SCIENCE-BACKED TOOLS ENHANCE WATER CATCHMENT MANAGEMENT

AFAC RESEARCH UTILISATION CASE STUDY

Critical success factors:

- Build strong researcher-end user partnerships from the outset
- Understand the research, scientific approach, findings and the practical implications, benefits and limitations
- Collaborate with stakeholders nationally through AFAC

THE UNIVERSITY OF MELBOURNE

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Cover image: Philip Noske installing equipment to measure runoff and erosion rates in a small headwater catchment.

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Ash, soil and debris is often transported by concentrated overland flow in the convergent headwater hollow, as shown by sections of exposed mineral soil in this picture taken near Kilmore in Victoria after the 2009 bushfires.

Erosion after heavy rainfall on a hillslope burned during the Black Saturday bushfire near Kilmore in Victoria.

Background

Heavy rain in areas burnt by bushfire can mobilise massive volumes of sediments and nutrients into rivers and water reservoirs, threatening the quality and supply of water to Australia's capital and regional cities and damaging freshwater ecosystems.

Researchers working with ACT Parks and Conversation Service (ACT PCS) and AFAC's Rural and Land Management (RLM) group have developed an innovative suite of tools and resources to help end users identify water catchments susceptible to post-fire soil erosion, flooding and water quality risks.

ACT PCS managed and trialled the suite of tools successfully in 2015/16 and now uses the resources to plan prescribed burning operations and also target drainage and infrastructure works in identified risk-prone areas with significant water assets and important ecosystems.

Dr Petter Nyman and colleague Dr Gary Sheridan of the University of Melbourne drew on their research with the former Bushfire CRC's Fire in the Landscape project and their former work with the Victorian Bushfire Rapid Risk Assessment Team (Bushfire RRAT) to develop the evidence-based tool kit. They investigated the link between factors such as fire severity, rainfall intensity and post-fire debris flow processes. This included site-specific studies in north eastern Victoria.

"Burned headwaters catchments contain large amounts of ash, sediment and debris that can be flushed into rivers and water supply reservoirs. High sediment loads from debris flows cause high turbidity and water contamination due to increased nutrient and metals from pollutants in the runoff," according to Petter, who completed his PhD during his work with the former Bushfire CRC.

This type of contamination occurred from post-fire debris flows after the Canberra fires in 2003, resulting in water restrictions to the ACT until a new water treatment plant was constructed.

"We also saw this type of contamination in the Ovens River after the Eastern Victorian alpine bushfires in 2003 due to sediment and nutrient from debris flows in burned headwaters," says Dr Nyman. "Debris flows also led to contamination of Lake Glenmaggie after the 2007 bushfires in Victoria. The impacts of burned catchment on water quality were also documented elsewhere in south east Australia, including the Nattai Catchments near Sydney and the Lofty Ranges near Adelaide, although we have not yet observed the extreme type of debris flow processes in these areas."

"These scenarios from various landscapes across south eastern Australia highlight the importance of considering water quality issues when managing fire in high value water-supply catchments."

The researchers worked directly with ACT PCS, as the lead end-user agency and in collaboration with AFAC's Research Utilisation Manager, Dr Noreen Krusel, and the RLM group to develop and implement utilisation of their CRC research.

Their collaboration delivered two key outputs for utilisation. The initial output funded by AFAC in 2014, was an Australia-wide assessment of post-fire erosion risk accompanied by generic guidelines for evaluating risk to water quality. This was followed by the development of a suite of GIS tools, funded, managed and successfully trialled by ACT PCS in 2016. The tools generate post-fire risk assessments of erosion, flooding and water quality and build on other collaborative work by the researchers for the Bushfire RRATs in Victoria.

"These scenarios from various landscapes across south eastern Australia highlight the importance of considering water quality issues when managing fire in high value water-supply catchments."

ACT PCS lead end user Dr Adam Leavesley says the work has changed the way the agency identifies and manages the potential impact of post-fire erosion.

"The tools have enabled us to integrate water quality risk into our burn planning and implementation, plus they have given us the capacity to assess the risk after planned and unplanned fires."

This case study examines the key factors that enabled this complex research to be utilised effectively. The researchers and end users agree that the key success factor was their partnership approach, which was built on mutual trust and commitment to deliver practical, science-backed resources. The partnership enabled the researchers to understand and address the problem as well as the different operating contexts of end user agencies. An appreciation of research and research methods also gave end users realistic expectations of what the science could and couldn't deliver. The project team also believe collaboration through AFAC groups provided a national perspective on different end user contexts and needs.

The general approach to risk assessment can be applied anywhere in Australia, however the specific risk algorithms are tailored for debris flow-prone landscapes in south eastern Australia and would require further development to fit the local geographic context and account for local factors that are important to post-fire hydrological processes elsewhere.

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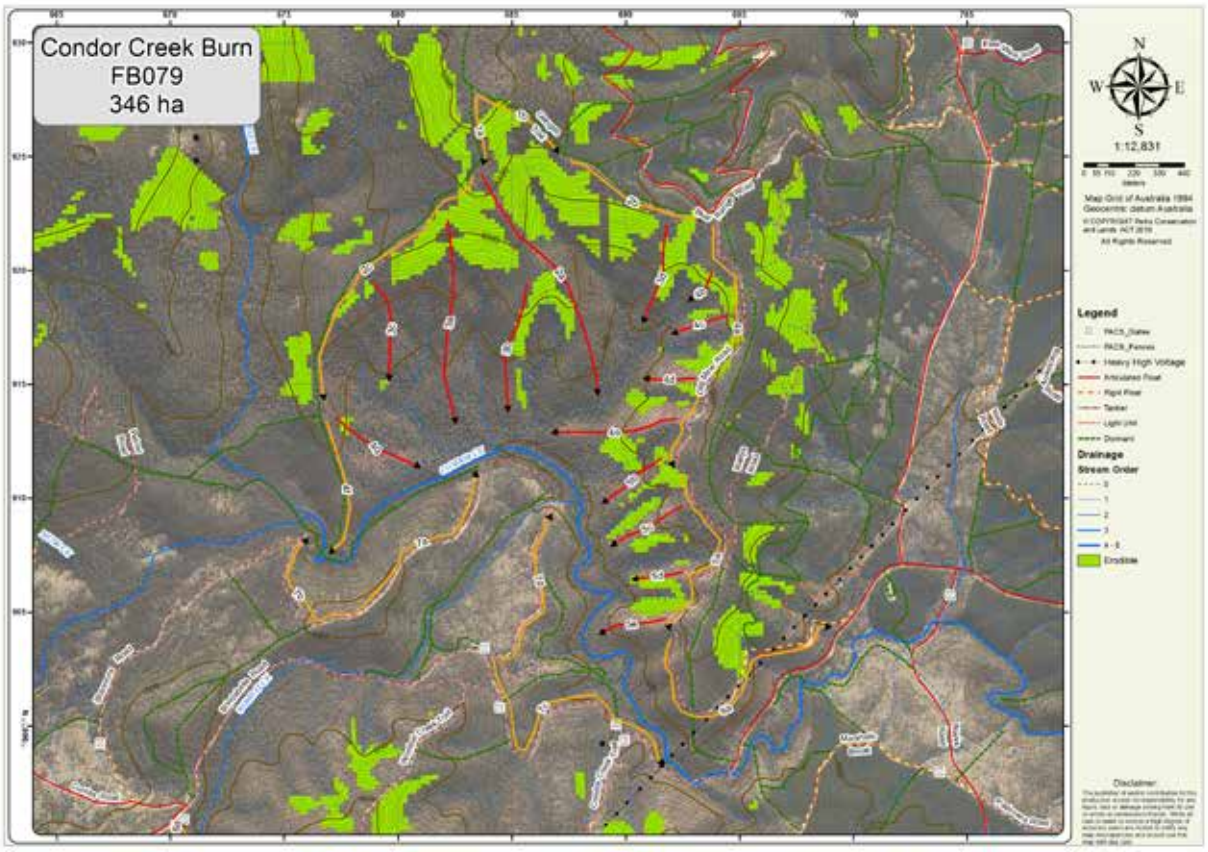
For further information on the ACT trial, contact Dr Adam Leavesley on adam.leavesley@act.gov.au



Burn map showing areas of erosion-prone ground and the ignition plan: red arrows indicate aerial ignition; orange arrows indicate hand ignition.

The research

Problem context

Fires pose a major risk to water supplies of Australian towns and cities held in forested water catchments. This is because Australian water treatment facilities typically cannot process water from catchments that have been burnt by fire, according to Dr Petter Nyman a University of Melbourne researcher for the former Bushfire CRC.

The 2003 Canberra fires, for example, resulted in water restrictions on the Australian Capital Territory after sedimentation (turbidity) levels in the Bendora Reservoir were assessed at 30 times more than the maximum on record before a new treatment plant was built, he explains.

Research also indicates there are similar risks to water supplies in other Australian capitals, such as Hobart, Sydney, Adelaide, Brisbane and Melbourne. In Melbourne, for example, approximately 80 per cent of the city's water is sourced from the Upper Yarra and Thomson forest catchments, the city having minimal treatment capacity.

In a bid to understand and address this problem, fire and land management agencies represented on the former Bushfire CRC commissioned the Forest Hydrology Research Group of the University of Melbourne to investigate the effects of forest fire on catchment processes. Specifically, the researchers investigated how fire severity and rainfall intensity in steep hilly landscapes contribute to sedimentation and pollution in forested water supply catchments in south eastern Australia. The aim was to deliver findings that could help inform and guide development of tools and resources for land and fire managers to assess and address risks to critical water assets in forested catchments.

Gary Sheridan standing on a debris flow deposit near Lake Buffalo in north east Victoria.

Understanding post-fire erosion risk

In the past decade, post-fire debris flows have been identified as a key erosion process following fire, according to forest hydrology researchers, Dr Petter Nyman and Dr Gary Sheridan.

When their erosion project began in 2011, the significance of debris flows generated from convective storm events had only recently been recognised as a risk to water quality (e.g. Nyman *et al.* 2011; Smith *et al.* 2011).

However, the magnitude of the risk to water quality (the probability of interruption to water supplies) and the degree to which this risk was modified by management actions (such as prescribed burning) was largely unknown.

The scientific aim of their research was to quantify the relationship between burn severity and the probability of water quality impacts in excess of water treatment thresholds in Australian catchments. The methods included model development, surveys of extreme erosion events and field experiments to quantify the relationships between fire severity and hillslope hydrologic and erosion properties.

The management aim of the project was to help fire managers answer the question "What are the real risks to uninterrupted water supply if this catchment is burnt by wildfire, and can I reduce this risk with prescribed fire?"

Research methods

The research primarily asked: "What are the real risks to uninterrupted water supply if (specific) catchments are burnt by bushfire, and can this risk be reduced with prescribed fire?" The scientific methods included reviews of the international research literature, surveys of extreme erosion events and field experiments to quantify the relationships between fire severity and hillslope hydrologic and erosion properties.

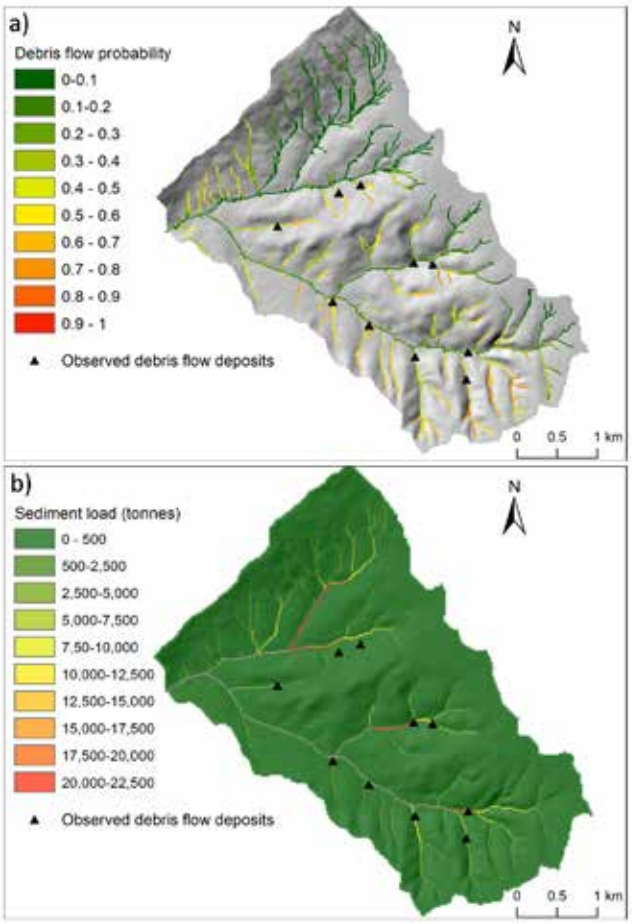
PhD research by Rene Van Der Sant also contributed to the project. She focused on using landscape dryness to assess the potential risk of extreme post-fire erosion events.

Research outputs

Dr Nyman and his colleagues used their CRC research to develop a model that predicts sediment delivery from debris flows (Nyman *et al*, 2015). The model was based on data collected in the areas burned by the 2009 Black Saturday bushfires. Through another research collaboration with Dr Owen Jones from the University of Melbourne, Petter and Gary also developed a model that represented water quality risk as a function of rainfall and fire regimes within particular catchments. This model provides a measure of how rainstorms and burned areas overlap across a landscape and was used as part of the utilisation work with AFAC to quantify the relative risks in water supply catchments across Australia (Nyman and Sheridan, 2014). In their research looking at the link between aridity and post-fire erosion, they found strong patterns across burned area in Victoria whereby drier catchments are much more prone to erosion than catchments located in wetter climates (Noske *et al*, 2016, Sheridan *et al*, 2015).

The findings of the CRC research can be found at https://www.afac.com.au/insight/operations/article/detail/fire-in-the-landscape

Their work has been published in international research journals. A full list can be found at the end of this case study.



Top right: Maps showing outputs from a model that predicts debris flow probability (a) and size (b) in areas that were burned by the Black Saturday bushfires (From Nyman et al 2015, Geomorphology*). Bottom right: Channel erosion by debris flow in headwaters of Myrtle Creek near Stanley in north east Victoria.*

High sediment concentration in a tributary to Sunday Creek Reservoir after erosion in burned headwaters.

Science to action

ACT PCS saw the potential benefits of using the CRC research findings and proposed a utilisation project. The proposal was supported by AFAC nationally through the RLM group and facilitated by its Research Utilisation Manager, Dr Noreen Krusel.

The project had two key phases, explains Dr Adam Leavesley. The first phase delivered a nationwide post-fire erosion risk assessment and risk guidelines for prospective end users. In this work, the researchers synthesised post-fire erosion literature for the Australian region and identified and mapped risk zones based on factors such as rainfall intensity, fire frequency and topography in major water supply catchments across Australia to evaluate water quality risks. The full report is available for download at https://www.afac.com.au/docs/default-source/ru/final-regional-synthesis-erosion-report.pdf

ACT PCS funded and managed the second component, which involved preparation and trial of an ArcGIS modelling tool for assessing post fire erosion risk, flooding risk and water quality risk to water assets in burned catchments. These tools were based on previous work that Dr Gary Sheridan had completed for the Bushfire RRATs in Victoria.

"The results of the trial in the ACT in the 2015/16 period were very good," says Adam. "We applied the tools to five large rural burns to estimate erosion risk from the burning," he says. "Only one of the five burns was found to have an increased erosion risk. As a result, we determined the appropriate risk mitigation treatments."

Application of the tool has also assisted us to collect quantitative data to feed into the department's monitoring, evaluation and review framework. "We used the risk assessments to determine where we needed to install instruments to measure erosion and sedimentation effects," says Adam.

Adam describes the tool as an operational breakthrough for water catchment management in fire prone areas, giving users capacity to assess and target flooding, erosion and water quality risk factors.

Critical success factors

According to the researchers and end users, a number of factors were critical to the success of this utilisation project. These included building a strong researcher-end user partnership, shared commitment to collaborative discovery to benefit use in practice and appreciation of the science and research methods.

Build strong partnerships

End user perspective

"The key for us, has been building strong and trusting relationships with a team of researchers who were committed to working with us as end users," says Adam.

"We were involved as end users at the outset, before the research began providing input on the problem/need and the context of our operating environments. We discussed how the research could proceed and the potential deliverables.

"It is critical to have this level of buy-in and two-way interaction and engagement from the start. Without this level of trust and commitment, it would be too easy to let things go when you reach roadblocks. It also gives you a realistic appreciation of both the limits and opportunities of science and particular research methods."

Researcher perspective

Extracting models from research for application is complex and involves a degree of creativity, says Petter. He describes it as a process of collaborative discovery that depends on the dynamic between the researchers and end users.

"Sometimes the answer is unknown. It is very difficult to say at the outset that this is what we're going to produce and this is what it's going to do. In reality, it doesn't work like that. Opportunities often present themselves in the process. This is quite different to pure research-based consulting or traditional scientific research," he says. "It takes a willingness from researchers to engage with end users in this way. Traditionally, many researchers have focussed on discovery, novelty and publishing, seeing applied science as a distraction from traditional research. The challenge for researchers working in research utilisation is to find the balance between the science and the usefulness of the science."

Petter says he and his co-researchers were motivated to make a difference on the ground, while also being able to publish the research and its findings in authoritative scientific journals.

"As an early career researcher at the time, I benefited from the experience and the collaboration."

Engage in collaborative discovery

End users contributed to the research plan and schedule from the outset through direct engagement as end users in the Bushfire CRC and later via AFAC's RLM group, which acted as an advisory group for utilisation project.

"Practitioners nationally in the RLM were kept abreast of the research and findings as they emerged," explains Noreen. "It was also an invaluable mechanism for prospective end users from across Australia to provide direct input into the utilisation plan and process."

The researchers also leveraged existing work with the University of Melbourne, the Department of Environment, Land, Water and Planning and Melbourne Water, importing some of the data and insight from that project into the research utilisation plan.

The CRC research had delivered good science, but it was site specific, based on catchments in Victoria, says Petter.

"Our challenge was to produce high-resolution knowledge that would be relevant to all land management agencies who are members of AFAC.

"The project team focussed on taking the knowledge forward to that next step, exploring how it could be applied and made useful for others in different locations.

"We directly engaged with end users through end user forums and in the user groups facilitated by AFAC to support and build collaboration around issues.

"This engagement forced me to think more broadly beyond just the work's scientific novelty to how to make it relevant," he says.

According to Noreen, who was directly involved in the first phase of the work, it was an unusual research utilisation project.

"We had to try and figure out what to do with the CRC research findings and potential applications," she says. "Initially, we thought we had to replicate the approach for all end users in their different contexts.

"At a workshop with the end users and researchers we reached the conclusion that the work had general application, but could be modified and adapted for different contexts," she says. This is illustrated in the shaded section of Figure 1 (below).

At this meeting, the project team members undertook the sense making and translation of the science to ensure it could apply more generally, recalls Adam. "It was a good moment, we were able to figure out what we needed."

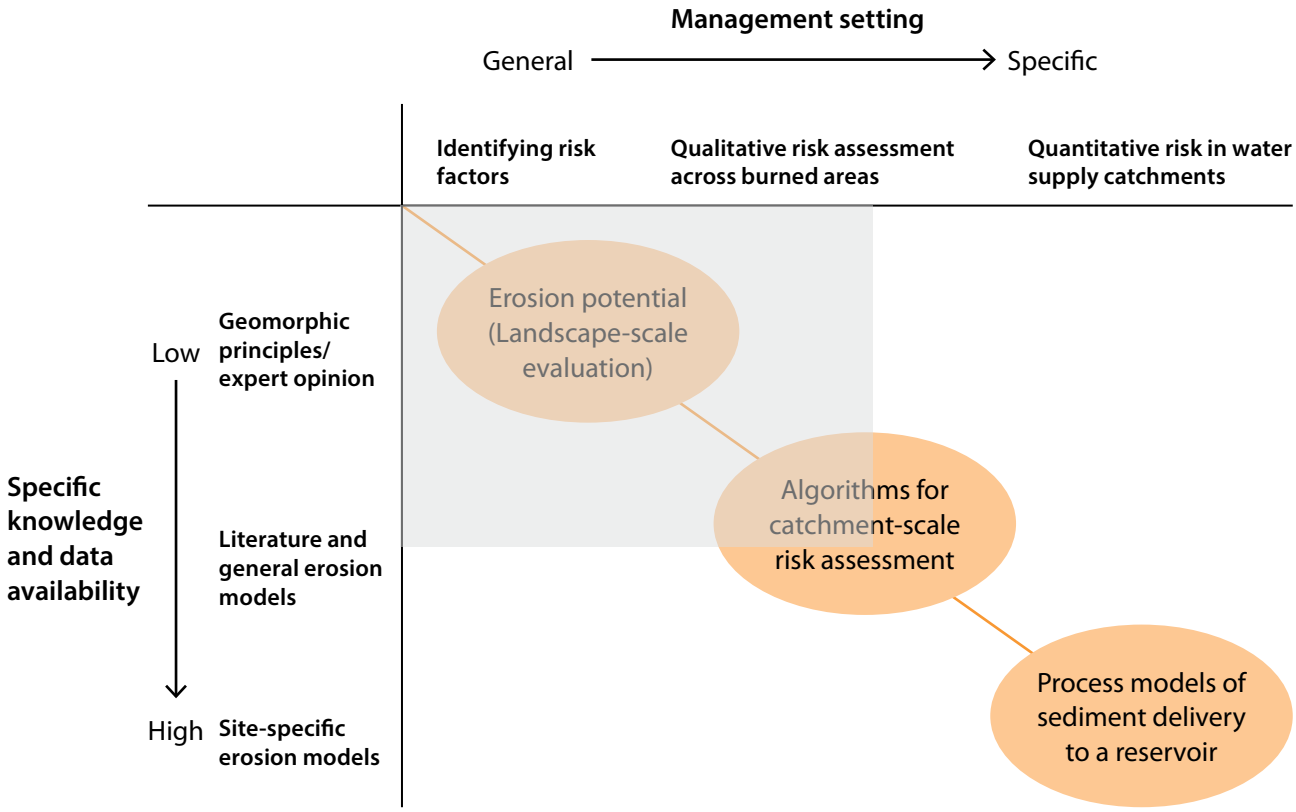


Figure 1. The types of models for risk assessments vary depending on the management setting (top axis) and the scientific knowledge (left axis) of the underlying hydro-geomorphic processes. This diagram illustrates how science gained from one specific site could be translated generally for application in different contexts. The shaded area represents the region of the science-management space that was targeted in this utilisation project.

Sand deposit in the foreground is from erosion after a planned burn in headwaters to the Naas River in ACT. The boulders in the background are from a previous and much larger event, possibly associated with bushfires in 2003.

Eroded material from burned areas consists of ash, organics and mineral soil.

Understand the science and research methods

End user perspective

Understanding research and the research process is advantageous for end users participating in research utilisation projects, according to Adam.

You don't have to be a scientist, but it helps to have a basic understanding of statistics and the limits of scientific inference, he advises.

A basic understanding of the fundamentals of science and scientific methods enables end users to provide meaningful contributions throughout the utilisation pathway, according to Adam and Noreen. End users can communicate the problem and context succinctly and effectively to researchers, contribute to conversations on the research plan, methods and utilisation options proposed by researchers, evaluate and translate the implications of research outputs for practice and provide valuable input into product development and guidance for user implementation.

"For example, in the research planning phase, a broad research question might provide too many uncertainties and not be publishable in the scientific literature, whereas a narrow tightly defined question might not deliver enough information to be operationalised," explains Adam.

A very large debris flow near Licola (East Gippsland, Victoria) after 2007 bushfires. Scars on trees and large boulders along the channel margin are typical features of these extreme erosion processes that can occur after bushfire.

Communicate and engage

Researcher perspective

Communication with end users was ongoing during all stages of the project, according to Petter and Gary. This included quarterly meetings, as well as project milestones such as research notes or discussion papers.

"In the early stages of the research project, these meetings provided an opportunity to discuss our research approach and finding areas where research questions overlapped with the key demands from land managers," Petter wrote in his research report, Fire in the Landscape.

"This type of interaction … helped ensure that our research objectives were aligned with the expectation of the agencies," he wrote.

"Discussion papers led to interesting dialogue with the lead end user regarding the needs of land managers in relation to the scientific issues underlying the research questions.

"The questions that intrigue the researcher might not be that relevant to the needs of land managers. The discussion papers helped build awareness around this issue.

"A field excursion to the research site in March 2012 provided an opportunity to discuss our research and share ideas with representatives from different end user groups."

A mountain creek weeks after a prescribed burn. Fuel consumption was patchy and regrowrth was rapid.

Research utilisation outcomes

End user perspective

This utilisation project has improved how we go about managing water catchments in forested areas, explains Adam.

"In the past fire management focused on treating fuels. We remain committed to fuel management but with this work we can integrate it with catchment management to the benefit of water quality and aquatic ecosystems," he says.

"This project has produced excellent outcomes for the ACT. And we have already had inquiries from other government departments whose staff see it as an example of innovation in using technology and data to enhance operations."

Researcher perspective

The process of doing fundamental research while delivering useful outputs to end users has been rewarding, says Petter.

"The research has been novel and improved our basic understanding of how fire impacts on catchment processes," he says. The research has been published in leading international journals such as Water Resources Research and Geomorphology.

"Working with end users and Noreen to extract useful bits from this research was a different challenge that involved several interesting discussions around how the science could be applied to help guide land management.

"This process of utilisation provided us with new insights and important experience in how to effectively work with end users to translate the new knowledge into something that could be used in both operational and strategic management settings.

"I can see potential for other end users to look at how we collaboratively worked through the problem and arrived at a utilisation pathway which maximised the available science and which met some of the key needs of the end user."

Read, click , view

View

A video and associated resources, including the initial Bushfire CRC research, relating to this project can be downloaded on AFAC's website at: https://www.afac.com.au/insight/operations/article/detail/fire-in-the-landscape

Read

Fire Note 90. 2012. http://www.bushfirecrc.com/sites/default/files/managed/resource/fire_note_90_lowres.pdf

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