Learning Australia
For the first time in Australia, researchers at CDU have developed a unique population model that is now widely used for planning and policy-making across the Northern Territory. The Northern Territory Population Projections (NTPoP) model was developed by Dr Tom Wilson and is maintained and improved by the Demography and Growth Planning group within the University’s The Northern Institute.

The project arose from a gap in existing models for separately projecting different population growth patterns in the Indigenous, who comprise about one-third of the population, and the non-Indigenous populations. Different growth patterns will result in different service demands, infrastructure requirements and investment decisions.

Work on NTPoP was funded by the Northern Territory Treasury, which supports a research program at The Northern Institute to build knowledge and expertise on the relationships between populations in the Territory and in remote areas.

The researchers aimed to meet the need for separate projections of Indigenous and non-Indigenous populations in regions across the Territory. The NTPoP model was developed between 2005 and 2008 and has been used to project impacts and implications from major economic and social developments, such as the long-term effects on the population of Darwin from the construction of the INPEX major gas processing plant, and the implications of closing the gap in life expectancies between Indigenous and other Territorians.
Assumptions used in the model specify how the components of demographic change (fertility, mortality and migration) will be affected in the future and how these will interplay over the projected timeframe.

The Territory Government endorsed the use of the model in October 2007. It also required the projections to be updated and reviewed following publication of the national Census data, ensuring that the projections continued to be relevant to government decision-making and policy formulation, and that the accuracy of projections was assessed and improved over time.

The intent of this ‘whole-of-government’ application is to eliminate the danger of different sets of projections being applied to major policy-making and infrastructure investments, such as deciding when and where to build hospitals, schools and transport infrastructure.

In developing the model’s conceptual and methodological underpinnings, the researchers aimed to be open, inclusive and user-focussed. This collaborative approach included workshops, interviews with users and public presentations.

So far, NTPoP has produced two publicly available projections for the Territory and its regions. The first, ‘Projections for 2006 to 2036’, was released in 2009 and had three variants: a baseline scenario, high migration scenario and a short-term variable migration scenario. The second, ‘Projections for 2010 to 2040’, was released in 2011 with two variants: a baseline and high migration scenarios.

The researchers have applied the model to determine the impacts from the INPEX gas plant development on the population and housing demand in Darwin, as well as to analyse Indigenous life expectancies so that informed decisions can be made about health and education funding both in the Territory and nationally.

In 2012, the model was adapted as a core resource in a new master’s degree subject at CDU called Topics in Human Geography. The subject develops high-level understanding of the human geography of sparsely populated and isolated regions, such as the Territory, and demonstrates similarities and differences to other regions. Those enrolled include middle-level managers and analysts in government departments who grapple with issues related to population change in the Territory. And in the Northern Territory, population change is connected to almost everything.

Dr Tom Wilson, 2005–2007
Professor Tony Barnes, 2004–2009
Dr Andrew Taylor, 2006–present
Professor Dean Carson, 2005–
Mrs Mary Beneforti, CDU Adjunct 2006–2008

KEY FUNDING SOURCES
Australia Research Council; Northern Territory Treasury
Tjunkiya Napaltjarri
b.c.1930 – d.2009
Language: Pintupi
Designs associated with the rockhole site of Umari 2008
Acrylic on linen, 122 x 91cm
Charles Darwin University Art Collection – CDU1830
Acquired by purchase through the CDU Foundation, 2010
Image © the artist’s estate and courtesy Papunya Tula Artists Pty Ltd
Photography: Christopher Knight, Digifilm Australia