

DECISION POINT

Connecting conservation policy
makers, researchers and practitioners

Issue #84 / December 2014

Conservation and genes

How demographic and genetic
research can improve
conservation outcomes



**Fire and the pale field rat in
the Kimberley**



**Securing a future for
Carnaby's cockatoo**



**Valuing the uniqueness of
the kakapo**

Decision Point

Decision Point is the monthly magazine of the Environmental Decisions Group (EDG). It presents news and views on environmental decision making, biodiversity, conservation planning and monitoring. See the back cover for more info on the EDG. *Decision Point* is available free from <http://www.decision-point.com.au/>

Plus

Species vs phylogenetic diversity
Genes and geographic surrogates
A new frame for conserving ecosystems
Cultivating new environmental leadership

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EDG's new leadership program.



ANU PhD student Robyn Shaw is pictured here. She is working with the Australian Wildlife Conservancy to understand small mammal population dynamics in fire-prone landscapes. New insights from demographic and genetic research may help us tailor fire management to ensure the ongoing persistence of native species in the Kimberley. See page 8. (Photo by Sam Banks)

On the point

Taboo and other 't'-words

Whatever you do, don't mention the 't'-word! Why? Because the moment you do (and the 't' word is 'triage') someone will respond by asking you: "So, if you're a supporter of TRIAGE, which species are you prepared to give up on?"

It's true – the idea of conservation 'triage' has become a bit of a taboo in scientific, political and public discussions because as soon as it's invoked proponents are always asked to nominate which species they are going to 'stop trying to save' – 'to give up on'. Because isn't that what triage is about? We have to prioritise, focus on those species we can save and withdraw our support from those we can't.

I find this simplification of the 'triage' debate down to picking winners and losers very frustrating. And my biggest frustration with this line is its insincere and naive starting assumption: that the system we currently use (an approach without 'triage') is effectively conserving all species (that we are not giving up on any). I find it frustrating because this assumption is horribly false. We are witnessing a biodiversity catastrophe. The existing resources allocated to the problem are demonstrably inadequate (by an order of magnitude or more) and we are not saving everything. Triage isn't the only answer but it's a lot more honest and effective than the existing status quo.

Okay, now that I've got that off my chest, let's talk about some of the challenges of conservation triage. For starters, it's a lot more than choosing between species. It's also about considering investments in conserving ecosystems and genes, though how these measures of biodiversity are incorporated continues to be challenging. In this issue of *Decision Point* we demonstrate that it is possible to look beyond species and discuss several pieces of research which examine how genetic information and an ecosystems frame can contribute to more effective decision making.

So, be brave, consider the evidence, and let's start making more effective environmental decisions (regardless of what we call it). 🍓

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DECISION POINT

Decision Point is the monthly magazine of the Environmental Decision Group (EDG). The EDG 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, RMIT and CSIRO.

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Short accounts of papers from EDG researchers. If you would like copies of any of these papers see: <http://decision-point.com.au/research-briefs.html>

Lizards, fire and genes

Fire mosaics are often maintained in landscapes to promote successional diversity in vegetation. However, there is little understanding of how this will affect ecological processes in animal populations such as dispersal and social organization. To investigate these processes, Annabel Smith and colleagues conducted a landscape genetics study of two woodland lizard species: a tree dragon (*Amphibolurus norrisi*) and a skink (*Ctenotus atlas*). Dragons have a more complex social and territory structure than skinks, so fire might have a greater impact on their population structure and thus genetic diversity.

The researchers found that genetic diversity increased with time since fire in the skink and decreased in the tree dragon. For the skink, this might reflect its increasing population size after fire, though the researchers could not detect increased gene flow that would reduce the loss of genetic diversity through genetic drift. Using landscape resistance analyses, they found no evidence that post-fire habitat succession or topography affected gene flow in either species and we were unable to distinguish between survival and immigration as modes of post-fire re-establishment.

In the tree dragon they detected female-biased dispersal, likely reflecting its territorial social structure and polygynous mating system. The increased genetic diversity in the tree dragon in recently burnt habitat might reflect a temporary disruption of its territoriality and increased male dispersal, a hypothesis that was supported with a simulation experiment.

These results suggest that the effects of disturbance on genetic diversity will be stronger for species with territorial social organization. 🍷

Reference

Smith AL, CM Bull, MG Gardner and DA Driscoll (2014) Life history influences how fire affects genetic diversity in two lizard species. *Molecular Ecology* 23: 2428-2441.

Genes in a fragmented habitat

Animals don't move across landscapes at random, and the way in which they disperse has important implications for the dynamics of populations in fragmented habitat. There are a number of ways in which we can use genetic data to improve our understanding of dispersal in fragmented ecosystems.

Sam Banks and David Lindenmayer used genetic tagging and parentage analyses to identify the natal locations and dispersal destinations of the agile antechinus (*Antechinus agilis*). They used this information to understand the individual and environmental factors that influenced the observed dispersal choices by these native marsupial carnivores in a fragmented landscape near Tumut, NSW.

Female antechinus barely moved at all from where they were born, but males moved an average of over 1 km, with some moving nearly 8 km from their natal site. Not bad for an animal that fits in the palm of your hand! Males were more likely to disperse out of their natal patch if it was not geographically isolated from other patches, and if they were highly related to the females in their home patch (to avoid inbreeding). Surprisingly, inbreeding avoidance also influenced their choice of dispersal destination, in that they were most likely to settle in patches containing females to whom they were highly unrelated. They also preferred to disperse to patches containing lots

Incorporating genetic data into conservation plans

Although evolutionary processes underpin the patterns of biodiversity we see, it is uncommon for resource managers to explicitly consider genetic data in conservation prioritization. Genetic information is inherently relevant to management because it describes genetic diversity, population connectedness, and evolutionary history. This provides valuable insights on behavioural traits, climate tolerance, evolutionary potential, and dispersal ability.

So, how can we better account for genetic information in conservation planning? Incorporating genetic information into spatial conservation prioritization starts with reconciling the terminology and techniques used in genetics and conservation science. Genetic data vary widely in analyses and their interpretations can be challenging even for experienced geneticists. Therefore, identifying objectives, decision rules, and implementations in decision support tools specifically for management using genetic data is challenging.

To help with this, Maria Beger and colleagues have outlined a framework for eight genetic system characteristics, their measurement, and how they could be incorporated in spatial conservation prioritization for two contrasting objectives: biodiversity preservation vs maintaining ecological function and sustainable use.

They illustrate how this framework might work with an example using data from the boring giant clam (*Tridacna crocea*) in the Coral Triangle. They found that many reefs highlighted as conservation priorities with genetic data based on genetic subregions, genetic diversity, genetic distinctness, and connectivity are not prioritized using standard practices. Moreover, different characteristics calculated from the same samples resulted in different spatial conservation priorities.

The results from this study highlight that omitting genetic information from conservation decisions may fail to adequately represent processes regulating biodiversity. However, they stress that conservation objectives related to the choice of genetic system characteristics require careful consideration. 🍷

Reference

Beger M, KA Selkoe, E Tremblay, PH Barber, S von der Heyden, ED Crandall, RJ Toonen and C Riginos (2014) Evolving coral reef conservation with genetic information. *Bulletin of Marine Science* 90: 159-185.

of females, good quality habitat, and those that were linked to their natal patch by corridors of eucalypt forest.

These findings highlight the importance of individual-level dispersal data for understanding how multiple processes drive dispersal in modified landscapes. The detailed individual-level data improved our understanding of the major environmental drivers of dispersal choices and identified novel genetic and behavioural processes shaping non-randomness in individual dispersal patterns.

The research also uncovered new genetic patterns by showing that the genetic context in which individuals make dispersal choices is likely to differ between fragmented and unfragmented habitat. The researchers showed that the spatial scale of genetic neighbourhoods can be large in fragmented habitat, such that dispersing males can potentially settle in the presence of genetically similar females after moving considerable distances, thereby necessitating both a choice to emigrate and a choice of where to settle to avoid inbreeding. 🍷

Reference

Banks SC and DB Lindenmayer (2014) Inbreeding avoidance, patch isolation and matrix permeability influence dispersal and settlement choices by male agile antechinus in a fragmented landscape. *Journal of Animal Ecology* 83: 515-524.

Balancing species numbers and phylogenetic diversity

Which 'books' do you save as the library of life burns?

By Joseph Bennett (University of Queensland)

The global extinction crisis shows no signs of abating, and conservation funding falls far short of what is necessary to stop declines in biodiversity. Thus, either implicitly or explicitly, conservation agencies engage in prioritization; they try to use their limited resources to maximize achievable goals. A large part of what EDG does is developing tools to make this process more efficient, to preserve as much biodiversity as possible within limited budgets (for example, consider [Decision Point #76](#))

Traditionally, biodiversity has often been viewed as species diversity. However, other measures of diversity are gaining acceptance. One of the most prominent of these is phylogenetic diversity, the diversity of evolutionary relationships among species. Phylogenetic diversity can also be thought of as the information in life's genetic library, representing the millions of years of evolution that have led to unique species (Cadotte and Davies 2010). Losing a species is like losing a book from this genetic library, and the unique information (ie, genes) associated with it.

Biodiversity is more than number of species

The amount of unique genetic information contained in a species is associated with that species' phylogenetic distinctiveness – the relative isolation of its branch on the tree of life (Fig. 1). A species with no close relatives, whose lineage has been isolated on the tree of life for many millions of years, contains more unique information than one with recently-evolved close relatives. The loss of the more distinct species means the loss of these millions of years of evolution, along with unique genetic information (information that may have been useful for science or for adaptation to future environments). It's like losing a rare old manuscript from life's genetic library. Thus, there is great incentive to conserve unique species in particular and phylogenetic diversity in general.

Conservation agencies are increasingly considering phylogenetic diversity in their decisions on which species to prioritize, and the Zoological Society of London now has a dedicated program to

conserve threatened, phylogenetically distinct species (www.edgeofexistence.org).

Unfortunately, highly distinct species can sometimes be expensive to conserve because they can have special requirements (and the actions required to conserve these 'very different' species may have less complementary value than for other species). This has the potential to set up a dilemma between conserving highly distinct species and conserving the maximum number of species possible.

Too much focus on expensive, highly distinct species could even have the perverse result of conserving low phylogenetic diversity, if resources used on a single distinct species could have been used to conserve several others with higher aggregate phylogenetic diversity. This problem, as well as a possible disconnect between evolutionary uniqueness and evolutionary potential (Schluter 2001), and the reluctance of managers to abandon the traditional conservation benchmark of species diversity, has led to debate on the relative importance of conserving species numbers versus phylogenetic diversity (Winter et al. 2012, Rosauer and Moors 2013).

Minimizing the trade-off

The good news is that, with careful planning, sets of species can be conserved that minimize the trade-offs between the goals of species numbers and phylogenetic diversity. We used a Project Prioritization Protocol (PPP) that has been used for threatened species in New Zealand (see [Decision Point #29](#)) to demonstrate how this could be done (Bennett et al., 2014).

By iteratively varying the importance of species' phylogenetic distinctiveness in the ranking protocol, we were able to find the suite of species projects that minimized the sacrifice in either species numbers or total phylogenetic diversity that could be conserved within a given budget. We needed to use an iterative approach because there was no mathematical solution to the problem, when the realistic constraints of cost, probability of success and benefits for species projects are considered.

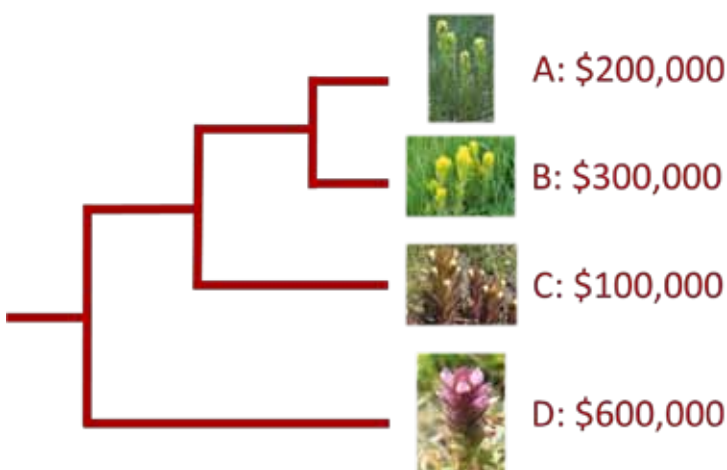


Figure 1: A phylogenetic tree showing evolutionary relationships for four hypothetical species, and the costs associated with conserving these species. Species D is more isolated on the phylogenetic tree than the other species, and contains more unique genetic information. However, its conservation costs are also comparatively high. If the conservation budget for these species is limited to \$600,000, should only one very distinct species be sponsored?



Naturalist Mark Carwardine (with a kākāpō on his head) and Stephen Fry in the BBC TV series, [Last Chance to See](#). The series explored the efforts to save some of the world's most rare and critically endangered animals. How much 'weight' should be given to saving a species based on its uniqueness or phylogenetic difference?

Two rare 'books'

Two phylogenetically-distinct (but very expensive) species.

The short-tailed bat (*Mystacina tuberculata*) is the only living member of its family, its last remaining relative having probably gone extinct in the last century. It is threatened by loss of its old-growth forest habitat, and also by invasive cats and stoats, since it spends a lot of its time foraging on the ground (which is unique for a bat). Unfortunately, costs to ensure this species' continued survival are estimated to be over \$60 million NZD over 50 years. The good news is that some colonies survive on offshore islands that are relatively safe from cats and stoats, and so this species is not necessarily doomed to extinction.



The short-tailed bat – the only living member of its family. (Photo by Jane Sedgely)

The critically-endangered kākāpō (*Strigops habroptilus*), has likely been genetically isolated from other parrot species for tens of millions of years. As a flightless bird, it is particularly threatened by feral cats, and its population is now so low that inbreeding may be reducing hatchling success. Controlling these threats and ensuring the survival of this species would cost more than \$40 million NZD over 50 years. Fortunately, the kākāpō's recovery has received a helping hand from public-private partnerships. This reflects the fact that this large flightless parrot has become a bit of a media star and cause celebre of the conservation world meaning it's likely there will be strong public support for funding its conservation into the future.



The critically-endangered kākāpō, has likely been genetically isolated from other parrot species for tens of millions of years. (Photo by Dianne Mason)

We showed that the best solutions meant giving up on a few very unique species that were so expensive that they would have seriously reduced the total number of species and even the total phylogenetic diversity that could be conserved. But the best solutions were still able to reach over 95% of both the maximum possible species numbers and phylogenetic diversity.

What this means for conservation agencies is that it may be possible to satisfy both sides of the species numbers versus phylogenetic diversity debate. In a realistic situation where aspects such as probabilities of success, benefits and project costs across many years are considered, this may mean a careful process of choosing among candidate groups of species. But the rewards are worth the effort.

“The best solutions meant giving up on a few very unique species that were so expensive that they would have seriously reduced the total number of species and even the total phylogenetic diversity that could be conserved. But the best solutions were still able to reach over 95% of both the maximum possible species numbers and phylogenetic diversity.”

The current extinction crisis can be thought of as a fire in the genetic library of life. In the scramble to save as much as we can, we want to save as many books (ie, species) as possible, but we also want to save as much total information (ie, unique genes) as possible. By carefully applying appropriate conservation decision frameworks, an effective balance between both goals can be achieved. 🍷

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Burning questions for black cockatoos

Fire may hold the key to the future of Carnaby's cockatoo

Leonie Valentine and Richard Hobbs (University of Western Australia)

The gregarious Carnaby's cockatoo (*Calyptorhynchus latirostris*) are such a common sight in Perth that it is easy to forget they are endangered, and that the urban and agricultural expansion of south-western Australia has removed the bulk of their habitat. How we manage their remaining habitat will have important consequences for the species' survival.

A species under pressure

South-western Australia is a global biodiversity hotspot that has undergone extensive habitat loss from agricultural and urban development. Less than 30% of the original vegetation now remains. As a consequence of this habitat loss, the endemic Carnaby's cockatoo has experienced widespread loss of nesting and feeding habitat and is considered endangered under the IUCN Red List, and Australian federal and state legislation. Since the 1950s, numbers of the Carnaby's cockatoo have declined by more than 50%, with its range contracting by over 30%. The species has disappeared from more than a third of its former breeding areas.

Carnaby's cockatoo forages predominantly upon seeds in coastal areas during the non-breeding season (January – June), with most adults migrating to the inland wheat belt during the Austral winter to breed. Foraging resources are limited in both the breeding and non-breeding range for this species.

The largest population of birds during the non-breeding season is to be found north of Perth, one of the most rapidly growing cities in Australia. In this fragmented peri-urban and rural environment,

“If optimising food resources was an objective, the availability of food may be manipulated by altering burning patterns. Importantly, this would involve retaining greater areas of woodland burned with less frequency.”

Carnaby's cockatoos feed on the seeds of a variety of native and introduced plant species and on insect larvae. Plants include kwongan heath plants such as banksias, dryandra, hakea, grevillea and also marri seeds. New research suggests fire management may make an important contribution to sustaining the cockatoo's food sources.
(Photo by Leonie Valentine)

birds feed on seed from dominant native species *Banksia attenuata* and *B. menziesii* in remnant native vegetation. They will also feed on the introduced maritime pine (*Pinus pinaster*) in plantations and other species. Where they occur, the plantations replaced native vegetation, and Carnaby's cockatoos have a strong ecological association with this introduced food. Currently, the pine plantations are being harvested and their removal will further reduce food availability increasing their reliance on native species in this increasingly fragmented landscape.

Habitat under fire

Fire plays a major role in maintaining the structure and function of ecosystems and is a broadly utilised management tool,

How many are there?

It is difficult to know how many Carnaby's Black-Cockatoos are left, but it is known that their populations have declined by over 50% in the past 45 years, and that they no longer breed in up to a third of their former breeding sites in the Wheatbelt.

They are gregarious birds and live in pairs or small flocks during the breeding season. After fledging, the young move with their parents from breeding areas to feeding areas where other family groups join the flock.

The cockatoos live for 40-50 years in the wild. A large proportion of the remaining population now is past breeding age. When these older birds die, there will be very few younger birds to take their place.

More info: <http://www.environment.gov.au/biodiversity/threatened/publications/factsheet-carnabys-black-cockatoo-calyptorhynchus-latirostris>

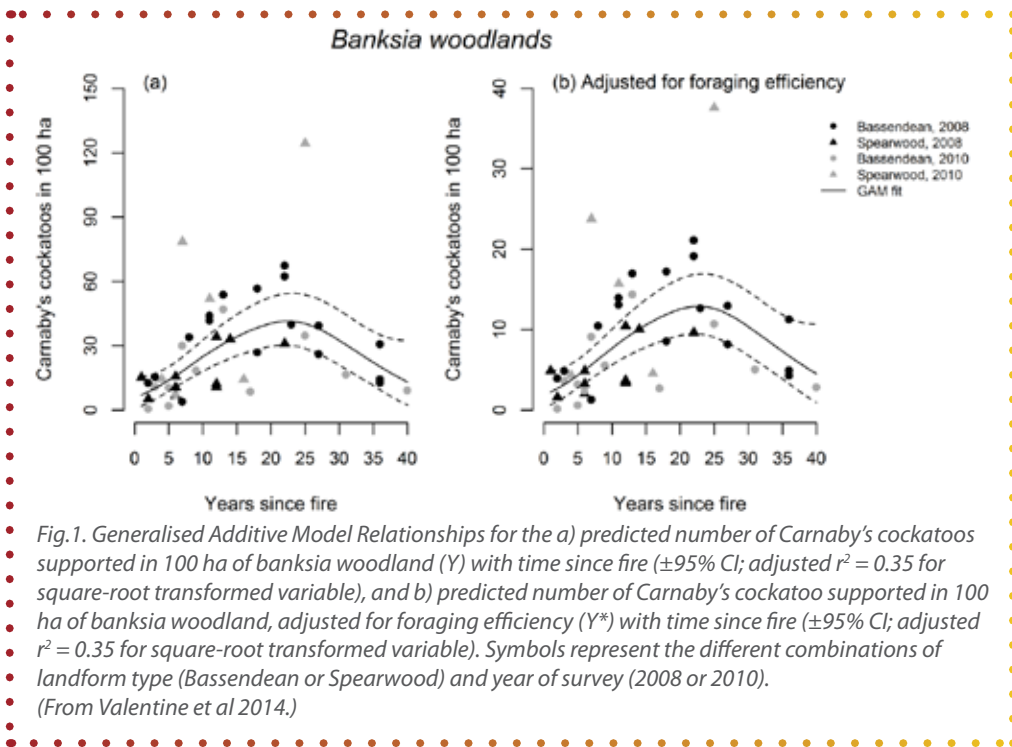


Fig.1. Generalised Additive Model Relationships for the a) predicted number of Carnaby's cockatoos supported in 100 ha of banksia woodland (Y) with time since fire ($\pm 95\%$ CI; adjusted $r^2 = 0.35$ for square-root transformed variable), and b) predicted number of Carnaby's cockatoo supported in 100 ha of banksia woodland, adjusted for foraging efficiency (Y*) with time since fire ($\pm 95\%$ CI; adjusted $r^2 = 0.35$ for square-root transformed variable). Symbols represent the different combinations of landform type (Bassendean or Spearwood) and year of survey (2008 or 2010). (From Valentine et al 2014.)

implemented by humans for a variety of purposes. Fire and conservation management is particularly complex in fragmented peri-urban areas, where there are multiple, often conflicting, objectives to fire management.

Fire management will influence the resources available for fauna. Consequently, if fire management is to play a role in the conservation of biodiversity it needs to be done with an understanding of the individual requirements of target species and community dynamics. A critical element for successful fauna management in fire prone-ecosystems is to understand how management actions affect resource availability.

To understand how fire influences food availability in the banksia woodlands we examined how time-since-fire influences plant and cone densities of the two dominant native woodland food species (*B. attenuata* and *B. menziesii*). We then estimated the number of Carnaby's cockatoo that would be supported in different post-fire aged banksia woodlands (including an estimation of the number of Carnaby's cockatoo that could be supported with the current distribution of post-fire banksia woodland habitat) (Valentine et al 2014).

Fire and food

We compared tree density and cone productivity of dominant banksias across 44 sites of varying post-fire aged vegetation. The number of Carnaby's cockatoos that could be supported in banksia woodlands was estimated using the bird's energetic requirements and seed energy content, and accounting for some aspects of their foraging ecology.

Banksia attenuata produced more cones at sites aged 10–30 years since fire in both survey years, while cone productivity for *B. menziesii* was highest in very old sites (>35 years since fire) in one year only. We predicted that higher numbers of Carnaby's cockatoos would be supported in vegetation aged between 14–30 years since fire, peaking in vegetation aged 20–25 years (Figure 1).

The current distribution of post-fire aged vegetation within this area (>60% burnt within the last 7 years) is predicted to support around 2,725 Carnaby's cockatoos, representing 25–35% of the

estimated birds reliant on the area. Our results indicate that food resources are influenced by time since fire. Therefore, if optimising food resources was an objective, the availability of food may be manipulated by altering burning patterns. Importantly, this would involve retaining greater areas of woodland burned with less frequency.

Current fire management is focused, understandably, on human and asset protection as a priority for prescribed burning. If management of landscapes for improved persistence of threatened species is also considered important, then complex trade-offs may have to be considered. However, it would be possible to modify existing practices to achieve multiple goals if, for instance, a zoning approach was adopted that maintained frequent fire close to housing and infrastructure, but allowed longer fire-free periods elsewhere.

Such solutions require more planning and effort but if we desire a future that includes the existence of iconic species such the Carnaby's cockatoo then it's effort we should all be demanding. 🍓

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Valentine LE, R Fisher, BA Wilson, T Sonneman, WD Stock, PA Fleming & RJ Hobbs (2014). Time since fire influences food resources for an endangered species, Carnaby's cockatoo, in a fire-prone landscape. *Biological Conservation* 175: 1–9.



Flocks of Carnaby's cockatoo are a familiar sight in Perth skies, and their calls evoke a strong sense of place. (Photo by Leonie Valentine)



Of ecological disturbance and genetic diversity

Using genetic info to better manage biodiversity in a changing world

By Sam Banks (Australian National University)

Environmental disturbances range from big events like bushfires, floods and volcanic eruptions to more mundane processes like a boulder being turned over on wave-pounded rocky shore. Ecologists have long realised that disturbance underpins the dynamics and diversity of many of the ecosystems of the world, yet its influence on the patterns and distribution of genetic diversity is poorly appreciated. How do changing patterns of disturbance affect genetic diversity in natural populations? This is an important question for conservation because genetic diversity influences the survival of individuals, the persistence of populations and the adaptability of species to environmental change. And regimes of ecological disturbances like fire, floods and extreme weather events are changing globally.

With colleagues I recently reviewed the challenges and opportunities of using genetics to understand the biotic impacts of disturbance (Banks et al., 2013). We found that disturbance can cause genetic changes that may affect the viability and adaptability of populations, that some species can show rapid evolutionary responses to novel disturbance regimes, and that there is considerable potential for genetic approaches, such as landscape genomics, to inform conservation management in landscapes where disturbance regimes are changing.

Evolutionary consequences of disturbance

Disturbance is known to be an important driver of natural selection on the traits of plants and animals. Many species have evolved in response to particular regimes of ecological disturbance, and a large proportion of Australia's plants and animals can almost be defined

“There is considerable potential for genetic approaches, such as landscape genomics, to inform conservation management in landscapes where disturbance regimes are changing.”



Pictured above is ANU PhD student Robyn Shaw. She is working with the Australian Wildlife Conservancy to understand small mammal population dynamics in fire-prone landscapes. Several species of native rodent such as the pale field rat (above left) and common rock rat (right) are in decline in the Kimberley (top image). New insights from demographic and genetic research may help us tailor fire management to ensure the ongoing persistence of these species. (Photos by Sam Banks)

by their relationship to fire (eg, many of our plants can be grouped as post-fire seeders or resprouters). So the selective ‘filter’ that fire imposes on these traits contributes to the differences in the species we find in parts of the landscape with different fire regimes, such as protected gullies vs. exposed ridges.

Less well understood is how the regimes of disturbances like fire influence genetic variation within species and the evolution of their traits. However, recent work provides some interesting insights. For instance, research from Juli Pausas's group at the University of Valencia in Spain has shown that frequent fire can actually drive the evolution of increased flammability in plants, documenting these changes at the genetic and physiological levels.

This evolutionary process occurs because these plants do very well under conditions of frequent fire. Individuals are killed by fire, but their offspring out-compete other species by highly effective post-fire regeneration from seed. Thus, traits that make the local neighbourhood more flammable are advantageous. These plants make some compromises in evolving to become more flammable, and flammability-enhancing traits appear less advantageous where fire is uncommon. Thus, evolutionary processes can be quite dynamic in response to changes in disturbance regimes, and these responses can have major impacts on the rest of the ecological community.



This mountain brushtail possum survived the 2009 Black Saturday bushfires at Cambarville in the Victorian central highlands. Mountain brushtail possums fared surprisingly well after Black Saturday, but many other arboreal marsupials, like the endangered Leadbeater's possum, have been completely absent from burnt sites since the fires. The increasing frequency of fires and logging in this region means that suitable long-undisturbed habitat occurs in ever-smaller patches, which may shift over time in response to disturbance ongoing patterns. The resulting extinction-recolonisation dynamics may cause major changes to the genetic diversity of such species in these landscapes. (Photo by Sam Banks)

Disturbance, population dynamics and genetics

In addition to evolution driven by natural selection, genetic variation can be shaped by what we know as selectively-neutral processes relating to population size, mating systems and movement patterns across the landscape. We know that landscape changes like habitat fragmentation can have major genetic effects in this way, often leading to losses of genetic variation in small, isolated patch populations. Can disturbance have similar effects? Certainly, such examples have been documented. Luciano Beheregaray (Flinders University) attributed the unusually low genetic diversity of the largest population of a subspecies of Galapagos giant tortoise to a volcanic eruption that decimated the population 100,000 years ago.

However, many species that exist in the presence of regular disturbance have mechanisms to avoid the negative genetic consequences of disturbance events, such as high levels of immigration from undisturbed areas (genetic 'rescue effects'), large-scale seed drop or soil seed banks that preserve the diversity of previous generations, or high survival of individuals in disturbed areas. For instance, we fitted radio-collars to mountain brushtail possums the week before the 2009 Black Saturday fires, and found that all survived and were perfectly healthy in the months after the fire. The population lost no genetic diversity as a result.

The more complex interactions between disturbance history, habitat suitability and population dynamics have the potential to cause major changes in genetic diversity for species in landscapes where the disturbance regimes are changing. In many vegetated ecosystems, fire history is the major determinant of whether or not habitat is suitable for some species. For instance, a number of our native rodents specialise in early post-fire conditions, and many arboreal marsupials in south-east Australian forests require long-unburnt old-growth forest for habitat.

In the latter case, the increasing frequency of fires, together with human disturbances like logging, means that suitable long-undisturbed habitat occurs in ever-smaller patches, which may shift over time in response to disturbance ongoing patterns. In the absence of very high migration capacity, this kind of ecological scenario does not favour the maintenance of genetic diversity in populations. Recent work by Sarah Brown, Paul Sunnucks and others at Deakin and Monash Universities shows that one species that fits this 'shifting-patch suitability' model, the mallee emu wren, displays very low genetic diversity.

Maintaining genetic diversity

So how much should we worry about this as a threatening process? We aren't about to rush out and measure genetic diversity in every ecosystem affected by disturbance (most places on the planet), but I would suggest that it is important to understand the conditions under which disturbance might cause 'conservation-relevant' changes to genetic diversity. This might be where disturbance regimes are changing drastically, or where species' responses to disturbance are constrained by other environmental changes like habitat fragmentation.

Improving our knowledge of how genetic diversity responds to disturbance might also give us some new research tools to inform better management of biodiversity. Robyn Shaw, a PhD student at the ANU, recently started a project in collaboration with Drs Katherine Tuft and Sarah Legge of the Australian Wildlife Conservancy (AWC), with the aim of developing joint demographic and genetic approaches to understand how populations of declining native rodents in the Kimberley recover from fire events.

Genetic data have not often been applied to research in disturbance-affected ecosystems because of the complex population dynamics at play. Robyn's work uses new computer simulation tools, combined with field and lab work, to determine the genetic signatures of different population recovery processes. She aims to use this approach to understand the importance of animal survival and immigration as drivers of post-fire population recovery, and how these are affected by the intensity, season, size and frequency of fires in the Kimberley.

Fire is one of the key drivers of native mammal declines in northern Australia, and our aim with this project is to feed the new information into the AWC's large-scale [EcoFire program](#) that focusses on developing and applying pro-active fire management strategies for mammal conservation in the Kimberley.

In a similar manner, understanding the interaction between gene flow and disturbance regime may contribute critical information about how to effectively manage biodiversity in a rapidly changing world. 🍷

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Reference

Banks SC, GJ Cary, AL Smith, ID Davies, DA Driscoll, AM Gill, DB Lindenmayer & R Peakall (2013). How does ecological disturbance influence genetic diversity? *Trends in Ecology & Evolution* 28: 670-679. <http://dx.doi.org/10.1016/j.tree.2013.08.005>



A recently-burnt landscape at Mornington Wildlife Sanctuary in the Kimberley. Fire has always been a part of this landscape, but changes in the season, intensity and size of fires are contributing to the ongoing decline of many mammals in this region. Pro-active fire management strategies are helping to halt these declines, and can be informed by combinations of genetic research and field-based ecology. (Photo by Sam Banks)

Genes and geography

In search of surrogates for genetic variation

By Rocio Ponce-Reyes (CSIRO)

Species that are threatened with extinction usually exist in small numbers and occur in groups that are often isolated from each other. Central to conservation planning is the effort to maximise representation and persistence of biodiversity at minimum cost. The great majority of plans, however, only focus on representation. To incorporate aspects of persistence it is essential to include processes that affect the amount and distribution of biological variability and the ability for organisms to adapt and evolve. And that means factoring in genetic variation. The genetic divergence that accumulates through time, leads to speciation; while the genetic diversity increases the reproductive variability.

Unfortunately, factoring in genes is easier said than done. Protecting all the populations of a threatened species is often an impossible task because financial resources for conservation tend to be limited and genetic analysis tends to be expensive. For example, if we had enough funds to protect only three populations of a threatened species found across an archipelago of many islands and we wanted to choose those islands where this species occurs with the highest genetic or phenotypic diversity and divergence, how would we make this choice?

One option would be to go out into the field and sample the different populations on a range of islands. Then we could take those samples back to the lab and using genetic tools determine which of the islands has the highest diversity. However, such analysis takes time and money. It's possible that we might be able to identify the three islands with the greatest diversity but then not have the funds to be able to adequately protect them. And the process of genetic analysis can add considerable time to the planning process, which might be problematic if an imperilled species needs rapid protection.

Alternative approaches

Is there another way to approach this? By identifying simpler ways that allow us to select islands with high genetic or phenotypic diversity and divergence we could potentially be able to make better conservation decisions. Would geographic measures allow us to identify the genetically most diverse or divergent populations? Distance between islands and the size of islands are both factors, for example, that contribute to genetic diversity over time.

Choosing populations with the largest distance between them might select for the highest divergence, as the geographic distance

“To incorporate aspects of persistence it is essential to include processes that affect the amount and distribution of biological variability and the ability for organisms to adapt and evolve. And that means factoring in genetic variation. The genetic divergence that accumulates through time, leads to speciation; while the genetic diversity increases the reproductive variability.”

will limit the gene flow between populations and therefore reduce the presence of shared alleles.

Another option is selecting the biggest islands. This could help minimize the effects of the genetic drift, and therefore capture the highest diversity. Genetic drift is more obvious in smaller populations (smaller islands) where rare alleles are sometimes lost.

Finally, selecting a subset of islands that best represent the geographical coverage of the archipelago might be the way to go. This would be the set of islands with the shortest average distance between selected and unselected islands. With this measurement we might expect to get a combination of diversity and divergence.

Testing with silvereyes

A few years ago, researchers from the Imperial College in London, assessed the genetic diversity, divergence and morphology of two species of silvereyes (*Zosterops flavifrons*, and *Z. lateralis*) in Vanuatu. They visited the 13 main islands of the Vanuatu archipelago, each with a different population of silvereye.

They found that the species have different genetic structures: *Z. flavifrons* is endemic to Vanuatu and it colonized the archipelago between 2-4 million years ago and the genetic structure is driven by genetic drift. The plumage of the populations can vary between yellow and dark.

Z. lateralis is not endemic to Vanuatu. It arrived half a million years ago and its population genetic structure is driven by a distance-mediated gene flow.

Using these genetic analyses we came up with a suite of geographic measures that could be used as surrogates (Ponce-Reyes et al., 2014) and then used these geographic measures in a conservation planning exercise to see if we could create a plan that effectively conserved genetic variation. If the geographic measures could be used instead of the actual genetic results it would enable a simpler and inexpensive way of incorporating genetic processes into conservation planning.

We found that if you only had money to protect half of the total populations, selecting islands with the maximum distance between them was the best approach in both species if the aim is to capture the highest genetic divergence. But this approach worked best when looking at protecting the phenotypic divergence (based on the morphology of the birds), especially for *Z. lateralis*.

If we were interested in protecting the genetic diversity, choosing the biggest islands worked well for *Z. flavifrons* when selecting less than 50% of the islands. However for *Z. lateralis* this was not the case, choosing the biggest islands was less effective than simply picking the islands randomly.

The maximum representation generally tended to perform as the best metric when a higher number of islands were selected (more than half of the total).

What's next?

Incorporating genetic variation in conservation planning is important to preserving evolutionary processes. However, it can be expensive and time consuming. Consequently, the use of surrogates for measuring this variation is worth exploring.

The effectiveness of the surrogates that we tested was variable. We didn't identify a measure that performed consistently better

than just selecting islands randomly. The next step will be to test if combing several surrogates will enhance the benefits for genetic and phenotypic variation and even serve to maximize the evolutionary potential of protected populations. For example, the rate of speciation on islands depends on the size, age, topography and habitat diversity, evolutionary and geological features and island isolation; as well as the targeted species.

We acknowledge that without previous knowledge of the population genetic structure, planners might be reluctant to use the geographic measures as surrogates for genetic analyses. However delaying the decision for conservation while gathering data may lead to lost opportunities for conservation.

We also acknowledge that insufficient prior knowledge may lead to poor decisions. Hence with this study we are not arguing that genetic studies are not desirable to improve conservation decisions but to analyze the trade-off between time and money required to gain genetic information and the benefits those data can provide relative to an immediately available surrogate.

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Reference

Ponce-Reyes R, SM Clegg, SB Carvalho, E McDonald-Madden & HP Possingham (2014). Geographical surrogates of genetic variation for selecting island populations for conservation. *Diversity and Distributions* 20: 640–651.



Zosterops flavifrons

The Vanuatu white-eye or yellow-fronted white-eye (*Zosterops flavifrons*) is a small passerine bird belonging to the genus *Zosterops* in the white-eye family Zosteropidae. It is endemic to Vanuatu, where it is one of the most common birds.

This bird is 11–12 cm long. The adult male is yellow-green above while the underparts are bright yellow or yellow-green depending on the subspecies. The forehead is yellow and there is a white ring around the eye. The legs and feet are dark grey and the bill is brown above and pinkish below. Female and immature birds are similar to the male but paler. The immatures also have a narrower eye-ring.

The contact call is short and high-pitched. The song is a repeated warbling.

There are seven subspecies distributed almost throughout Vanuatu from the Banks Islands in the north to Aneityum in the south. The species occurs in a variety of habitats including forest, plantations and gardens from sea-level to the mountains. It forages in bushes and trees, moving around in pairs or small flocks. The varied diet includes insects, nectar and fruit such as lantana berries and wild figs.

The neat, cup-shaped nest is built 2.5 metres or more above the ground and is made of grass, pieces of bark and spider webs. The eggs are bluish-white and there are three in a clutch.

http://en.wikipedia.org/wiki/Vanuatu_white-eye



Conservation collaboration in the western Indian Ocean

A CEED/NERP workshop

(University of Qld, May 2014)

In Eastern Africa and the Western Indian Ocean (WIO), many people depend on marine resources and their sustainable use for their living. This region harbors a wide diversity of coral and fish species, extending from South Africa in the South to Somalia in the North and from the East coast of Africa to island states such as Madagascar Seychelles and Reunion to the east. The objective of this workshop was to investigate the role of collaboration in conservation planning and prioritization among countries in the West Indian Ocean. Organized by Salit Kark (CEED) and Maina Mbui (CEED & Wildlife Conservation Society – WCS), the workshop brought together marine biodiversity, conservation planning, and spatial analysis experts including Tim McClanahan (WCS, Kenya), Noam Levin (CEED & Hebrew University of Jerusalem), Maria Beger (CEED), James Watson (UQ & WCS) and Tessa Mazor (CEED).

To set the stage for the workshop's discussions, Salit Kark familiarized the group with the previous work undertaken in the Mediterranean Sea, and introduced the concept of regional conservation planning within the framework of collaboration among countries (or lack of), biodiversity distributions, conflicts, and regional economic and geopolitical issues. Noam Levin and Tessa Mazor presented their work in the Mediterranean (see [Decision Point #73](#)). Maina Mbui introduced the region's spatial extent and constituent nations, sociopolitical and biodiversity distributions, and the examples of relevant previous work undertaken in the region.

Discussions that followed led to the outlining of a paper that will aim to help prioritize coral reef systems in the WIO on the basis of ecological and socio-political economic factors. For example, prioritization considers fish biomass sustainability and conservation targets, and the cost (units=time) of fish biomass recovery. In so doing, the planning takes into account the importance of coral reef fisheries as a source of livelihood in the WIO, where many people depend on marine resources on a daily basis and where high socio-economic diversity occurs amongst countries and regions. The aim was to examine spatial options for maintaining fish biomass at a level where yields are high, and at the same time prevent the undermining of ecosystem by heavy exploitation.

Preliminary outputs of these applied analyses were then presented by Tim McClanahan at the regional meeting of the Consortium for the Conservation of Coastal and Marine Ecosystems in the Western Indian Ocean (<http://www.wiomsa.org/wioci/>) in Dar Es Salaam, Tanzania in June.

Overall, this two days workshop was very productive and succeeded in building further ties between CEED and WCS's marine experts (see [Decision Point #79](#)), and streamlining the project's outputs to spatial scales, conservation goals and targets that are applicable to the region, in addition to forging new collaborations with conservation practitioners and scientists in the WIO region.

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From left: Maria Beger, Salit Kark, Tim McClanahan, Maina Mbui and James Watson. (Missing are Tessa Mazor and Noam Levin who were busy running GIS analyses for the West Indian Ocean at the time.)

(Photo by Heather Christensen)

A new list to frame biodiversity conservation

Moving from species to ecosystems

I spy an outcome

To highlight the many contributions our research is making towards conservation outcomes, *Decision Point* is running a series of short stories on what we have achieved. In this instalment we discuss the contribution made by our researchers to the recently launched IUCN Red List of Ecosystems, one of the biggest advances in many years in international conservation.

Much of the debate on declining biodiversity has been framed around disappearing species. A new IUCN Red List promises to enlarge this debate to take ecosystems into account and CEED researchers have made several important contributions to its development.

The status of threatened species is but one facet of the conservation problem of declining biodiversity. Scientists have become increasingly concerned about the ecosystems and their processes that support species, their interactions and environment.

What we have long needed is a Red List of Ecosystems, and last year the IUCN (the International Union for the Conservation of Nature) delivered one. It's a risk assessment framework for ecosystems that lets the IUCN rank ecosystems as endangered, vulnerable or not threatened according to the risks they face.

Defining, measuring and comparing ecosystems is a much tougher proposition than defining, measuring and comparing the status of threatened species (which is challenging enough in itself). It's easy to observe that the Aral Sea is a collapsed ecosystem; the sea itself has largely disappeared and with it many of its native animals and plants – never to return. In terms of area, composition and function, this ecosystem is gone. But what about the Coorong wetland or the Great Barrier Reef? They're under tremendous pressure but at what point should they be considered vulnerable as opposed to endangered?

The Red List of Ecosystems assesses an ecosystem against multiple criteria: how rapidly is it declining and what is its current extent? How rapidly and how extensively are its physical and biological components degrading? And what is the nature of the multiple threats it faces and how are these threats interacting?

Workshopping the criteria

In 2012, some 32 people from all around the world met at the School of Botany, University of Melbourne, at a CEED-sponsored workshop on the IUCN Red List of Ecosystems (see [Decision Point #62](#)). The focus of the workshop was on the application of the draft criteria to marine systems, definitions of collapse (analogous to extinction for species), and ways of assessing change in ecological function as they move towards collapse.



The Tepui shrublands of Southern Venezuela occur on tepui summits, pictured here, and are characterised by a high degree of plant endemism. They were assessed as Least Concern under the IUCN Red List criteria, however long term threats include damage from tourism and climate change. (Photo by Tracey Regan)

The ecosystems framework that has been released by the IUCN is the product of many discussions and workshops between scientists. CEED researchers Dr Emily Nicholson and Dr Tracey Regan spent 2012 and 2013 hosting workshops and collaborating with the IUCN, and state and federal conservation agencies to develop definitions and measurements of ecosystems and threat status. They were co-authors of the paper that described the new IUCN Red List criteria, and applied them to 20 illustrative case studies (Keith et al., 2013). Nicholson and Regan are part of a research team (funded by an ARC Linkage grant) to systematically test these criteria under a range of conditions.

Of the ecosystems they compared, the remote mountain ecosystems of the Venezuelan Tepui are among those at least risk of collapse. These systems are showing little evidence of decline in distribution or function in the past or near future. At the other extreme is the Aral Sea, which collapsed during the 1980s and 1990s.

In May 2014, during the IUCN's 83rd meeting in Switzerland, the categories and criteria for the identification of threatened ecosystems and the creation of Red Lists of Ecosystems were officially adopted. This marks the end of a long process that started back in 2007. The criteria are described in Keith et al., 2013.

The criteria are currently being applied across the whole of the Americas, and have been used in over 40 countries. This includes a suite of assessments in Australia (to appear in a forthcoming issue of *Austral Ecology*).

In terms of local influence, the Australian government has revised some of its criteria for assessing ecological communities to match those of the IUCN and South Australia is looking to use the criteria directly in setting up a list of threatened ecosystems/ecological communities there.

The world now has a conservation tool that allows us to look beyond species to the ecosystems they are a part of. 🍷

Note: See Emily Nicholson's blog for more background on the IUCN Red List of Ecosystems with links to other papers and other information on this important new tool for conservation: <http://emilynicholson.wordpress.com/>

Reference

Keith DA, JP Rodríguez, KM Rodríguez-Clark, E Nicholson, et al. (2013). Scientific foundations for an IUCN Red List of Ecosystems. *PLoS ONE*, 8(5): e62111

Conservation talk in Oceania

2014 Conference of the Society for Conservation Biology – Oceania (SCBO) Fiji

By Jutta Beher, Nancy Auerbach and Christopher Brown (University of Queensland)

Pacific Islanders, and the environments they live in, face some of the most pressing conservation challenges on the globe. These include habitat loss (due to logging), land clearance, over-harvesting, overfishing, invasive species, pollution, climate change, rising sea levels and extreme weather events. In an effort to constructively engage with these challenges, the 2014 Conference of the Society for Conservation Biology (Oceania section) was held in Fiji in July this year. The event brought together a wide range of scientists and conservation practitioners working across the whole spectrum of theory and practice.

The University of the Southern Pacific, the region's leading research institution, co-hosted the Conference in Suva. Over 50 of their local students participated as volunteers giving them experience and contacts. The conference brought together more than 200 scientists from 25 countries from all over Oceania. Matching this diversity of nations was the variety of disciplines on show, with researchers presenting work from social, ecological and political spheres, coming from backgrounds in policy, non-governmental conservation agencies, planning, humanitarian institutions and universities.

Besides the tremendous exchange and discussions of different ideas for addressing conservation challenges, generous refreshments, and engaging activities, a silent auction raised AU\$1500 for Nature Fiji-MareqetiViti (see <http://www.naturefiji.org/>). This local environmental group was set up to enhance biodiversity and habitat conservation, endangered species protection and sustainable use of natural resources of the Fiji Islands.

Twenty researchers from CEED and NERP (EDG) nodes participated in various symposia at the conference. They inspired their audiences with the EDG approach of incorporating economic data into conservation decision-making and discussions on interactions among multiple threats.

CEED researchers Hugh Possingham, Carissa Klein and Jutta Beher organised and chaired a symposium on integrated land-sea planning, an emerging field that focuses on the interactions between marine and coastal ecosystems. The main emphasis was on the implications of sediment and pollution runoff from land. Additional and related discussions were focused on the conservation of species that migrate between fresh and salt water, human population growth, and infrastructure for fisheries. The range of topics in this symposium covered social, political and ecological dimensions, with key take home messages including:

- It is crucial to **consider cost-effective investment options across the land and the sea**. They can help inform transparent funding decisions and can deal with uncertainties.
- The **theory and models exist for decision-making under multiple threat scenarios**, and we need to improve their uptake by decision makers.
- **Conservation actions taken on land can sometimes have a greater benefit for marine ecosystems** than conservation actions in the sea.

SCB Oceania

The Society of Conservation Biology (www.conbio.org) was founded in 1985 and focuses on advocating support for conservation science, as well as increasing the application of science to management and policy. The society's global journal is *Conservation Biology* and their regional journal for Oceania is *Pacific Conservation Biology* which recently featured a special issue on the conference (Volume 20 issue 2) titled "Conservation of Biodiversity in the Pacific Islands of Oceania". The Oceania section and the detailed resolutions of the conference can be found at <http://www.conbio.org/groups/sections/oceania>.



Conservation scientists on the look-out over Oceania.

- Case studies on sediment runoff from industrial and pristine regions demonstrate that **runoff does not always pose more of a threat at higher concentration as its impact depends on the ecosystems** and local oceanographic characteristics.
- **The most-effective conservation examples involve collaboration** with local communities and involve stakeholders from an early stage.

Conference participants discussed and agreed upon general resolutions of the conference. These emphasised the importance of integrating the needs and knowledge of indigenous communities into conservation efforts to secure the best outcomes. Of no less importance is a strong connection to local stakeholders and communities.

The resolutions were framed around work in Oceania but apply just as much to any conservation project. The time is right for research and conservation collaborations across the Pacific. Through symposia such as this, and by making informed choices in addressing conservation challenges, Oceania may still hope to maintain its unique wildlife and environments. 🍌

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Most Pacific Islands are surrounded by vast reef-flats. Fishing and collection of seafood is a tradition in most coastal communities. The loss of species through overharvesting is even described in indigenous poetry, as was presented in a plenary talk.

Cultivating our next generation of environmental leaders

What is leadership and why does it matter to us?

By Colleen Corrigan (University of Queensland)

Forbes Magazine contributor Kevin Kruse recently defined leadership as “a process of social influence, which maximizes the efforts of others, towards the achievement of a goal.” (Forbes.com 2013). This broad definition matches the aim of the new environmental leadership program being implemented by the EDG. The program has been titled: empowering leadership for impact.

Around the world, academic institutions are increasing investments in specialized leadership development as a means to enhance training for their students. For example, since 2007 the University of Cambridge has created a Master’s degree in Conservation Leadership and Harvard’s Business School has introduced field learning in MBA leadership training. For those engaged specifically in higher degrees in the conservation science sector, leadership has been identified as a critical skill for having influence (Manolis et al 2008, Dietz et al 2004). This is supported by evidence that successful conservation projects have been positively correlated with effective leadership (Black et al 2011).

Why a new program?

The idea for creating a leadership program within EDG was generated at the 2013 CEED Biannual Conference at the University of Queensland. A small group of participants with a keen interest in the principles and practice of leadership formed a focus group to explore the topic in depth, discussing personal experiences and brainstorming ideas about how this important area could be examined further in the CEED network. Thus the seed for this enterprise was first planted by CEED.

Since most leadership programs are located in Europe and the US, or run through private sector companies, creating an opportunity for EDG students and staff in this hemisphere was deemed important.

What does the program look like?

Following an initial scoping process, the program has been designed in its pilot year (2014-2015) to comprise a 15-person cohort including PhD students in their second year and postdocs representing almost all EDG nodes. This audience was selected because the timing of training should benefit their career options shortly after completion of the program.

A survey of existing leadership programs in Australia and overseas, most with an environmental focus, was conducted to learn about what has worked well in various situations and to gain advice from those already experienced in leadership training. The EDG program aims to maintain a balance between the theories and practice of environmental leadership



The first cohort of EDG’s new leadership program.

development, and flexibility for participants already committed to their studies. The first cohort began their program with a week of intensive leadership training in November 2014. The rest of the year will entail additional gatherings of the cohort, focused skill training events, and cohort-designed activities that foster team leadership development as well as personalized action plans for self-assessment and growth.

In July 2014, we visited three U.S. academic institutions (University of Minnesota, Harvard University, and Stanford University) to examine their programs in greater depth, explore potential partnerships, and gain insights for EDG’s leadership program. These schools were selected based on the difference in their approaches to leadership development and their enthusiasm for exchanging knowledge and experience.

While each program varies according to audience, structure and investment of time and resources (see Table 1), there are similarities in strategies and cross-cutting themes. For example, all programs include skills training that is technical (eg, presentations) and soft (eg, negotiation skills) in nature. Utilizing trust and activities for team-building, using multi-disciplinary approaches particularly from the social sciences, applying principles of design thinking, and considering the importance of evaluation are other core aspects in common.

Each of the programs is responsive to the needs of participants and open to evolving as a result. The EDG leadership program is exploring a range of insights gained from these sources, particularly the importance of a cohort approach where multiple, structured gatherings and small-team engagement will be used to build trust and personal accountability.

Institution	Program	Inspiration	Structure	Participants
University of Minnesota, Institute on the Environment	Boreas Environmental Leadership Program	Staff member’s experience in another leadership program.	Weekly ‘booyas’ or gatherings organized by voluntary student advisory team, monthly structured activities developed by program manager to give in – depth skill training and networking opportunities; guided by flexibility so no core requirements.	Open to current University students (across 19 colleges) with interest in environmental leadership; dozens of participants over the course of a year.
Stanford University, Woods Institute for the Environment	Leopold Leadership Program	Originally developed to provide training for fellows working with decisions makers beyond academia, including in the US Congress.	Year-long program book-ended by intensive residential training in Wisconsin. Other activities take place remotely, with fellows participating from their places of work and within the context of teams organized during the first gathering.	Highly selective; Twenty mid-career environmental academic researchers, tenured or near tenure.
Harvard Business School	Field Immersion Experiences for Leadership Development (FIELD)	Findings from a global review of MBA programs indicated team leadership skills were falling short in graduates despite their excellent critical thinking capacities.	Three components completed in first year of MBA training: (1) leadership skills training in communication and negotiation (2) globalization field excursion, and (3) Integrating intelligence in team marketing assignment.	Roughly 900 students enrolled in Harvard’s two-year MBA program.

Leadership Links

University of Minnesota Boreas Leadership Program
<http://boreas.environment.umn.edu/>

Stanford University's Leopold Leadership Program
<http://leopoldleadership.stanford.edu/>

Harvard University Business and Environment Initiative
www.hbs.edu/environment/Pages/default.aspx

Harvard University Field Immersion Experiences for Leadership Development (FIELD) program,
www.hbs.edu/mba/academic-experience/FIELD/Pages/default.aspx

East West Center Asia Pacific Leadership Program
www.eastwestcenter.org/education/aplp

The value of leadership

Each of the reviewed programs exhibits characteristics that demonstrate the value of leadership development. Benefits to existing students at the University of Minnesota include opportunities to meet a range of colleagues from across disciplines, advise the program's direction, and receive hands-on training sessions, such as working with media, where skills are utilized immediately in practice. Because Stanford's program is targeted to high-achieving environmental researchers, it largely leverages the determination and drive exhibited by its fellows, almost all of whom have reached tenure prior to participation. The influence of this program on other institutions is evident, with Minnesota's Boreas program having been started by a former Leopold fellow.

Connections are paramount. The quality of Harvard's alumni network demonstrates the value of connections in the delivery and success of training; funding and field opportunities for leadership development arise directly from this network. As a result of the FIELD leadership training, professional staff have already found that second-year MBA students are better at collaborative work in teams and possess the interpersonal skills necessary for future employment.

Harvard has also recently developed a Business and Environment Initiative as a means to increase its work in this interdisciplinary field. It is a member of the Network for Business Sustainability, an international network of business leaders and academic experts focused on responsible management practices and research. CEED has recently acquired membership in this network in partnership with the UQ School of Business.

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Black et al. (2011). Leadership and conservation effectiveness: finding a better way to lead. *Conservation Letters* 4: 329-339.

Dietz et al. (2004). Defining Leadership in Conservation: a View from the Top. *Conservation Biology*. 18: 274-278.

Forbes.com 2013. *What is Leadership?*
<http://www.forbes.com/sites/kevinkruse/2013/04/09/what-is-leadership/>

Manolis et al. (2008). Leadership: a new frontier in conservation science. *Conservation Biology* 23: 879-886.

My engagement with leadership

The content and structure of this EDG program has been largely informed by my own experience in the Asia Pacific Leadership Program at the East West Center in Honolulu, Hawaii, now in its 14th year. In 2009, I took a 5-month sabbatical from my work at the United Nations Environment-Programme's World Conservation Monitoring Centre to engage as a fellow in the selective and residential leadership program, which hosted 40 members from over 20 countries. During the program, my research focused on developing a regional approach to marine conservation in the Pacific, which has since become a global undertaking by the Convention on Biological Diversity through regional workshops. Five years later, lessons gained from the program remain a significant influence on my career and continues to provide strong relationships with former fellows around the globe.

Dbytes

Dbytes is EDG's internal eNewsletter. It gets sent to members and associates of EDG each week, and consists of small snippets of information relating to environmental decision making. They might be government documents, research articles, blogs or reports from other research groups. Here are six bytes from recent issues. If you would like to receive the *Dbytes* eNewsletter, email David.Salt@anu.edu.au

1. Blueprint for a Healthy Environment & Economy

The latest publication from the Wentworth Group of Concerned Scientists. Transformative, long-term economic and institutional reforms that Australia must implement if it is to create a healthy environment with a productive economy.

<http://wentworthgroup.org/publications/>

2. Kakadu threatened species strategy

Kakadu National Park is home to 75 threatened species - probably more than any other Australian conservation reserve. A strategy has been released to bring threatened species back from the brink of extinction in the Park. A team of conservation experts and Parks Australia staff have contributed to the development of the strategy written by leading wildlife expert Prof John Woinarski, through the NERP Northern Australia Hub.

http://www.nerpnorthern.edu.au/sites/default/files/managed/files/kakadu_strategy_-_31-10-14.pdf

3. The Australia we Love report

The Australia We Love report compiles recent, relevant information about the state of Australia's rivers, climate, food, forests, waste and pollution, land management, oceans and reefs.

<http://www.placesyoulove.org/AustraliaWeLove/>

4. IPCC Working Group II report – impacts & risks of CC

Working Group II of the Intergovernmental Panel on Climate Change is launching the full version of its contribution to the IPCC *Fifth Assessment Report Climate Change 2014: Impacts, Adaptation, and Vulnerability*.

http://ipcc.ch/pdf/press/141015_WGII_Final_Report_Launch.pdf

5. UN guidelines to minimise risk of invasive species

The guidelines address a major pathway for introduction and spread of invasive alien species, as a significant percentage of global invasive introductions result from pets, aquarium and terrarium species that escape from confined conditions and then get into the natural environment.

<http://www.cbd.int/doc/press/2014/pr-2014-10-10-cop12-ias-en.pdf>

6. The Outback Papers

Pew Charitable Trusts have released the first of its papers in a series on the Australian outback: *The Outback Papers*. Lead author, Professor John Woinarski says the paper is about conservation, focusing more broadly than national parks and threatened species, and discusses practical approaches that are already improving development and conservation outcomes.

<http://www.pewtrusts.org/en/research-and-analysis/reports/2014/10/the-modern-outback>

Down for the count

"The iconic Carnaby's black cockatoo may die out in the Perth region within 15 years, a report has found, prompting calls for the state and federal governments to protect remaining habitats. The 2014 Great Cocky Count report by Birdlife Australia and Western Australia's Department of Parks and Wildlife estimated the current rate of decline in the cockatoos' population on the Perth-Peel coastal plain was 15% per year. The minimum count for the birds in the region was 7154, with 59% of those found around the Gnangara Pine Plantation, north of Perth. The figure represents up to 10% of the entire population of the species, which is endemic to Western Australia's South West. Birdlife Australia said the cockatoos had adapted to the pine plantations in the 1950s to survive the loss of 1,000 hectares of native bush around Perth each year."

<http://www.abc.net.au/news/2014-08-25/carnabys-black-cockatoos-threatened-with-extinction-in-perth/5695710>



Carnaby's cockatoos are in decline. See our story on page 6 that examines whether it's possible to improve food resources for Carnaby's cockatoo by altering burning patterns. (Photo by Leonie Valentine)

What's the point?

What price security?

EDG's James Watson and colleagues are calling for a fundamental step change in funding, planning and enforcement of our protected areas (Watson et al, 2014). Not only are we falling behind meeting the Aichi targets we all signed up for (see [Decision Point #83](#)), our existing protected area estate is being degraded across the developed and the developing world. They conclude with a spending comparison: "The package of responses needed for the step change is neither impossible nor unreasonable, although individual countries may struggle with some of the components. Fundamentally, it requires the recognition that protected areas are core to the future of life on our planet. Estimations of the annual cost of adequately managing an expanded network of marine and terrestrial protected areas range from \$45 billion to \$76 billion, the lower of which is just 2.5% of the global military expenditure. But adequate protection of marine and terrestrial environments is also crucial to global security. It seems sensible to invest an amount equivalent to a tiny percentage of global military spending to help provide security for humans and all other living organisms on Earth through a system of marine and terrestrial protected areas that is operating at its full capacity".

Reference: Watson JEM, N Dudley, DB Segan & M Hockings (2014). The performance and potential of protected areas. *Nature* 515: 67-73.

"The annual cost of managing an expanded network of protected areas is just 2.5% of the global military expenditure."



ENVIRONMENTAL DECISIONS GROUP

The Environmental Decision Group (EDG) 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, RMIT and CSIRO.

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