DECISION POINT

Connecting conservation policy makers, researchers and practitioners

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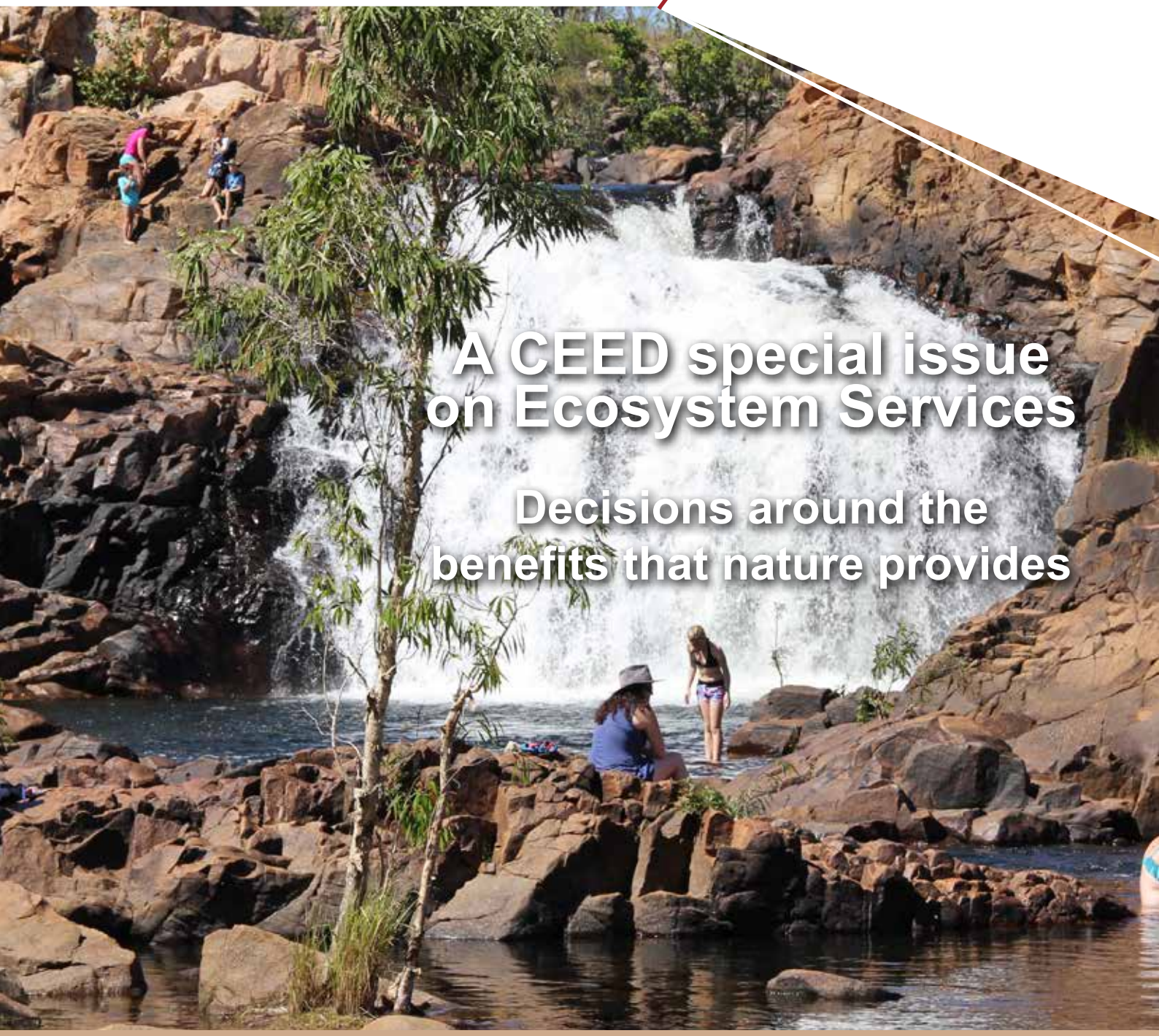

A CEED special issue on Ecosystem Services

Decisions around the benefits that nature provides

In this issue

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Centre of Excellence for Environmental Decisions

Inside this issue

Decision Point **is the free bimonthly magazine of the ARC Centre of Excellence for Environmental Decisions (CEED). CEED is a network of conservation researchers working on the science of effective decision making to better conserve biodiversity. Our members are largely based at the University of Queensland, the Australian National University, the University of Melbourne, the University of Western Australia and RMIT University.**

Editor David Salt
Website decision-point.com.au

Our cover Edith Falls in the Daly Catchment (See our story on page 4.) Ecosystem services emphasizes the benefits that nature provides – benefits that are both tangible and intangible. (Photo by David Salt)

On the point

A brief history of ecosystem services

When did the notion of 'ecosystem services' take on real meaning? In one sense, it stretches back to the beginning of history with Plato noting the connection between deforestation, soil erosion and the drying of springs. However, attempting to frame the benefits of nature in a way that enabled us to make decisions around the manner in which we managed natural resources didn't really happen till the Twentieth Century.

Some suggest it arose after the Second World War with eco philosophers like Aldo Leopold promoting a recognition of human dependence on the environment. Others claim it was the 1970s when the term 'nature's services' and then 'environmental services' began to be used (along with the idea of 'natural capital'). The term 'ecosystem services' was first used by Paul and Anne Ehrlich in their book *Extinction* in 1981. Through the 80s and 90s a number of efforts were made to put a variety of values on the benefits of these services.

However, it was probably the publication of the Millennium Ecosystem Assessment in 2005 that put the idea on centre stage for the world to play with. This monumental work, involving over 1300 scientists, included a framework for how it might be assessed. It found that 15 of the 24 ecosystem services it investigated around the world are in a state of decline and this is likely to have a large and negative impact on future human welfare.

The Millennium Ecosystem Assessment defined ecosystem services as 'the benefits people obtain from ecosystems'; and since the release of the Assessment the number of studies addressing ecosystems services has risen exponentially, so clearly the idea has had enormous traction. For all that, ecosystem services has yet to fundamentally change land-use decision-making (see *Decision Point #94*), however there is growing body of evidence linking decisions to impacts on natural capital and ecosystem services. In this special issue we showcase some of CEED's work in this area.

As always, I'd like to thank the CEED researchers who helped with the preparation of stories in this issue but special mention goes to Maria Martinez-Harms who provided much appreciated assistance in planning and organising the line up we have for you here.

Is ecosystem services an idea whose time has come? Consider the stories in this special issue of *Decision Point* and see what you think.

David Salt
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Ecosystem services: an idea with enormous value

And CEED is active in realising that potential

By Maria Martinez Harms and Kerrie Wilson (University of Queensland)

The idea of ecosystem services emphasizes the benefits that nature provides – benefits that are both tangible and intangible. This, among other things, includes the production of food and clean water, the regulation of floods, the provision of recreation and scenic beauty, a connection to place, and inspiration. These are things that make life possible and worthwhile.

Ecosystem-service assessments have become very popular within both scientific and policy circles as a means of documenting the values that humans place on ecosystems and of evaluating the benefits arising from nature.

Not everyone is happy with this approach. A recurring critique is that the ecosystem-services concept reduces nature to a dollar value that can be sold, used and (sometimes) abused. We appreciate this concern, but also see that quantifying and valuing the benefits that nature provides people gives us another data point for use in appraising solutions.

CEED is active in the field of assessing ecosystem services. Our particular focus is on using the information provided by such assessments to improve environmental decision-making. Our researchers were involved in the Millennium Ecosystem Assessment (over a decade ago), have been active contributors to GEOBON (Group on Earth Observations Biodiversity Observation Network) processes, and are lead authors in several IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) initiatives (see *Decision Point #61*).

This special issue of Decision Point brings you a selection of our work in this area. Up front we have Vanessa Adams describing how sustainable development and the protection of ecosystem services is all about respecting the different values people have for a region (in this case the Daly Catchment in the Northern Territory). She uses a scenario-based approach to evaluate options.

Jessie Wells assesses flood events and its impacts on local people in Indonesian Borneo (pages 6 & 7). Given how data sparse this region is she uses novel sources of information, villager interviews and newspaper reports, to deliver insights on how landscape changes have influenced the regulating service of flood mitigation. Still on Borneo, Elizabeth Law shows that it is possible to achieve both biodiversity conservation and ecosystem-service benefits in mixed tropical forests and thereby meet production expectations and conservation targets simultaneously (page 15).

Fleur Maseyk then takes us across the ditch to present farmers' perspectives on the costs and benefits of replanting riparian margins in the Taranaki ring plain in New Zealand (pages 8 & 9).

Rebecca Runting reviews a large body of ecosystem-service studies to see how climate change is affecting the benefits provided by nature (pages 10 & 11). She provides guidelines on how to integrate climate change into ecosystem-service assessments.

Nooshin Torabi determines factors most likely to influence program participation in biodiverse carbon planting (page 12) and Marit Kragt complements this with the results of an Australia-wide choice experiment on the public's willingness-to-pay for climate change mitigation by farmers (page 13).

Brett Bryan then discusses designer policies and assesses the mix of regulations, targeting, levies and incentive payments that will deliver the best outcomes for biodiversity benefits and carbon sequestration (page 14).

The central challenge of the century ahead is to develop economic, social, and governance systems capable of ending poverty and achieving sustainability while securing the life-support systems underpinning human well-being. Essential to meeting this challenge is the incorporation of ecosystem services into decision-making. We hope the stories presented here in this issue of *Decision Point* provide some insights into what this means and how it might be achieved.

Accounting for ecosystem services may not be the complete solution to meeting the conservation challenges facing us but it is another important tool that promises to improve our capacity to make more informed environmental decisions.

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Sustainable development in the Daly Catchment

Getting the balance right

By Vanessa Adams (University of Queensland)

Developing our land resources can increase economic productivity but it can also have adverse impacts on native vegetation cover, native species, water quality, and a range of ecosystem services. For land and economic development to be sustainable it needs to respect the different values people have for the region, and balance decisions across economic, environmental and social values. How can the values of different stakeholders be integrated into the process?

We designed a development and conservation plan for the Daly Catchment in the Northern Territory which illustrates how this might be achieved. We used a novel scenario-planning approach that couples optimal land-use design and social evaluation of environmental outcomes (Adams et al, 2016).

Key messages:

- For economic development to be sustainable it needs to respect the different values people have for the region
- We developed a conservation plan for the Daly Catchment using a novel scenario-planning approach coupled with optimal land-use design
- We found that scenarios involving 10% clearing are most aligned with stakeholder preferences and best balance impacts and benefits across stakeholder groups

Understanding diverse resident values

For development to be sustainable, land and water policies need to protect the diverse values of residents in the catchment and direct development towards suitable land. The first step is therefore to understand resident values. We sent a survey to residents in the Daly Catchment asking people to identify what aspects of life in the catchment were most important to them and how satisfied they would be with environmental changes in the future (changes such as the clearing of native vegetation). Over 200 residents participated in the survey (about 10% of the households in the catchment).

Overall people ranked biodiversity and socio-cultural aspects of life in the catchment as being most important (Adams et al, 2014; and see Figure 1). For example, the statement 'It is important to keep the area in good condition for future generations' was the most strongly agreed to across the group.

Commercial values were ranked the least important across the group. These results reflect what we heard from residents in community forums: that having a livelihood is important but there are other reasons people like to live in the catchment.

Integrating values into land use planning

We used the survey results in two innovative ways. The first was to set objectives for our land-use scenarios and the second was to evaluate the performance of the scenarios across the full range of values that residents hold. Our scenarios were designed to consider variable levels of land clearing to support development and different approaches to directing this clearing to suitable land (see Figure 2 for maps of final four scenarios).

Importantly, our survey identified that some stakeholder groups had different priorities. In particular, people who earn an income from agriculture and indigenous people. People connected with agriculture ranked commercial values much higher than indigenous people (who ranked biodiversity and social-cultural values higher).

Pastoralism is the primary land use in the catchment. (Image by Vanessa Adams)

Many areas in the catchment, like Edith Falls, are highly valued for recreation such as fishing and swimming. (Image by David Salt)

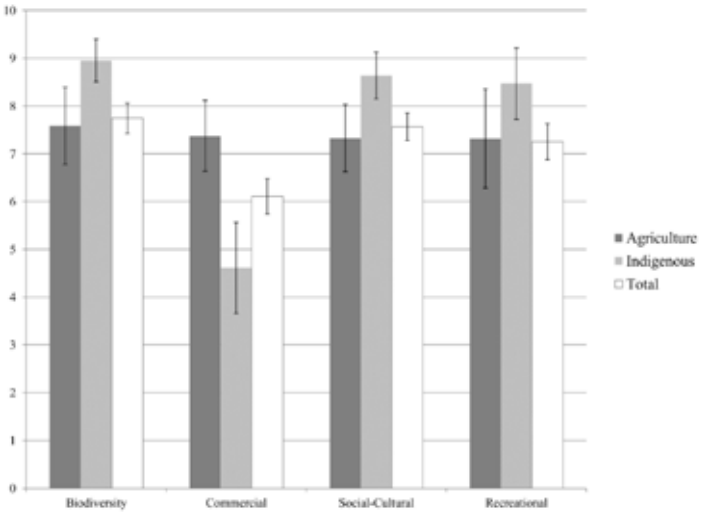

Figure 1: The average importance scores given to different aspects of well-being are shown for the whole group (total=white bar), people who earn an income from agriculture (agriculture=dark grey) and indigenous people (indigenous=light grey).

Because of this, we estimated how satisfied these different groups would be with changes in the catchment associated with our different land use scenarios (Figure 2). For each scenario we identified possible changes in the catchment and then, based on our survey results, we estimated whether our stakeholder groups would be more or less satisfied than they currently are with life in the catchment.

We found that the change in clearing and agriculture in the catchment associated with our scenarios impacted on our stakeholder groups differently: Agricultural stakeholders would be much more satisfied and Indigenous stakeholders would be much less satisfied.

Other aspects of development such as changes in the number of people living in the catchment, changes to the water level in the Daly associated with water extractions for cropping and associated changes in fish numbers all result in decreased

The catchment has many important natural values such as national parks and areas identified as high conservation value sites. (Image by David Salt)

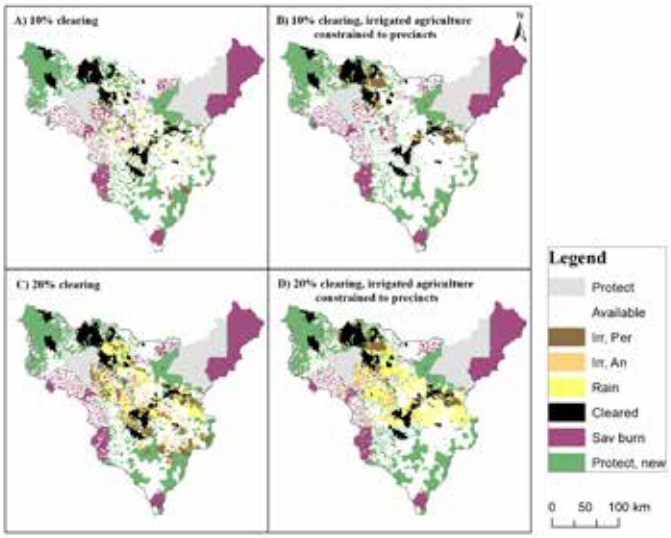

Figure 2: The Daly plan, a set of land use scenarios that help decision makers understand what the catchment can look like if different decisions are made. Each land-use scenario meets the plan objectives (eg, clearing limited to suitable soil, 17% of all vegetation types protected). However each scenario delivers different ecosystem services with possible positive and negative impacts across different stakeholder groups.

satisfaction across all stakeholder groups. This means that any future development needs to be carefully evaluated in terms of these changes to balance out both the benefits and costs to residents' well-being.

Maximising preferences

Based on the range of benefits and potential adverse impacts of each scenario, we suggest that the scenarios involving 10% clearing are most aligned with stakeholder preferences and best balance impacts and benefits across stakeholder groups. Our approach to scenario planning allows for changes in ecosystem services and therefore potential conflicts between goals and stakeholder preferences to be quantified and negotiated during the planning process.

Developing land and water resources is important for increasing economic productivity but can also have negative impacts on the environment. Getting development right means bringing together scientific evidence and public values to inform good land and water resource policies. Doing this means we can maintain ecosystems and the services they deliver across the range of diverse values held by people.

Note: This research was supported by the NERP Northern Australia Hub.

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Floodwaters rising

Relating flooding to land-use in Indonesian Borneo

By Jessie Wells (University of Queensland)

Floods are a major concern in many parts of the world, yet data and knowledge on their extent and impact simply doesn't exist for many regions. This includes places where people are highly exposed and vulnerable to flooding, such as many urban and village communities in Indonesian Borneo.

Flood regulation by native vegetation is widely viewed as an important ecosystem service, but it is extremely hard to estimate or value this service when whole regions have little or no data on the impact of floods or their frequency.

We sought to fill this information gap for Indonesian Borneo by documenting where and when floods occur, how they affect local communities, and how they relate to forests and other ecosystems in the surrounding landscape. To gain insights into these questions, we developed two new and independent sources of information – village interviews and news archives (Wells et al, 2016).

A community affected by flooding in the village of Ujoh Bilang, in Kutai Barat District, East Kalimantan, in June 2006. (Photo by Godwin Limberg)

(Above) Long Duhung village in Berau District, East Kalimantan, experiencing torrential rain in April 2014. The impact of flooding that results from such events relates to the surrounding land management. (Photo by Jessie Wells)

Frequency and impact

Interviews with village leaders in 364 villages enabled us to estimate the frequency of recent floods (during the past five years), and whether this had changed over the last 30 years. Floods were defined as inundation of the main road or path at the centre of the village, in order to encourage consistency of recall and to reduce possible changes with population size over time.

We also collated all news reports of flooding from the archives of 16 news agencies over a 3 year period (April 2010-2013), to show where flooding occurred and estimate how many houses were flooded and people displaced.

We found that flood impacts are far more frequent and widespread than government risk assessments have estimated. Many individual flood events were large and affected thousands

Key messages:

- Flood events are widespread in Indonesian Borneo, and have large impacts on communities
- Two novel sources of information – village interviews and news archives – give new insights into where and when floods occur, and how they relate to the surrounding landscape
- Floods have large impacts on lives and livelihoods in Borneo, and are more frequent in areas affected by mining and loss of forests and wetlands

of people, but we also found that more frequent, local, events can have large cumulative impacts. For example, 58% of villages experienced one or more floods every year over the last 5 years (and only 10% of villages reported no experience of flooding in recent decades).

Over the 3 years we examined, local news agencies reported floods that affected 868 settlements, 966 times (including 89 in urban areas), inundated at least 197,000 houses, and displaced more than 770,000 people, possibly as many as 1.5 million (which is between 5%–10% of the total population).

Flood context

When asked about changes in flooding over the past 30 years, floods were perceived to have increased in frequency in around 20% of all villages. In contrast, declines were reported in only two villages (0.8%).

Next, we analysed the frequency, trends and likelihood of flooding in relation to features of the surrounding landscape. These features included rainfall, topography and land use in upstream watersheds. Using Boosted Regression Trees to model these relationships, we showed that flooding was related to climate and topography (as expected, eg, more flooding closer to rivers or at lower elevations), but was also related to land uses in the upstream watershed, especially mines, forests, and wetlands. Variables describing land use or land cover accounted for 24% – 30% of the total variance in each dataset.

These models also enabled us to map predicted patterns of flooding across Indonesian Borneo (see Figure 1).

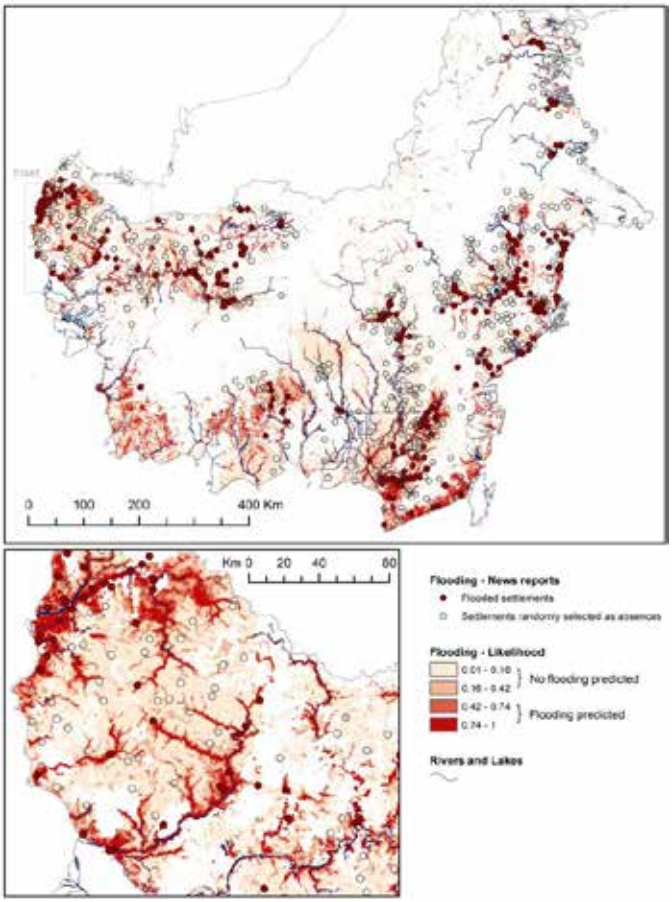

Figure 1: Map of news-reported floods and modelled flood probabilities for populated areas of Kalimantan. Points show the locations of 380 news-reported floods over the period April 2010 – April 2013. Predictions were generated for populated areas from modelling that related the presence/absence of reported floods to 35 environmental and socio-economic variables.

Mining in the landscape – an aerial view of coal mines and adjacent degraded forests, near Samarinda in East Kalimantan, in April 2014. (Photo by Jessie Wells)

Recent flood frequency, and the likelihood of a trend (perceived increase over the past 30 years), were both higher for villages closer to mines (up to a distance of 80 km from open-cut coal or gold mines). The likelihood of a trend was also slightly higher in watersheds with higher cover of oil palm plantations.

Conversely, both were lower for villages in watersheds with higher cover of natural wetlands, peatlands, intact forests, or selectively-logged forests. News-reported floods were similarly related to upstream land covers, especially wetlands and peatlands, and were also more likely in watersheds with higher impervious cover.

The independent data sources (from villages and news reports) together give strong evidence of widespread and frequent flooding. They also revealed many similar relationships with aspects of the landscape, giving maps with similar areas predicted to have low or high flooding hazards.

Land management and flooding

These findings indicate the large potential value of further research to understand how these land uses alter flooding hydrology, including the effects of specific management systems for logging and plantations. Such research would enable quantitative projections for flooding hazards under alternative land use and climate change scenarios.

This research has demonstrated how novel information sources can be combined to assess flooding patterns in data-scarce regions, and highlights the need for more comprehensive assessment of flooding risks to inform land use decisions, as well as options for ecosystem-based adaptation to climate change.

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Stream-side plantings and ecosystem services

What do dairy farmers think about planting riparian margins?

By Fleur Maseyk (University of Queensland)

Over two stormy days in 2015, a group of dairy farmers working on the Taranaki ring plain in New Zealand left their flooding paddocks to gather at the Stratford Multisports Centre. They had been invited to participate in an interactive meeting with the purpose of describing their experiences and views on the costs and benefits of planting riparian margins on their farms (Maseyk et al, 2017).

Following European settlement in the mid-1800s, the once forested plains around Mt Taranaki (one of New Zealand's most iconic volcanoes) were rapidly converted into a pastoral landscape dominated by exotic pasture species. This transformation made Taranaki a nationally important dairy region. In the process, native vegetation was reduced to less than 10% of its former cover. The benefit of food production had come at a considerable cost to native biodiversity and the provision of a range of other ecosystem services.

In 1993 the Taranaki Regional Council initiated a voluntary planting program to restore vegetation to riparian margins with an aim of maintaining water quality. Twenty years on, we were interested in finding out how farmers perceive the costs and benefits of undertaking riparian planting.

Key messages:

- We surveyed Taranaki dairy farmers on their perceptions of the value of riparian plantings
- They reported many different values with the plantings; some positive, some negative
- Farmers who carried out riparian plantings reported improvement to both farm peformance and the environment

Two groups of farmers participated in the meetings; Group A (17 farmers) who have or are implementing riparian planting and Group B (five farmers) who have fenced, but not planted their riparian margins (Figure 1).

Figure 1: Group A farmers opted for planted margins (image on the left shows multi-tier planted margins) whereas Group B farmers used fenced grass strip margins (as pictured on the right). (Image on the left and at top by Fleur Maseyk; image on the right Taranaki Regional Council.)

Not surprisingly, the two groups of farmers had quite different perspectives, with Group A perceiving 21 positive aspects and 11 negative aspects associated with riparian margin plantings, and Group B perceiving only 15 aspects, all of which were negative. These pros and cons fell across production, environmental, and social values (Figure 2), and show that our participant farmers are thinking about additional ecosystem services and benefits beyond water quality as well as trade-offs.

The writing is on the wall: Taranaki dairy farmers review the issues regarding riparian margins raised during the group discussion. The question they asked themselves was: "Which of these are most important to me?" (Image by Fleur Maseyk)

Critically, Group B identified that neither grass strip or planted multi-tier riparian margins can address sub-surface nutrient flows. Consequently, this group of farmers felt the objective of the planting program — to protect water quality — was misguided, and this view obscured the recognition of all other potential values and benefits of planting riparian margins and prevented them from implementing planting on their farms.

However, we found that farmers who had planted as well as fenced riparian margins experienced increased benefits for both farm peformance and environmental enhancement.

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Note: This study was a collaboration between CEED, AgResearch New Zealand, and Taranaki Regional Council.

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From our structured discussions we found that while Group A identified many benefits from planting riparian margins, they also shared some common ground with Group B in recognising associated costs and liabilities, such as the loss of production land, and increased weeds and pests. However, Group A suggested that many of these issues can be balanced by positive aspects of riparian margin plantings. For example, they observed that cows will graze longer in the shade provided by riparian plantings (which means more milk) and this can be enough to make up for the loss of production land.

In contrast to Group A, Group B farmers were disinclined to plant their riparian margins as they did not think there were any additional benefits to be gained that could not be achieved by fenced-only (grass strip) margins. Indeed, both groups observed that fencing excludes livestock from waterways, and allows for greater precision mapping of the farm, improved rotational grazing, and better allocation of feed. The farmers observed that not only did fences prevent their lifestock from falling into, or getting stuck in waterways, they saved them money (by avoiding lifestock injury or loss, labour time to retrieve animals, and damage to farm equipment used in retrieval), and increased the safety of farm staff who were no longer retrieving animals from waterways.

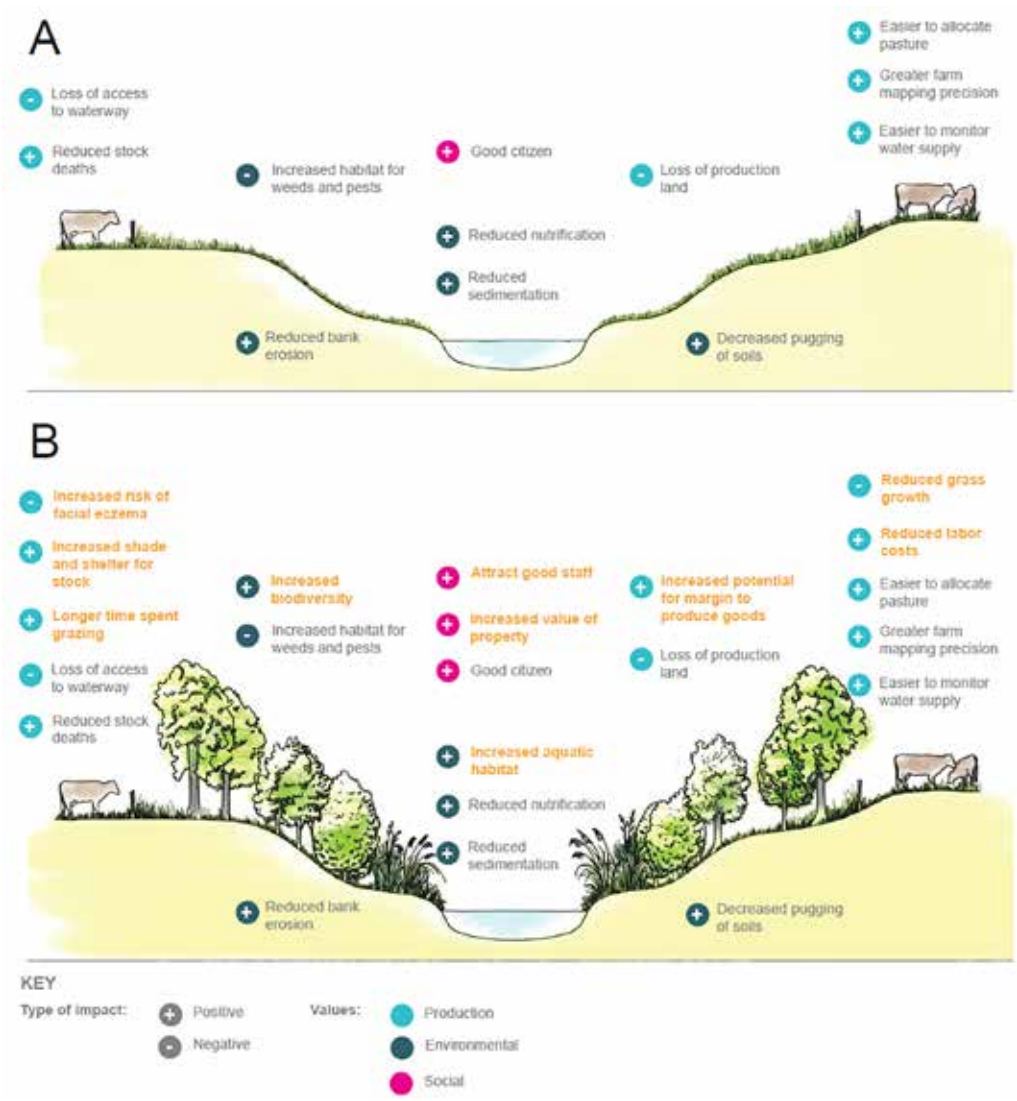

Figure 2: The pros and cons of fenced-only grass strip riparian margins (Panel A) and fenced and riparian margins (Panel B) as identified by Taranaki ring plain dairy farmers. Individual attributes of riparian margins can contribute values across the board, for example, a well managed farm attracts better staff which is shown here as a social value, but also ultimately contributes to productivity of the farm and "more milk in the vat".

Putting the heat on ecosystem services

A review of climate change impacts on ecosystem services

By Rebecca Runting (University of Queensland)

Most of us worry about climate change in one way or another, but not many of us explicitly consider how it will be impacting the ecosystem services we rely on. Maybe that's because ecosystem services themselves are often taken for granted or undervalued, as we expect services like clean air and water to be perpetually available. However many of the decisions made, such as the ongoing emissions of greenhouse gases, threaten the provision of numerous ecosystem services. Different approaches to managing ecosystem services are being developed to deal with this problem. But how well do these approaches engage with climate change?

Key messages:

We carried out the first quantitative synthesis of the literature on climate change impacts on ecosystem services

We found
(1) more research needs to take place in regions with a lower capacity to adapt to the impacts of climate change
(2) using (only) expert opinions to determine the impact of climate change can overestimate the negative impacts on ecosystem services
(3) incorporating other stresses into an analysis leads to greater negative impacts
(4) greater attention needs to be given to uncertainty and how an analysis can be applied in decision making

The fact is that climate change is having a substantial impact on ecosystem services, yet many assessments don't link to our decision-making processes. Integrating climate change into assessments and planning for ecosystem services is vital if we are to avoid poor management decisions. For example, coastal land-use zoning that ignores the effects of sea-level rise could lead to a long-term decline in ecosystem services, such as flood protection, provided by coastal wetlands (I explored the connection between coastal wetlands, ecosystem services and rising sea level in *Decision Point #97*).

To add to the challenge, climate change doesn't impact ecosystem services in isolation, it interacts with other local or global stresses on the environment. Land-use change, population growth and pollution, for example, all create their own stresses and will interact with the impacts of climate change. For instance, a logged forest could become more susceptible to erosion if climate change leads to increases in the intensity of rainfall.

So, what is the state of our understanding of the connection between climate change and ecosystem service assessment? We did a review of the scientific literature to see if we could identify important gaps. There are many studies of individual cases of climate change impacts on ecosystem services, but our review provides the first quantitative synthesis on this topic. What did we find?

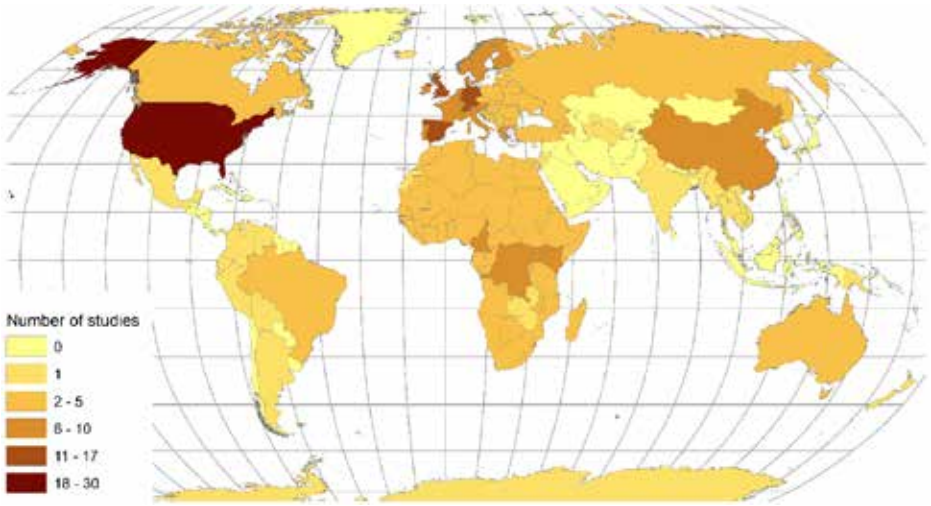

Figure 1: The number of studies of the impacts of climate change on ecosystem services by nation. Each study could span more than one nation. The USA and Europe dominate the academic literature.

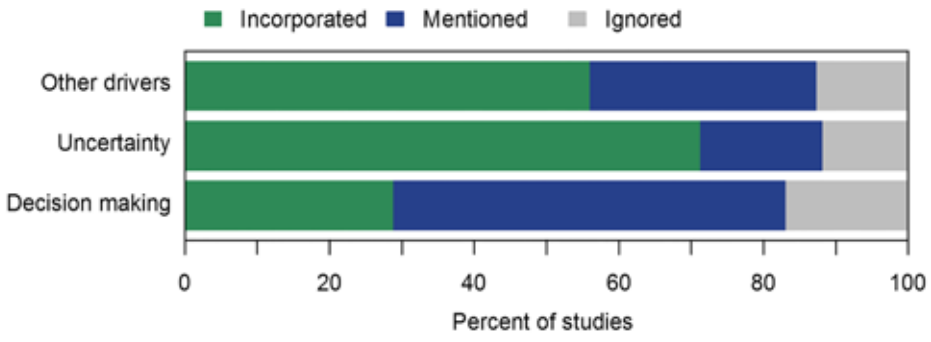

Figure 2: Proportion of studies that incorporated drivers in addition to climate change, uncertainty or decision making in addition to climate change.

A regional bias: First up, most of the papers that were identified in our review came from the USA or Europe (Figure 1), so there is a clear need for more studies beyond these regions, particularly in South America, Asia and Oceania. This is particularly important as these regions generally have a lower capacity to adapt to the impacts of climate change (see *Decision Point #97*). (This reflects other reviews of the research effort on conservation science related issues. Kerrie Wilson and colleagues, for example, found

that most of the biodiversity conservation research was not being done in the places it was most needed, see *Decision Point #98*.)

Mostly negative, some positive impacts: While climate change generally has a negative impact on ecosystem services, the news isn't all bad (59% of the analyses reviewed showed negative impacts, 24% mixed, 13% positive, and 4% neutral). For instance, as temperature and the concentration of carbon-dioxide increases, carbon storage is increasing in some places, particularly higher latitudes.

Expert bias: We found that using (only) expert opinions to determine the impact of climate change can overestimate the negative impacts on ecosystem services.

Almost all studies that used expert opinion to determine the impact of climate change produced negative results (94% negative, 5% mixed, 2% neutral). In contrast, only 47% of studies using computational models, or experiments in the laboratory or field found negative results. The overestimation of negative results produced by expert opinion could be explained by 'accessibility bias' – the knowledge that the impacts of climate change are generally negative can disproportionately influence the judgment of the experts (even in cases where the impacts may be positive). This suggests that we should make more use of techniques that minimise bias and corroborate the information provided by experts (see *Decision Point #93*).

Interactions exacerbate negatives: Climate change interacts with other stressors on the environment, such as land use change. Where a stressor in addition to climate change was included, 62% of analyses were negative. Therefore, it is important that we do not consider climate change in isolation when making management decisions (see *Decision Point #72*).

Climate change can interact with local stressors. A recently logged forest in East Kalimantan may become vulnerable to erosion if climate change leads to increases in heavy rain. This land was cleared to make way for a pulp and paper plantation. (Photo by Rebecca Runting)

Damage to Beaver Reef (up on the Great Barrier Reef) after Cyclone Hamish in 2009. The Great Barrier Reef provides a raft of ecosystem services to Australia and is under threat from multiple stressors. Storm frequency and bleaching events are related to climate change but these stressors interact with the damage caused by Crown-of-Thorns starfish, outbreaks of which are connected to nutrient outflows from adjoining agricultural catchments. Such interactions are essential in assessing the impact of climate change on ecosystem services. (Photo by AIMS Long-term Monitoring Team)

Uneven attention to uncertainty: Some degree of uncertainty was usually incorporated in the assessments (71%), but this was usually surrounding the magnitude of climate change and other drivers, with very little attention given to the uncertainties associated with how ecosystem services are modelled, or the mechanisms by which the services were impacted by climate change. Relatively few studies (29%) integrated any kind of decision making (management actions, policies or other interventions), and even fewer studies aimed to make decisions that were robust to uncertainty.

These results tell us that if management or policy decisions are to ensure the continued provision of ecosystem services, then an integrated approach is needed. Such an approach must include multiple threatening processes and account for multiple sources of uncertainty. This is definitely not an easy undertaking, but ignoring these complications could misrepresent the true impacts of climate change, and result in poor outcomes for climate adaptation decisions.

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Runting RK, BA Bryan, LE Dee, FJF Maseyk, L Mandle, P Hamel, KA Wilson, K Yetka, HP Possingham & JR Rhodes (2016). Incorporating climate change into ecosystem service assessments and decisions: a review. *Global Change Biology* 23: 28-41 dx.doi.org/10.1111/gcb.13457

The money or the trees

What drives landholders' participation in biodiverse carbon plantings?

By Nooshin Torabi (RMIT University)

Many believe that biodiverse carbon plantings hold the key to sustainable land management. In addition to storing carbon, planting trees has the potential to preserve vital ecological processes and provide habitat for wildlife.

Like any private-land conservation scheme, the number of participants has a direct impact on the expected environmental outcomes of the program. The number of landholders participating in carbon and biodiversity related programs directly influences the amount of carbon stored and biodiversity protected. The rate of landholder participation depends on many social and environmental drivers. My research has focussed on determining what these drivers are.

With colleagues, I undertook a literature review on the factors influencing landholder participation in agri-environment schemes, voluntary carbon plantings and private land conservation. Next, we surveyed and interviewed 17 landholders who participated in a voluntary biodiverse carbon planting program in Victoria. We explored landholders' drivers and motivation for participation in the program in each step of adoption. There was a diverse range of people in our survey which included commercial farmers, semi-commercial farmers, hobby farmers and life-style landholders.

We also interviewed 14 science and policy stakeholders working in the field of carbon and biodiversity conservation in Australia. Interviewees were from universities, CSIRO, government organisations and NGOs. We asked them about challenges and opportunities in bundling and stacking carbon and biodiversity ecosystem services.

Biodiverse carbon plantings in an agricultural landscape in Victoria. (Photo by Nooshin Torabi)

Key messages:

- We developed a Bayesian Belief Network that predicts landholder participation rate for any type of carbon-farming scheme
- We found that program characteristics are more influential at driving participation than financial incentives
- Biodiversity co-benefits of carbon planting is another important factor

Bundling refers to paying a premium price for the biodiversity co-benefits of carbon plantings and stacking relates to selling carbon and biodiversity credits separately in their related markets. Bundling and stacking could offer landholders more incentives for their participation in biodiverse carbon plantings.

Using these inputs (literature review, surveys and interviews), we developed a Bayesian Belief Network. This is a probabilistic graphical model that predicts landholder participation rate for any type of carbon-farming scheme. We examined the impact of three main factors on the participation rate: program design (eg, management requirements), landholders' values for co-benefits (eg, biodiversity) and financial incentives (eg, bundling or stacking). We ran an expert elicitation workshop to parameterise our model.

Our analysis found that program design was the most important factor, followed by the value of co-benefits with financial incentives being the least important factor.

We also examined the influence of different scenarios on the participation rate. Each scenario was a combination of an incentivising scenario (bundling, stacking or carbon only payments) and a program permanence option (100 year, 25 years and on contract agreements). Our results revealed that 'on contract agreement' and stacking/bundling carbon and biodiversity credits could increase landholder participation rate more than any other scenario.

These findings could help policy makers to design programs that are more flexible and appealing to a broader range of landholders. Such programs need to ensure that the landscape-specific co-benefits of participation are effectively communicated to landholders. This is because both conservation and productivity related co-benefits matter to landholders.

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Are people willing to pay for carbon farming?

Public 'willingness-to-pay' for co-benefits

By Marit Kragt (University of Western Australia)

Agricultural production is a major emitter of greenhouse-gases in most developed nations. It is therefore no surprise that there has been a lot of scientific and political focus on reducing greenhouse-gas emissions from the agricultural sector. Our research looked at general community preferences for the potential benefits of carbon farming (see the box 'What is carbon farming').

There have been two Australian policy programs that aimed to reduce carbon emissions by rural landholders: the Carbon Farming Initiative (2011-2014) and the Emissions Reduction Fund (since 2014). Both of these programs provide(d) financial rewards to farmers who adopted practices to reduce greenhouse-gas emissions or increase carbon storage in soils or vegetation. Only practices meeting prescribed eligibility criteria are eligible for funding.

Our previous research has shown that adopting carbon-farming practices often leads to a loss in profit for farmers (Kragt et al, 2012). Financial incentives offered by the government are typically too low to offset such losses. We therefore investigated other ways to increase funds for farmers' adoption of carbon farming.

Some carbon farming practices can deliver environmental benefits in addition to climate-change mitigation. For example, planting native species on cleared lands or protecting native forests could have co-benefits for biodiversity or landscape aesthetics. It is very likely that some of the 'co-benefits' will provide socio-economic benefits to the wider community. The values provided by these co-benefits could partly offset the private profit losses to farmers.

We set out to measure those values, by estimating the public's 'willingness-to-pay' for the co-benefits of carbon farming. To do this, we conducted a choice-experiment survey of Australian residents in NSW, Queensland, Victoria and WA (Kragt et al, 2016). An example of one of the choice questions we used is shown in Figure 1.

In the choice experiment, respondents chose their preferred alternative out of the three options provided (these options change in each choice question and respondents saw six choice questions each). We showed four impacts of carbon farming: (1) climate change mitigation (emission reduction/carbon storage); (2,3) two possible co-benefits of carbon farming (increase in native vegetation, reduced soil erosion); and (4) costs to the respondent. Through an econometric analysis of respondents' choices, we can ascertain the relative weight that people put on the various impacts presented.

CS 4 Choice question 4

Please carefully consider each of the following three alternatives for carbon farming. Suppose that alternatives 1, 2 and 3 were the only ones available. Which one would you choose?

Impacts	Alternative 1	Alternative 2	Alternative 3 – no action
Emissions reduction / Carbon storage	11.5 Mt CO_2-e/yr (2.0%)	11.5 Mt CO_2-e/yr (2.0%)	No emission reduction or carbon storage
Increase in native vegetation	1.2 million ha (4.0%)	0 ha (0%)	No increase in native vegetation
Reduction in soil erosion	0 t/yr (0%)	500 million t/yr (30.6%)	No reduction in soil erosion
Annual net cost to your household	$300	$20	$0
My preference:	☐	☐	☐

Figure 1: An example of one of the choice questions used in the survey.

Key messages:

Adopting carbon farming practices often leads to a loss in profit for farmers

We estimated the public's 'willingness-to-pay' for the co-benefits of carbon farming

Respondents were willing to pay $19.20 per year for every extra hectare of native vegetation, and $1.13 per year for every metric tonne of CO_2-e reduced

What is 'carbon farming'?

A set of activities that increases carbon storage or avoids greenhouse-gas emissions. Storage activities can include:

- re-introducing woody vegetation into landscapes,
- protecting native forests,
- new farm-forestry plantations, or
- increasing soil carbon by reducing soil disturbance (eg, through no-till farming or increased stubble retention).

Practices that can avoid greenhouse-gas emissions can include early savanna burning, changing manure handling practices, or changing livestock feed.

The model results demonstrate that people cared about costs, emission reduction, and protecting native vegetation – but that preferences varied significantly across the population. For example, we found that people who believe that climate change is happening and at least partly caused by humans had more positive preferences for the benefits of carbon farming than other respondents.

Using our econometric model, we can estimate people's individual willingness-to-pay to receive carbon-farming benefits. On average, respondents were willing to pay $19.20 per year for every extra hectare of native vegetation, and $1.13 per year for every metric tonne of CO_2-e reduced. These willingness-to-pay estimates varied for respondents with different climate-change opinions.

The results of our work have important implications for carbon-farming policies. Given that the Australian community derives a positive value from carbon-farming benefits (carbon mitigation and biodiversity protection), there is a strong case to broaden policies to include co-benefits in the value calculations – rather than considering greenhouse gas reductions alone.

To increase the social welfare from carbon-farming policies, higher incentive payments should be offered to encourage changes in agricultural practices that generate environmental co-benefits.

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References

Kragt ME, FL Gibson, F Maseyk & KA Wilson (2016). Public willingness to pay for carbon farming and its co-benefits. *Ecological Economics* 126: 125-131.

Kragt ME, DJ Pannell, MJ Robertson & T Thamo (2012). Assessing costs of soil carbon sequestration by crop-livestock farmers in Western Australia. *Agricultural Systems* 112: 27-37.

Making the most of carbon farming

Carbon *AND* biodiversity benefits on agricultural land

There's been much discussion recently about carbon farming: paying farmers to plant trees on their farm to sequester carbon. This could also be a boon for biodiversity and the environment and provide an alternative source of income in marginal agricultural areas. However, studies in recent years suggest that focusing on carbon by itself is unlikely to give the most biodiversity bang for our buck.

To better achieve biodiversity benefits from carbon payments a mix of regulation, targeting, levies and incentive payments could be used. But what policy mix will deliver the best outcomes for both carbon and biodiversity? This was the question posed at a CEED/NERP workshop at the University of Western Australia and a group of CSIRO and CEED researchers have come up with some interesting results.

The researchers evaluated 14 policy options for supplying carbon and biodiversity through carbon farming in Australia. They found that payment design is paramount, with substantial gains made by putting it to auction, and paying farmers differing amounts depending on their expected costs.

"Without regulating plantings to ensure they are biodiversity friendly (ie, they include a diversity of species), it's likely that monoculture plantations will dominate," observes CSIRO's Brett Bryan, the researcher who led the analysis. "But straight out regulation, while great for biodiversity, wouldn't be so great for achieving carbon objectives."

Interestingly, paying farmers a premium to adjust their plantings to increase the biodiversity benefit is not as efficient as applying a levy on carbon plantings; and using the funds raised to encourage plantings that will deliver greater biodiversity benefits elsewhere. But while a levy was better than a biodiversity premium, the researchers believe they have found an even better option.

"It turns out that the best type of policy would pay farmers to cover the costs of their plantings through auction, and target areas for both carbon and biodiversity outcomes," explains Bryan. "Such a design has the best chance of cost-effectively and efficiently delivering both carbon and biodiversity outcomes, giving over 100 times the biodiversity benefits when compared with a simple, carbon-focussed policy."

The analysis suggests a clear policy direction for carbon and biodiversity, but also for payments for ecosystem services more broadly, both in Australia and globally. However, the researchers are careful to point out that implementation of such policies needs care.

"The implementation of this approach needs to be informed by the local social, economic, and environmental context if the potential gains we have identified are to be realised," says Bryan.

Key messages:

Researchers evaluated policy mechanisms for supplying carbon and biodiversity co-benefits on Australian agricultural land

Uniform payments targeting carbon achieved significant carbon sequestration but negligible biodiversity co-benefits. Land-use regulation increased biodiversity co-benefits, but was inefficient in regards to carbon

Discriminatory payments with land-use competition were efficient and, with multifunctional targeting of both carbon and biodiversity co-benefits, increased the biodiversity co-benefits almost 100-fold

"And sustainably financing large payment schemes from a combination of government and industry sources will probably require additional, flexible policy mechanism design.

"Ultimately, the level of investment will depend on the levels of carbon sequestration and biodiversity conservation desired by society, and the costs it is willing to pay for them."

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Reference

Bryan BA, RK Runting, T Capon, MP Perring, S Cunningham, ME Kragt, M Nolan, EA Law, A Renwick , S Eber, R Christian & KA Wilson (2016). Designer policy for carbon and biodiversity co-benefits under global change. *Nature Climate Change* 6: 301-305. http://www.nature.com/nclimate/journal/v6/n3/full/nclimate2874.html

Establishing native trees on agricultural land can yield both carbon and biodiversity benefits. CSIRO and CEED researchers have examined what policy settings will deliver the greatest returns in both. (Photo by David Salt)

Modelling Kalimantan's tropical forest landscapes

Mixed policies can meet multiple expectations

By Elizabeth Law (University of Queensland)

Land-use planning in complex landscapes is a major challenge. Meeting the needs and desires of multiple stakeholders competing for the same area of land is never easy, and this is especially the case for tropical forest landscapes. Some stakeholders focus on the conservation of biodiversity, others on the maintenance of ecosystem services and there is usually strong demand for the development of forestry and agriculture and their perceived economic benefits. It is challenging but it can be surprising what you can achieve when you incorporate these multiple expectations into the same plan that seeks to maximise everyone's expectations. Our modelling of land-use planning in mixed tropical forests in Indonesia has shown how it is possible to achieve good biodiversity outcomes while still meeting production expectations and carbon mitigation targets.

Key messages:

We analysed the potential outcomes of 10 alternative land-use policy scenarios for a high-priority region for forest protection, restoration and rural development in Central Kalimantan

All 10 policy strategies are capable of achieving all stakeholder objectives provided at least 29–37% of the landscape is conserved for biodiversity

The study region in Kalimantan is known as the Ex-Mega Rice Project Area. It was originally tropical peat forest (such as pictured here) that was converted for rice production in the 1990s. The venture failed and the government is now examining options for restoring some of the values that have been lost in the region. But how do you reconcile conflicting goals and conservation and production?
(Photo by Ruanda Agung Sugardiman)

Land-sparing and land-sharing have emerged as contrasting strategies to manage the trade-offs between production and biodiversity conservation in such landscapes. Land sharing refers to production done simultaneously with conservation (on the same land). Land sparing refers to setting aside land in one place where conservation is maximised while maximising production over the rest of the land.

Both strategies are evident in land-management policies in many places around the world. However, studies rarely report on the impacts of these strategies for multiple stakeholders and multiple ecosystem services, particularly in real landscapes. We set out to do this.

Our study focussed on a multifunctional landscape in Central Kalimantan, Indonesia. The region we looked at is being considered for forest protection, restoration and rural development. We analysed 10 alternative policy scenarios of how the land might be used. These included land-sharing, land-sparing and mixed strategies (Law et al, 2016).

We developed a novel optimisation process that identified 'production possibility frontiers'. Production possibility frontiers show the maximum outcomes possible when land allocation is optimised for different purposes. We used these to highlight the trade-off between smallholder agriculture and oil palm, subject to the achievement of a set of carbon, timber and biodiversity conservation targets.

We found that mixed strategies gave the greatest flexibility to achieve targets, followed closely by land-sparing. The strategies assessed required a minimum of 29–37% of the land to be placed in conservation zones, and these areas would need to be actively managed to reduce the occurrence of fire. To achieve biodiversity targets, these zones would need to protect the majority of remaining forest, but might require little reforestation.

All 10 policy strategies assessed in our case study are capable of achieving all stakeholder objectives, provided around a third of the landscape is conserved for biodiversity. What's more, in demonstrating this for the Ex-Mega Rice Project, we have shown that our novel methodological approach can provide practical options for the systematic analysis of complex, multifunctional landscapes.

When integrated within a larger planning and implementation process, our technique could inform the design of land-use policies that maximize stakeholder satisfaction and minimize conflict.

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Reference

Law EA, BA Bryan, E Meijaard, T Mallawaarachchi, MJ Struebig, ME Watts & KA Wilson (2016). Mixed policies give more options in multifunctional tropical forest landscapes. *Journal of Applied Ecology* doi: 10.1111/1365-2664.12666 http://onlinelibrary.wiley.com/doi/10.1111/1365-2664.12666/abstract

And see Elizabeth's blog for more details on the paper and on the methods applied.

Eucalypt regen in central Victoria

The processes of eucalypt recruitment are infrequent, patchy and difficult to predict. Long timeframes with appropriate incentives are needed to manage natural regeneration. These are the conclusions of Peter Vesk and colleagues who sought to investigate the processes of eucalypt regeneration within the Bush Returns trial, a native vegetation management incentive scheme in the Goulburn Broken Catchment of Victoria. By year 4 of the 10-year program, eucalypt seedlings were found at about 24% of sampled quadrats. This varied substantially across sites, with only half the participating properties having any seedlings. Individual trees varied widely in their seed production, but seed rain was not related to the spatial context of the trees. Seedling emergence was infrequent and seed sowing trials had very patchy, and overall low, success. Seed removal experiments indicated that seeds were removed faster and more completely in sites with more bare ground (less grass and litter) and during warmer weather.

Reference

Vesk PA, WK Morris, W McCallum, R Apted & C Miles (2016). Processess of woodland eucalypt regeneration: lessons from the bush returns trial. *The Royal Society of Victoria* 128: 54–63. http://www.publish.csiro.au/?act=view_file&file_id=RS16005.pdf

Restoring the Brazilian Atlantic Forest

Forest restoration enhances the provision of many ecosystem services, is an important tool for combating climate change and helps protect biodiversity. In a recent issue of *Applied Vegetation Science*, Leticia Garcia and coauthors (including CEED's Richard Hobbs) examined restoration outcomes in the Atlantic Forest area in Brazil. They show that simply planting trees is insufficient for fully restoring rain forest complexity, and highlight the need for longer-term restoration plans, including continued management and enrichment plantings that speed the recovery of non-tree forest components once planted trees have established.

Reference

Garcia LC, RJ Hobbs, et al. (2016). Restoration over time: is it possible to restore trees and non-trees in high-diversity forests? *Applied Vegetation Science* 19: 655-666.doi:10.1111/avsc.12264

A restoration site in Sao Paulo state, Brazil. Originally this site was a hyper-diverse Atlantic Forest that was cleared for sugar cane. Now it supports a clonal eucalypt plantation. Monocultures of fast growing trees like this can return tree cover to an extensive area quickly. It can produce rapid biomass growth but it does not restore diversity, structure and function, and it lacks resilience to disturbance and environmental change over time. See *Decision Point #68* for a discussion about restoration and scale. (Photo by Richard Hobbs)

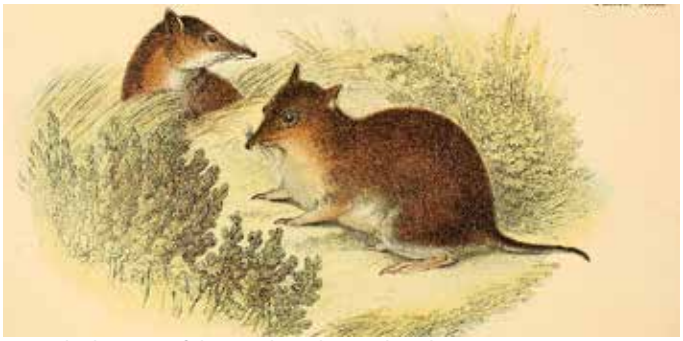
Of bandicoots and ecosystem processes

UWA's Leonie Valentine and co-authors recently examined how small-scale digging activities of the southern brown bandicoot (*Isoodon obesulus*) influence broader-scale landscape processes by modifying soil and litter properties, trapping organic matter and seeds and altering seedling recruitment. Valentine and colleagues examined environmental characteristics of the bandicoot's foraging pits and found they typically contained a higher moisture content and lower hydrophobicity than undisturbed soil; as well as higher amounts of fine litter material, and lower amounts of coarse litter. Foraging pits are likely to provide a conducive microhabitat for litter decomposition, potentially reducing litter loads and enhancing nutrient decomposition. Seedling recruitment for native plant species was also higher in areas with artificial diggings.

The majority of Australian digging mammals are threatened, with many suffering substantial population and range contraction. However, their persistence in landscapes plays an important role in maintaining the health and function of ecosystems.

Reference

Valentine L, M Bretz, KX Ruthrof, R Fisher, GE Hardy & PA Fleming (2016). Scratching beneath the surface: Bandicoot bioturbation contributes to ecosystem processes. *Austral Ecology* e-view doi:10.1111/aec.12428.



An early drawing of the southern brown bandicoot. (From *The hand-book to the marsupialia and monotremata*, 1896)