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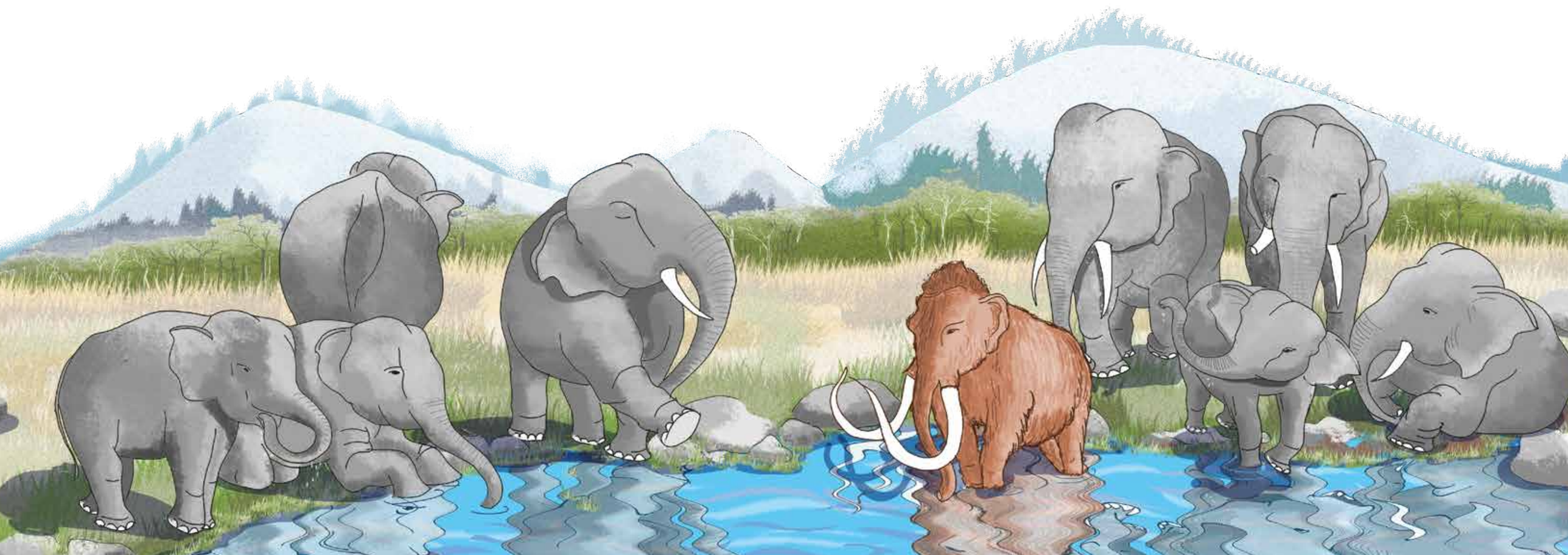

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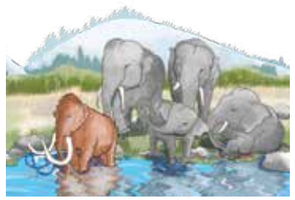

Cover art by Megha Vishwanath

For the longest time, extinction only evoked images of mammoths, dinosaurs, trilobites even. Animals that disappeared millions of years ago. In the twentieth century though, it became abundantly clear that another wave of extinction was upon the planet. The impact of humans on the natural world and the consequent disappearance of species is known as the sixth mass extinction. Some claim that a species goes extinct every 20 minutes, while others estimate that 1 in 6 species are threatened by climate change. Whether some of these claims are overly dramatic or scarily close to the truth we do not know with certainty, but what is clear is the idea of extinction is central to the arenas of conservation and environmentalism. A species that has become extinct will never be seen again on Earth.

Well, maybe not. A group of scientists and campaigners around the world have been working on the idea of 'de-extinction'. Alba Charles writes about the technical and philosophical aspects of bringing back extinct species. On the flip side, Chris Bowden describes the efforts to prevent species - Asian Vultures - from going extinct. Hari Sridhar interviews Jim Nichols, doyen of quantitative ecology about using rigorous science for decision making in conservation. Matt Creasey takes a journey with the rufous Hummingbird, a remarkable 8000 mile round trip for a 3 gram bird. And finally, focusing on another species that has been threatened with extinction, Caitlin Kight reviews a book on the future of cheetahs by Laurie Marker.

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Arboreal trinket

Wandoor, Andamans

Adhith Swaminathan

Gonyosoma oxycephalum, or the red tailed trinket snake, is found in bushes around brackish water creeks in Andamans.

Asian vulture crisis – 40 million gone, but have we reached a turning point?

Kalyani Ganapathy

Four of South Asia's nine vulture species are classified by the International Union for Conservation of Nature (IUCN) as 'Critically Endangered' - the very highest threat category short of extinction. These are the Oriental white-backed vulture, the long-billed and slender-billed vultures and the red-headed (or 'king') vulture. The battle continues to prevent them from disappearing altogether, and combat the major threat posed by the veterinary drugs used as a cattle painkillers, that have proved to be such catastrophic killers of vultures that consume the meat of animals treated with diclofenac.

It was only in the late 1990s that anyone realised how dramatically fast vultures were disappearing, and then there was a race to track down the cause. Various theories were circulating for investigation before the true cause was identified in 2003, first in Pakistan by the Peregrine Fund team, and quickly afterwards by Bombay Natural History Society (BNHS) and partners across the rest of the subcontinent. A common human painkiller, diclofenac (a non-steroidal anti-inflammatory drug– NSAID) which had been switched into veterinary practice on a huge scale and produced very cheaply, turns out to be extremely toxic to all vultures that consume the carcasses of animals that have been treated shortly before their death! It is a relatively safe and quick acting drug for humans and cattle, and it seemed unbelievable that such a potent drug could be used sufficiently widely to cause these dramatic declines – causing no less than 99.9% of the Oriental white-backed vulture population to disappear in barely fifteen years!


Chris Bowden/RSPB

Oriental white-backed vultures suffered the sharpest declines with 99.9% already gone

Once the main cause was clearly identified, the task to remove the drug could start, along with the need to take some birds into captivity in time to secure the populations for future release. Various partners came forward to take up that challenge, led by BNHS and Bird Conservation Nepal, with strong support from UK's Royal Society for the Protection of Birds (RSPB). Undoubtedly the biggest breakthrough came in 2006, when the Indian Government (the Drug Controller General of India) took the bold step to ban veterinary diclofenac formulations, making their use illegal. This step was immediately followed in Nepal and Pakistan, and in 2010 in Bangladesh. The fact that at least one alternative drug, meloxicam, was safety-tested on vultures and other species, and found to be a safe alternative was a key element in the willingness of the governments to take this important step so quickly.

Nine thousand km of repeated road-transect and other vulture surveys across India, Nepal and Pakistan showed that the population declines had significantly slowed by 2011 (Chaudhry *et al.* 2012, Prakash *et al.* 2012), and heralded what we still hope will prove to be the turning point. There were even hints of the very first signs of localised recovery in some areas, although a further repeat of these surveys this year will tell us more on how well founded those hopes are. The key to the slowing of population declines is the effectiveness of bans of veterinary diclofenac imposed by the governments of these countries. But having already lost the vast majority of these species in just fifteen years, will this be enough?

The latest information shows that the levels of diclofenac being found in dead cattle have come down quite dramatically (70% reduction by 2010; Cuthbert *et al.* 2014). But although diclofenac use in cattle (the main food of these vultures) has almost certainly fallen further since then, the usage today is still sufficient to exterminate vulture populations (Green *et al.* 2006). These unacceptable levels are undoubtedly due to the illegal use of diclofenac formulations designed for humans. Although diclofenac is used extensively for humans, the dose of 2-3ml is all that is required for people, but larger 30ml vials have been marketed which make it all too convenient and cheap for illegal use in veterinary doses. BNHS and some Ministry officials have been seeking to ban these large 'multi-dose' vials for human use for several years, and in July 2015 this ban has happened in India, and is a further welcome breakthrough which should significantly improve the chances for the vultures.


Mandy West/RSPB

Soaring Long-billed vultures these birds have an important environmental cleaning role

A common human painkiller, diclofenac (a non-steroidal anti-inflammatory drug– NSAID) which had been switched into veterinary practice on a huge scale and produced very cheaply, turns out to be extremely toxic to all vultures that consume the carcasses of animals that have been treated shortly before their death!

Meloxicam is still the only comparable alternative known to be safe for vultures and the good news is that more manufacturers (now over 70 in India alone) are producing it. Fortunately, it is also out of patent, so any company can take up its manufacture. And a further positive is that the German company Boehringer Ingelheim, which originally developed meloxicam, has released their patent of the formulation for India to further encourage companies to produce it in an effective form.

Just when it seems that the future for vultures is looking a lot brighter, we have learnt of a growing serious worry: there are other drugs (NSAIDs) apart from meloxicam that are taking the place of diclofenac, and we know that some of these are also toxic to vultures. One is aceclofenac, which is a 'pro-drug' which is immediately metabolised into diclofenac in the cow, and so is clearly a threat. Others such as ketoprofen, and now we know, nimesulide are already known to be unsafe for vultures, and are picking up in veterinary pharmaceutical markets and practice. Trying to get all such drugs banned will be important, but instead, (and far preferable) there is a need for safety-testing on vultures of any such drugs, before they are introduced to the market. This option has already been agreed upon, together with protocols by the Indian Veterinary Research Institute, but this urgently needs funding and to be put in place before these other drugs gain popularity with the vets.

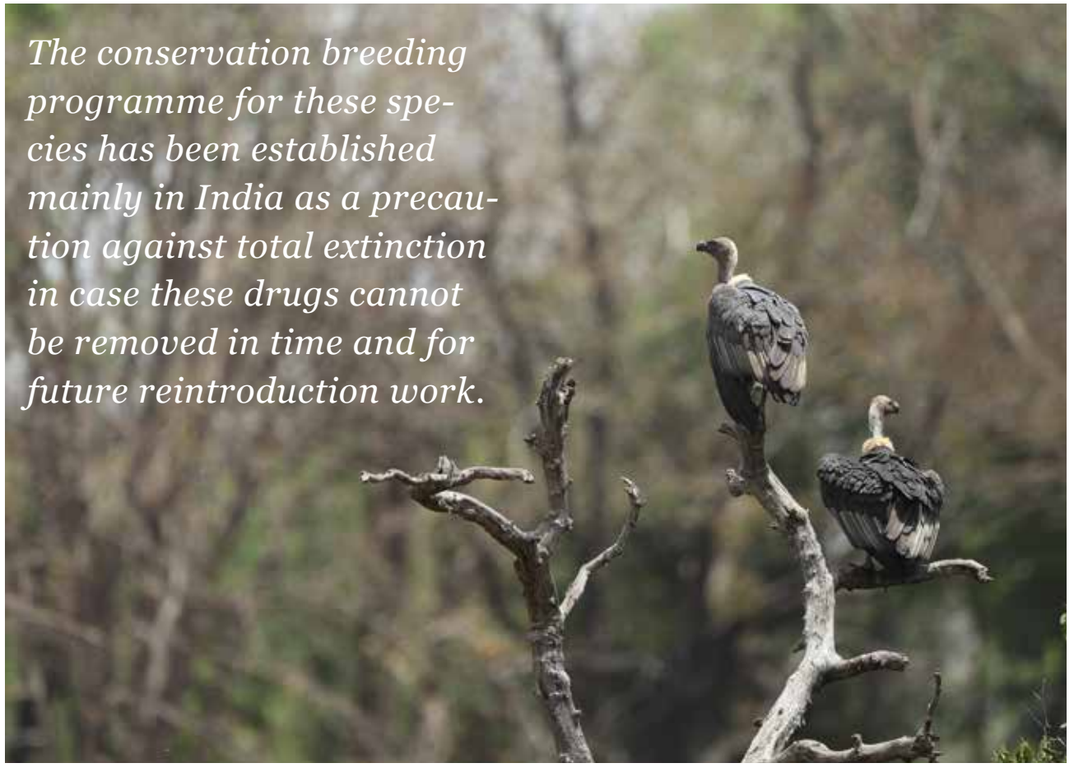
To ensure conservation measures are taken seriously on the ground, on a scale that can really save the vultures, the 'Vulture Safe Zone' (VSZ) programme has been developed, working in huge areas within a 100 km radius of important vulture breeding colonies, where intensive advocacy and awareness work is carried out by dedicated teams.

V Prakash/BNHS

Removing the first egg to an incubator induces the birds to lay again, and the chick can then be given back to the parents while removing the second egg for hand-rearing

To ensure conservation measures are taken seriously on the ground, on a scale that can really save the vultures, the 'Vulture Safe Zone' (VSZ) programme has been developed, working in huge areas within a 100 km radius of important vulture breeding colonies, where intensive advocacy and awareness work is carried out by dedicated teams. The VSZ approach was originally developed in Nepal and involves a range of advocacy and awareness measures, in collaboration with state Government officials, particularly with veterinarians and drug distributors etc. It is now being taken up more widely in South Asia, with programmes led by BNHS in four Indian states and other independent Indian initiatives replicating the approach more widely. Two new VSZ projects are underway, run by IUCN Bangladesh and the Bangladesh Forest Department and coordinated by the Bangladesh National Vulture Steering Committee. It is hoped that the VSZ work alongside the other national advocacy efforts will allow the first pilot releases of birds back to the wild to take place as early as 2016.

Meanwhile, the conservation breeding programme for these species has been established mainly in India as a precaution against total extinction in case these drugs cannot be removed in time and for future reintroduction work. This has been making major headway recently, with support from State Forest Departments particularly of Haryana, West Bengal, Assam and Madhya Pradesh. The total number of birds fledged at the first three Indian centres has already exceeded



Ramakrishnan Aiyaswamy

180 for all three Critically Endangered *Gyps* species combined since 2008, with a record 58 produced in 2015 alone. There was also the first successful fledging of a Oriental white-backed vulture *Gyps bengalensis in* Nepal in 2014—from the birds held at the Kasara centre, Chitwan. A number of other milestones have also been passed in India recently, including all three species being successfully reared by artificial incubation. There was another first in 2014 when four pairs had their first egg removed and artificially incubated to hatching, prompting them to then lay a second egg, which was in turn swapped with the chick from the incubator. This has been successfully replicated on a larger scale in 2015. The parents then successfully reared the first chick, whilst the second egg was artificially incubated and then successfully hand-reared. One further achievement in 2014 was that 'Phoenix', one of the first two *Gyps bengalensis* fledglings from Pinjore, Haryana from 2008, herself reared chicks for the first time.

Progress, so far, has been possible through the concerted efforts of several partners all in close liaison with the Governments. They came together under the umbrella and banner of 'Saving Asia's Vultures from Extinction' (SAVE), which was formalised in February 2011 and has now expanded to include fourteen full partners (a mix of national and international NGOs and Government institutions). The partners meet annually and review the necessary priorities They took an important further step by developing and updating the February 2014 'Blueprint for the Recovery of South Asia's Critically Endangered Gyps Vultures' (downloadable from www.savevultures.org) which maps out the actions to 2025 for Bangladesh, Cambodia, India, Nepal and Pakistan. SAVE updates the conservation priorities for these species annually and provides a transparent and widely respected identity for these scientifically backed actions to gain credibility and hopefully attract the resources required to conserve the three Critically Endangered Asian *Gyps* vultures.

Ramakrishnan Aiyaswamy

Red-headed vulture is also Critically Endangered and faces similar threats of NSAIDs including diclofenac

One new spectre has recently emerged more prominently for vultures in the region. This is the problem of people deliberately poisoning animal carcasses to target either large carnivores such as leopards, or probably more often feral dogs that have themselves increased in the absence of vultures (and thereby increasing the problems of dog bites, dog attacks and very significantly – rabies!), but unfortunately these poisoned carcasses often inadvertently kill remaining vultures.

Major efforts are urgently needed across South Asia to address the immediate and increasing gap in funding for vulture conservation, which is now jeopardising the whole programme. These efforts will need to include charitable and corporate support from industry from within the region, as surprisingly, the main resources so far have come from UK charity Royal Society for the Protection of Birds as well as other external sources that SAVE Partners have managed to engage. But even more crucially, only if the restrictions and this safety-testing regime for these lethal veterinary drugs are taken seriously by Governments in time to prevent replacement drugs becoming popular with veterinarians, can we save these majestic species – the environmental cleaners – from extinction.

For more information see: www.save-vultures.org

Chris Bowden is Globally Threatened Species Officer at Royal Society for the Protection of Birds & Saving Asia's Vultures from Extinction (SAVE) Programme Manager, chris.bowden@rspb.org.uk.

Megha Vishwanath

Reviving extinct species - future of science or fool's errand?

What do the passenger pigeon, the Spanish Ibex and the woolly mammoth have in common? Although officially extinct, they are all now challenging the meaning of the word because, in each case, scientists are working on bringing them back to life. The groups working on the projects are confident that mammoths will graze Siberia again and passenger pigeons will fly over the skies of New York. The genomes i.e. the full DNA code, of the mammoth and passenger pigeon have been sequenced, bringing both species a step closer to what is being labelled de-extinction. But with the project comes controversy. Not everyone in the science community sees de-extinction as a good idea. For some, the fact that technology has evolved to the point where cells can be cloned or engineered to bring back an extinct animal does not mean it should be done. Power should be demonstrated by restraint and not by crossing lines, they say. Others, while agreeing that de-extinction is about power, believe that it is acceptable. After all, humans are driving species to extinction by exerting dominance in very destructive ways. De-extinction is about using that power constructively.

One thing is clear: recent advances in biotechnology are making things possible that may have seemed inconceivable just a few years ago. While these advances may be inevitable, their consequences have to be considered. Conservationists and ecologists have debated a range of both practical as well as moral and ethical issues surrounding de-extinction. One of the key tools for de-extinction is cloning, using preserved DNA from an extinct animal. The process starts with isolating the nucleus of a viable cell from the extinct animal. This

nucleus is then placed into an egg from a closely related species, previously emptied of its own nucleus. The egg is then chemically or electrically stimulated in order for the cell to begin dividing. Once the division has happened, the egg is placed into the uterus of a surrogate mother. If the pregnancy is successful, the mother will give birth to a de-extinct animal. This poses numerous practical problems. Cloning requires the use of a surrogate mother to accommodate the foetus during pregnancy. Even though the surrogate mother would be from a genetically similar species, there could nevertheless be complications during pregnancy and afterwards.

In 2003, a group of scientists in Spain succeeded in cloning the Pyrenean ibex, also known as bucardo. The last bucardo, a female named Celia, disappeared in 2000. A sample of her cells had been stored in laboratories in Madrid and Zaragoza. Reproductive physiologists injected nuclei from those cells into goat cells emptied of their DNA and then implanted those into surrogate mothers. There were 57 implantations but only seven resulted in pregnancies. Of those, six ended in miscarriages. Only one mother, a hybrid of goat and ibex, carried a clone of Celia. The group performed a caesarean section on the mother and the first de-extinct Pyrenean ibex was born. But it died less than ten minutes later due to congenital lung problems.

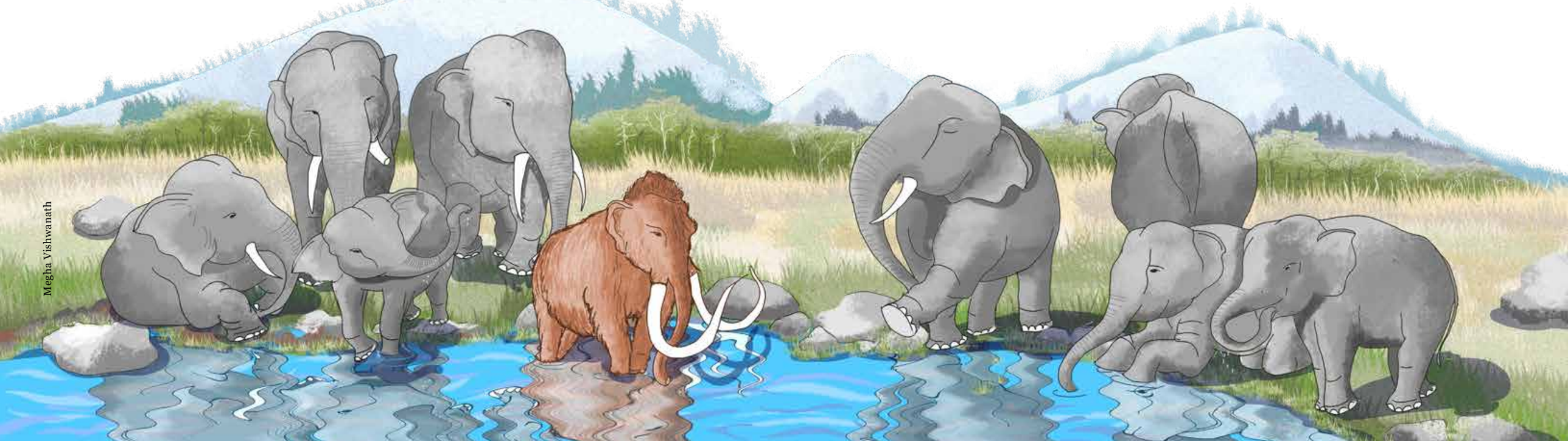
Further experimentation in this field means that many animals will share the fate of the bucardo, being born only to die within minutes, which raises the first ethical question. Animal rights activists would argue that the deaths and suffering of the animals are not justified. However, ecologists point out many more issues. Cloning a single animal does not equate to de-extinction. Entire populations have to be created and rehabilitated in the wild, which could be even more challenging than the biotechnology involved. For example, the Long Now Foundation in California is working at the laboratory level to bring back the passenger pigeon. However, there is the need to create a population of animals large enough to live in the wild. The passenger pigeon used to be very social, flying in flocks of millions of birds. Information from the 19th century confirms the flocks were so big they even darkened the skies. Ben Novak, lead researcher for the passenger pigeon project at the Long Now Foundation, believes 10,000 would be the minimum number to be reintroduced. Different questions arise: would it be possible to create so many animals through de-extinction? Or even, how would people react to a massive flock of birds flying over their heads covering the streets with droppings? Of course, this may only be answered if the passenger pigeon is ever brought back to life.

The effects of these de-extinct reintroductions on humans is difficult to quantify. Would they become attractions? Surely the return of the mammoth would bring curious visitors to Siberia, willing to behold the majesty of the animal. That these animals might become the centre of attention for tourists is significant, but that is both a risk and an opportunity. It might not differ much from current forms of wildlife and ecotourism and these animals might become flagships to save endangered habitats. But how would they adapt to these habitats? Stuart Pimm, Doris Duke Chair of Conservation Ecology at Duke University, expressed his concern on this issue in an article for National Geographic magazine. The habitats these animals used to live in surely have changed and the de-extinct species might not be able to adapt to them.

Some conservationists argue that bringing back extinct animals could lessen concern about threatened species. If we can bring them back once they are extinct, there is no perhaps a less pressing need to take care of them when they are alive. Cost is another argument against de-extinction for many scientists. Funding is a major constraint in conservation programmes, and de-extinction diverts money that could be used for these conservation programmes. But others say that all the funding of de-extinction laboratories comes strictly from private funds. As long as the project stays within the laboratory walls, there is no direct competition with conservation. The arguments against de-extinction also argue that these de-extinct animals could become invasive species in a habitat different from the one they used to live in. The species may also become vectors for illnesses that could be transmitted to other animals or humans. The pathogens in the environment are constantly changing and an animal whose genotype is based on a species that lived years ago may not be prepared to survive to modern diseases.

On the other hand, engineering animals could bring solutions to other endangered animals that need genetic diversity. In the case of the passenger pigeon and the mammoth, it could also restore ecosystems that were modified by these animals. Since de-extinction has not been attempted, the risks are hard to quantify. However, closely one examines similar scenarios, it is still a roll of the dice. The Long Now Foundation is optimistic and thinks the first passenger pigeon will be born in 2022. Then the meaning of the word ‘extinct’ really would be changed forever.

Alba Charles, a graduate from Cardiff University, is a freelance environmental journalist, albamcharles@gmail.com.



Megha Vishwanath

Integrating science into conservation decision-making:

an interview with Jim Nichols

Smitha Shivaswamy

James D Nichols has been a wildlife biologist with the US Geological Survey for more than 40 years and a long-time collaborator on conservation research projects in India.

At the Student Conference on Conservation Science, Bengaluru (SCCS-Bengaluru)-2015, Dr Nichols spoke about ways to integrate science into conservation decision-making, drawing upon his own experiences working with wildlife managers in North America.

Hari Sridhar spoke to Dr Nichols after the talk, to find out more about his work.

HS: In your talk at SCCS-Bengaluru, you said that the way in which scientists usually engage with park managers and conservation decision-makers is inefficient. Why do you think so?

JN: I guess the first thing I should say is that inefficiency is not a horrible crime. It is just that, in the conservation world today, our dollars and efforts are so limited. If we can do better within our limited means, why not do so?

I think the inefficiency comes via a lack of communication and a lack of a central programme within which everyone works. What often happens - or at least what I have seen in my world - is a group of scientists interested in a particular system will get money for studying that particular system, claiming that what they learn will be useful to conservation folks. They will then go out and perform the study, learn something and then give that information to the manager or conservation guy who is actually on the ground doing things. I don't claim that what is learnt is never useful, but very frequently it doesn't hit the mark. In other words, what scientists learn is not exactly what the decision maker needs to make a conservation decision. And that's where the inefficiency is. So then you basically have two groups who are angry at each other – the scientist says, 'oh this guy is not paying attention to my work', or 'he is not reading the right journal' or something, and the conservationist guy says 'well, the scientist is pursuing his own interests rather than thinking exactly about what I need to help me make my decision'. It is in this sense that I view what we do today as inefficient.

HS: Do you think part of the problem is that the scientist and decision-maker don't work together right from the beginning?

JN: Yes, one way that ought to hold promise for getting rid of this problem is having

scientists and conservation folks working together from the beginning, and treating science basically as a useful piece of a much larger conservation programme. That way the science itself ends up being directed at things that are most useful to the conservation decision maker. What might these be? Mainly, trying to predict the effects of the usually pitifully small number of actions we can take on the system that we are working on. Once the scientists recognise exactly what the decision maker needs, you are ensuring that the kinds of hypotheses tested are directly relevant to the decision process.

HS: In your talk you called this process 'Adaptive resource management'. Is this something that has been around for a while in a formal way?

JN: Okay, that's an interesting story. The fundamental idea of adaptive management is trying to manage in the face of uncertainty. As a conservation guy, if you knew exactly what to do you don't really need this. But we are involved in so many situations where there is a lot of uncertainty. In such situations there are two approaches one can take - the old approach would be to have scientists go out and study the problem for a long, long time – 5-10 years – and then provide results that hopefully reduce the uncertainty associated with the management problem - uncertainty associated with how actions translate into responses. The claim of adaptive management is that that's foolish for a couple of reasons – first is time - bad things continue to happen when the scientist is off trying to learn stuff. The other problem is when the scientist comes back at the end of 10 years or so, almost invariably there is all kinds of uncertainty still left -you never just solve everything completely. And so a guy named Buzz Holling ended up saying 'why don't we go ahead and begin management right away – let's not delay, but what we will do is try to embed science within the management process so we learn while we are doing'. So, it's a 'learning by doing' kind of an idea.

HS: Can you give us an example?

JN: The United States Fish and Wildlife Service (USFWS) has, for a long time, been responsible for hunting regulations for ducks in my country. In 1995, there was a political play on this whereby a state got hunting regulations tilted in its favour. They had gone around a process which had been in place for a good 30 years. When this happened, virtually one congressman from every state that had not benefited from this play wrote to the Secretary of Interior saying 'boy, you really messed up'. People were really, really mad and brought all kinds of political pressure to bear.

I'll back up a tiny bit here - there was a visionary guy named Fred Johnson who, in the early 1990s, realised that for this kind of duck harvest management, adaptive management will be a really smart thing to do. So he formed a working group, of which I and a small number of others were part. From 1991-95 we developed an adaptive management framework for duck hunting, basically saying that if ever the situation came up, this is how we would go about attacking the problem. So when this problem happened in 1995, we went before the USFWS director and made our case. At that time the director was looking for any process that she could claim was transparent and defensible. And so it was just the perfect time for us to march in and present our adaptive management plan, and she readily agreed. For the next six months, folks, where I work, had to drop everything else to take this forward. All the modelling and optimisation stuff that had to be put in place was a huge effort -we called it our 'Manhattan project'. Anyway, we (led by Johnson) got the thing together and since 1995 this adaptive harvest management has been implemented for our biggest population of hunted ducks - mid-continental mallards (*Anas platyrhynchos*). It has been a success story in the sense that it has reduced the contentiousness that accompanied the establishment of hunting regulations each year. It has reduced the uncertainty - to begin with we had four competing models - four different scenarios of how hunting regulations might affect populations – and now we have ended up having a pretty high degree of confidence in one model, a little confidence in another, while the other two are not good predictors at all. And so this adaptive management tenet, of learning while you are doing, has absolutely happened - we can show you how our formal degrees of confidence in different models have changed over time. The idea is that you don't just learn, but while you are learning you use what you have learnt. Our idea of what is the optimal/smartest thing to do has changed – we are giving the two best models more and more influence - not in a folksy way but in mathematical way - in the optimisation process. We are not only learning by doing but we are using what we have learnt at each time step.

HS: This process requires the scientist and manager to work together, to collaborate right from the beginning. Does that mean that the managers need to have an appreciation and an understanding of the numbers that go into it?

JN: I think it is important. However, there are degrees. I don't think it is important necessarily that the manager know all the details of how we build our models, how we estimate things like survival rates, and certainly how we do the optimization - that stuff gets fairly ugly. But I do think it is important that the managers have at least a folksy understanding of how the process works. It is very important for those of us who do the more detailed mathematical stuff try to explain what we are doing to the managers, to the degree possible. A lot of interaction is needed.

My vision for the future, for conservation biology, is that this [adaptive management] will be something much more common place, that it will be the norm, but it's nowhere close to that right now, either in the US or anywhere else in the world.

HS: Is communicating the uncertainty and likelihood of error in science particularly difficult, especially since people usually think of science as 'truth' and 'fact'?

JN: Yes it is. Getting the ideas of uncertainty across, in terms of how we quantify it, how we can make statements about it, and I guess most importantly how we deal with it when we have to make decisions is difficult. But it shouldn't be difficult - I mean think about your most important decisions – choosing somebody to marry, how many children to have, where to send your kids to school - every decision we make is characterised by uncertainty. Yet we find a way, through intuition most of the time, to make the 'right' decisions. All we are doing differently here is using a mathematical formalism in the place of intuition, not because formal is necessarily good, but because very often the optimal solutions are different from what we might have thought of intuitively. My intuition doesn't work as well as I would like it to. The other reason to use formalism is transparency – we can show people exactly how we arrived at a decision step-by-step. Anyway, communicating the uncertainty is a big deal for sure.

HS: Especially because managers are likely to be making most others decisions based entirely on their intuition?

JN: Sure, and I get that and maybe that is good a lot of the time. What's most interesting is that the managers who are most interested in listening to our ideas are often the ones in the most contentious situations. Now if you are a manager and nobody is complaining to you about the decisions you are making, why bother with this tedious process? But the folks we see who are most interested in this stuff are like the USFWS in the duck case. THE USFWS was getting it from both sides - people suing them, taking them to court for allowing hunting and others being angry because they couldn't shoot enough. Endangered species folks are very interested in this approach. Why? Because they are constantly getting thrown into court and need to defend the decisions they have taken in a detailed step-by-step fashion.

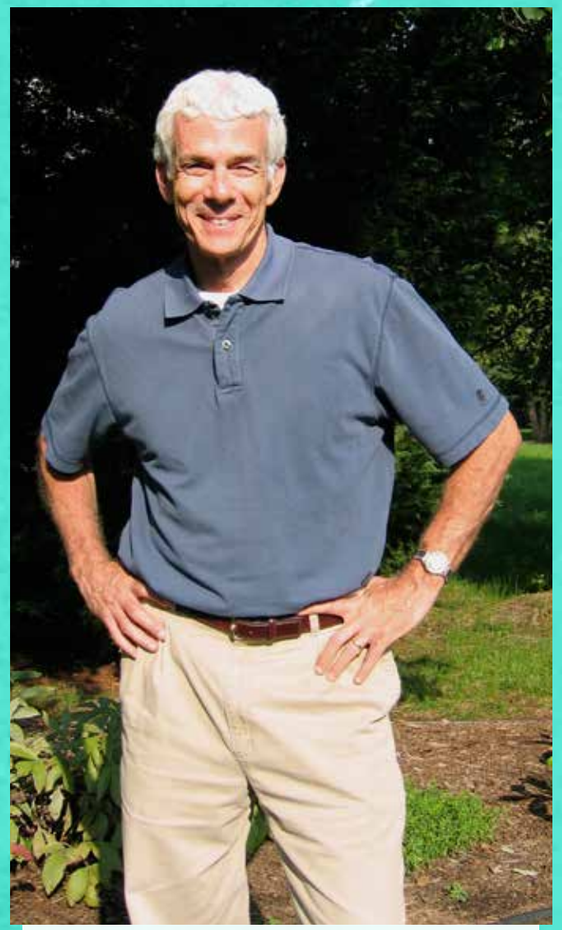
HS: You speak about court cases. At least in working with the manager you might have the luxury of time, you can sit with him or her for a few days/weeks and explain all this stuff. When you have to make a case using numbers in a short period of time in front of a judge, is that a lot more difficult, to get them to appreciate the nuances of numerical arguments?

JN: It's difficult for sure. The only court case I was in happened before we adopted this adaptive management sort of approach. It had to do with setting of hunting regulations for one species of duck. The law stated that the regulations had to be set in a manner that was not 'arbitrary and capricious'. So all we had to do was bring in all the computer print outs and convince the judge that we were trying really hard to figure out how this population was doing and what regulations made most sense. That basically won the day

Adaptive management is designed for situations where there is uncertainty. It is also setup as a recurrent management decision process. In other words, if you are making a one-time decision, and you are never ever going to revisit that decision, and you are not going to make similar decisions in similar situations elsewhere, then there is no need for adaptive management, because there is no need for learning.

in that case. But I would approach it differently if I find myself in court again in the future – I would actually try to lay out the details of how we come up with a particular decision.

Your question brings to mind a famous murder case in our country – the OJ Simpson case. In that case, one very important consideration was how likely it was that the blood at the crime site - which was a very close match to OJ Simpson's – how likely was it that it came from someone else. The probability turned out to be very very small. Unfortunately, the guy who came up with the probability made a mistake initially and then revised it. Now, the mistake was ridiculously small – the number was different only after



10 decimal places so it did not change the inference in any way. But yet it allowed the defence to say 'hey wait, this guy messed up. He gives us one number one day and another number the next day. Why should we to listen to him?" Just an illustration of the danger and difficulty of presenting and defending numbers in a court case.

HS: Do you think this process of adaptive management you describe is suitable for certain kinds of systems more than others – e.g. simpler ecological systems where one or two factors are dominant; systems where management interventions are simpler? Or do you think it is useful no matter what the complexity? What if your interest was in a community of organisms and if there were multiple problems that interact?

JN: I think there are two situations where it is not useful. If you really have certainty - if you know, for example, that villagers inside a protected area are 100% the reason for the problem with tiger prey numbers and you know that you can somehow find them a better livelihood outside the protected area, then your problem is solved - there is no need for adaptive management. Adaptive management is designed for situations where there is uncertainty. It is also setup as a recurrent management decision process. In other words, if you are making a one-time decision, and you are never ever going to revisit that decision, and you are not going to make similar decisions in similar situations elsewhere, then there is no need for adaptive management, because there is no need for learning. But given there is uncertainty and a need for recurrent decisions it is useful no matter what the complexity of the situation. It is useful but more difficult.

Some people use that to say that's way too complicated and that we can't possibly go through all these steps and get agreement. But my claim there is that there is no alternative. What's the alternative? I guess you just do whatever you feel like and hope it works, but there is no alternative that I would know how to defend.

HS: You spoke about how environmental variation can influence all of this and therefore needs to be incorporated. But what about externalities that influence the management decision itself, e.g. factors outside a park that influence a manager's decision? Is this process insulated from all of that and are you working with the assumption that the manager has full control over decision making and implementation? Or are you

moving to a process that also incorporates externalities - political pressures, changing societal values etc.?

JN: Okay, I guess there are two things I want to say in response. So far we have been lucky that the USFWS, has always accepted and implemented what we come up with every year. But the USFWS director has the power to override what we recommend and say 'you know, I am going to try something different this year'. I don't think anybody would ever do it because they would have to defend it, and it would not be possible to defend it. Basically you have to answer the question - 'why is it that you are doing something other than what's been shown to be the smartest thing you can do given your objectives'. That's a hard thing to answer. But you are right, in many cases the ultimate decision maker could override you. So the first thing we made sure is that the main decision maker is at the table when you are going through all this stuff. You don't just do it in a vacuum and say – 'hey, I came up with a smart way to make decisions for you guys'. So you need to have them in from the very beginning and they should formally accept your process, although they always have the power to override. The second point I want to make is about other externalities – if it turns out, as you say, that political support or societal values are changing. We try very hard to ensure that all relevant stakeholders, all people who even think they are stakeholders or should be stakeholders are included in the first part of this setup phase when we are coming up with the objectives. The 'kiss of death' for one of these projects would be to have one group that thinks it should be part of this process but is not included. Then, even if you come up with suggestions that are consistent with that group's point, they might not support you because they are mad at not being included. So, it is crucial that politicians, members of civil society, different groups – conservation groups, hunter groups, etc. - whoever thinks they have something to say about this, is brought to the table when the objectives are being discussed.

HS: In terms of the kinds of interventions possible – is this process more useful in the case of interventions that have a very direct bearing on the problem e.g. allowing or not allowing hunting of a species, as against interventions that might only have an indirect impact, e.g. controlling tourists in an area that houses an important species?

JN: Yes, it is easier to think of it in the former, but I almost think that adaptive management may even be more important in the latter, because there is probably greater uncertainty. For example, I am involved in a re-introduction programme for this duck species called Steller's eider (*Polysticta stelleri*) in the Yukon-Kuskokwim delta in Alaska. And there one of the things we talk about is public education. We debate about the importance an education programme that might help reduce hunting by local indigenous people. That's a potential action in which there is a great deal of uncertainty about whether or not it will be useful to the project. But I think the less certain we are about its influence the more important it is to use a process like this to help you learn how relevant the action might be.

HS: Is this process used widely now?

JN: No, not at all. I am not even sure of a number. I am involved in I guess five different formal programmes right now. As I said earlier, the difficulty is you can't just convince people by giving a talk or making a presentation. There's a long way between that and getting it done. In each one of the five programmes I am involved in I have had to spend a lot of time and effort and basically be a part of that programme for a number of years. Obviously, I am not the only guy -

*I am involved in a re-introduction programme for this duck species called Steller's eider (*Polysticta stelleri*) in the Yukon-Kuskokwim delta in Alaska. And there one of the things we talk about is public education. We debate about the importance an education programme that might help reduce hunting by local indigenous people. That's a potential action in which there is a great deal of uncertainty about whether or not it will be useful to the project.*

I have got a small number of colleagues who have done exactly the same thing. But what that has resulted in is a relatively small number of places where this form of programme has been carried out. In the duck world for example, it has been extended now to a number of different species and populations. My vision for the future, for conservation biology, is that this will be something much more common place, that it will be the norm, but it's nowhere close to that right now, either in the US or anywhere else in the world. That vision maybe way further off than I would like it to be. But I think the more case studies we present that show that this thing works – that it is transparent and gives defensible results - my hope is, the more widely it would be adopted.

HS: What about in work you have been associated with in India – e.g., do you think this process might be useful in managing the tiger population in Nagarhole? Has it been tried?

JN: We have talked about that. My last visit here, about a year ago, was for that purpose exactly. First we went to Thailand and then we came here and in both places we were talking about the potential for using decision processes for tiger management. Our duck work started out with that working group and after 3-4 years we were finally able to implement something. My hope would be that, now that the seeds that have been planted for a similar programme for tigers, we will see something in the near future, at least an example programme from India. Just three days before this conference we had a meeting on writing a second edition of this book on monitoring tigers. We decided that in the new edition there is going to be a much greater emphasis on embedding monitoring within a larger management framework. So yes, I would like to think that things are rolling in that direction. Has it happened yet? No.

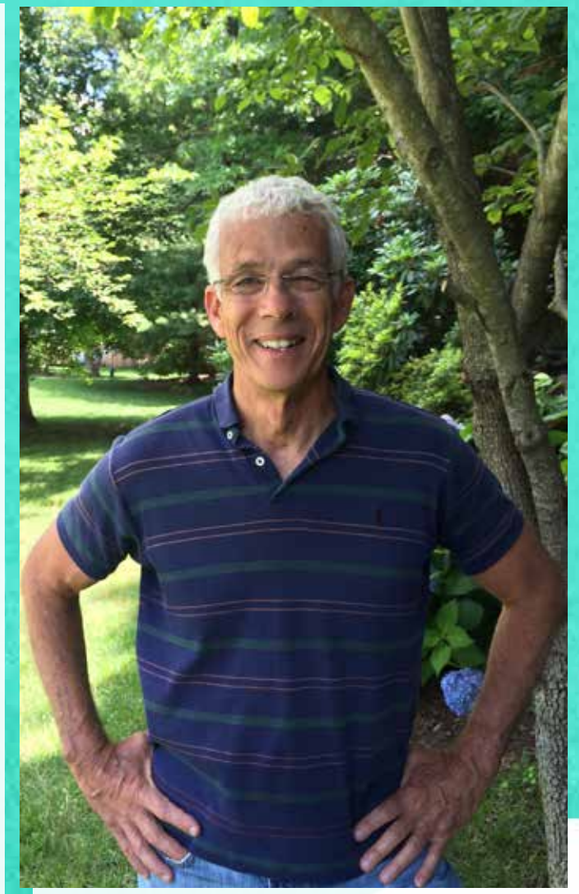
HS: The dynamic between manager and scientist – seems crucial for this process to work. Does the fact that you work for a government agency make for an easier, more equal, working relationship with managers, as compared to, for example, if you were from a university?

JN: I don't know. I would like to think that a university person could do it. We have this umbrella agency called the Department of the Interior and the USFWS is part of that Dept. I happen to work for the US Geological Survey- it seems strange but they do have a

biology group. The idea is that all the science folks work in this Geological Survey and the folks concerned with on- ground management are in places like USFWS or the National Park Service. So even in my case we do have this separation - yes, I work for a government agency but I am identified as a science guy. And a lot of the time I think the successes that we have had have been in spite of, rather than because of, our organisational structure. In other words, because we think it is very very important to interact with managers we have made the effort to do so even though the way in which we are organised is somewhat antithetical to that. If I was developing big organisations I wouldn't separate managers and scientists organisationally. So even though I am in the government, there is still this big distinction made – maybe not quite as much as between university and managers. Even the mechanics of promotion are different – we are evaluated on scientific stuff, managers are evaluated for different things.

HS: You mentioned earlier in the conversation and in your talk that while science can aid conservation decision-making, the choices we make and the values underlying them need to come from society. Therefore, do you also feel that scientists should have limited, clearly-defined roles – restricted to their research - in conservation?

JN: That's a good question. I hadn't thought about it exactly that way so my top of the head thought is this: the role of the scientist is very clear in the process I laid out. In coming up with objectives scientists should have no more say than anybody else in the public. They do have a place at the table, but it absolutely is not any more important than



that of anybody else. Like I said earlier, you want to make sure that all the stakeholders are there and the scientist is just one stakeholder at best. Now with regard to the second step - coming up with management alternatives – there scientists have a somewhat bigger role, but again, the manager is most important here, because he or she knows what's feasible much better than a scientist. The steps where the scientist has the most important role is in the development of models, development and implementation of the monitoring programme and the implementation of the decision analysis. That's interesting - the way I see adaptive management it seems like there are very clear roles for people.

I'll also add that I see a very important role for social science within conservation science. In the process I envision, social science is extremely important in setting objectives. In the cases I have been involved in - I was never trained in that social science stuff – but yet I was sitting there in the front of the room trying to get people who hate each other – or rather hate each other's ideas - to come up with a compromise set of objectives. I am guessing a social scientist or somebody who is trained to do that will probably have done that a lot more effectively than I was able to. So there is a role for social scientists in this, not necessarily in the development of models or monitoring, but there is a clear role.

HS: But you often find scientists going beyond their science and becoming advocates for particular causes. Often, they weigh in on conservation issues that they might not have researched themselves. Do you think that part of the problem is a mixing of personal values and professional responsibilities, i.e. that many scientists in conservation get into the field because of their interest in protecting wild species and places?

JN: I have no problem in a scientist expressing to people what his or her values are – that doesn't bother me at all. Any stake holder should be able to do that. But that my values should be privileged over yours because I am a science guy and I know more than you – that I disagree with. The reason why I value a species might be because it plays an important ecological role. Someone might value it because he or she like's going to bed somehow knowing that it's out and would feel poorer if it wasn't. Other people might have other - economic - priorities in mind. So there is no reason why scientists' opinions should be taken any more importantly than anyone else's, with respect to objectives.

Hari Sridhar is a postdoctoral fellow at Indian Institute of Science, Bangalore, harisridhar1982@gmail.com.

column Matt Creasey

Ananya Singh

Appetite for travel

It is January, and deep in the Mexican tropics, a change is coming. Shifting, swirling forces in the upper stratosphere bring another flowering season to an end, and with it a signal to one extraordinary little bird to begin one of the greatest journeys in the natural world. Almost 4000 miles, the Sonoran desert and both the Rocky and Sierra Nevada mountain ranges separate this tiny traveller from its destination, but this trip must be completed twice a year if it is to breed. A little over 9 cm long and weighing just three and a half grams, the rufous hummingbird (*Selasphorus rufus*) is about to embark on the longest migration, relative to its size, of any bird in the world.

There are five aspects that make this such an astonishing undertaking. The first is simply the distance - 4000 miles one way, an 8000 mile round trip. That is a distance more than twice the length of India. To drive that distance averaging 60 mph would take more than five days. Even to travel by jumbo jet would require a ten hour flight*1! For the hummingbird this amounts to 78,470,000 body lengths. For a human to cover an equivalent distance, would mean walking around the circumference of the earth more than 3 times.

This is all amazing enough, but it is made all the more so if we consider the 2nd astonishing fact - the energy required to live life as a hummingbird. When hovering it must beat its wings 52-62 times per second, and at this time have the highest metabolic rate of any vertebrate. This means that they are never more than 20 minutes from starvation. Truly a life on the brink. To cope with such extreme energetic demands, they possess a number of physiological and behavioural adaptations. They have big hearts for their size and their blood contains a high number of red blood cells. These traits enable them to transport enough oxygen round the body as efficiently as possible. Other adaptations help them conserve energy. Fat, which yields more energy compared to carbohydrates, is burned during migration. Fat is also burned while resting, but when feeding the birds switch to burning carbohydrates. This keeps fat stores in reserve and avoids the need to use energy producing the fatty acids which are needed to metabolise fat. What is more - something I'm sure we can all relate to - these birds do everything possible to avoid cold toes. When they are feeding, , how far they hold their feet from their body varies with the ambient temperature. When it is particularly nippy, they keep them tucked up in their abdominal plumage, but when it is warmer, they dangle their toes in the cooling breeze. Finally, they maximise energy intake by being very fussy eaters, preferentially visiting flowers from which the nectar flows quickly, or in which sugar composition is particularly high.

Ross Hawkins

Even with these adaptations, the locations this bird chooses to breed in are extraordinary. Their breeding range spans from the northern tip of California, through the mountains of British Columbia - where the altitude of nests can vary from sea level to 1,830m - right up Alaska, the most northerly latitude reached by any hummingbird.

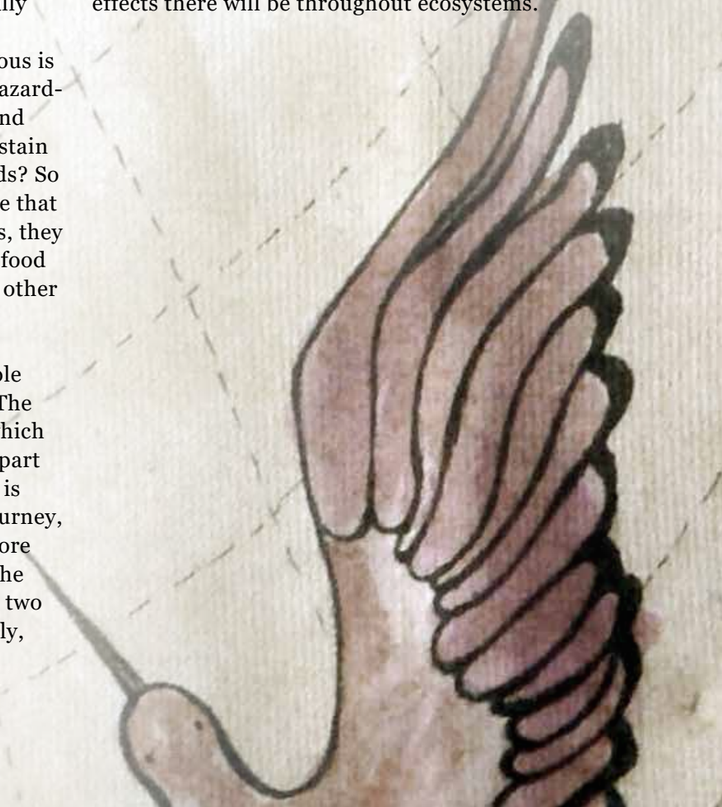
And if they weren't already burning enough energy, one additional trait exacerbates this even further. They have larger than average brains, and possess a range of cognitive abilities which exceed those expected for a bird of this size. This is intriguing, because brains take a lot of fuelling, and storing information for any period of time requires significant energetic effort. Consequently, how species choose to allocate their energy resources, particularly when they must be so carefully guarded as with the hummingbirds, gives us a hint to the most important factors influencing hummingbird survival. If their particular cognitive abilities didn't confer a real advantage, they would quickly lose them.

This unexpected braininess has made rufous hummingbirds the subject of much research investigating both their cognitive and physiological abilities. This research has uncovered a lot about these birds, and has revealed a web of relationships between the hummingbirds and other species which span a continent. We now know for example, that the birds are able to remember when they last visited a particular flower, avoiding ones they know will be empty and returning to those which have had time to re-fill with nectar, thus maximising their foraging efficiency. This memory does not only retain information for short periods of time - individual hummingbirds return to the same breeding and wintering sites year after year, follow similar routes while on migration, and even appear to visit sites where good food sources have been found in previous seasons. This suggests impressive navigation and a spatial memory which is maintained between years.

These discoveries reveal a lot about what really matters to these little birds, but also pose a number of questions. Perhaps the most obvious is why do they undertake such an apparently hazardous journey at all? Surely between Mexico and Alaska there is enough suitable habitat to sustain the whole population of rufous hummingbirds? So why continue north? The answer seems to be that by reaching such isolated and difficult climes, they ensure that they have exclusive rights to the food supplies on offer, avoiding competition with other nectar feeding species.

The next question is how? What factors enable them to be successful in their undertaking? The physiological and behavioural adaptations which enable them to survive so far north are only part of the answer. After all, the final destination is only a small part of the whole astonishing journey, across a hugely varied landscape. To get a more complete understanding, we must consider the interactions between the hummingbirds and two other, apparently unconnected species. Firstly, along the length of the migration route, humans put out feeders containing sugar rich water to attract the beautiful birds. This provides an important opportunity for the tiny travellers to top up waning energy reserves, enabling them to survive the journey. The second interaction occurs as the birds reach the northern limits of their journey. Here, resident red-naped sapsuckers (*Sphyrapicus nuchalis*), small woodpeckers found across the upper states, move between willow and alder trees, using their strong bills to remove circles of bark, and allowing the sugar rich sap to trickle out. Hummingbirds arriving on the breeding grounds early have learnt that by following the sap-suckers, they can take advantage of this free meal when most plants are yet to begin flowering.

The delicacy of the balance which enables rufous hummingbirds to live is hard to imagine, and harder to predict. Scientists have revealed a great deal about this astonishing little bird, and the complex and intricate web of relationships which cross national and species boundaries and comprise the different 'compartments' of their lives. Yet it is still all but impossible to predict what effect small changes at a local level will have for a given species, or even more so, what cascading effects there will be throughout ecosystems.



We can never truly know someone until we understand the elements which comprise their complicated, messy, fascinating lives. In the same way, we can never truly understand the important elements of any organism's existence until we recognise the multidimensional nature of it. Nor can we easily predict how far reaching changes to one small part will be...

Take a moment to think about the species you see every day in your own garden, or that you passed on your journey to work or school this morning. How many of them were migratory? For those that were, what sort of lives, and what world do they experience during the times when they are away in other parts of the world? We get but a snapshot of the whole picture when we see any animal in a single setting, a single window into a life of many rooms and hidden passageways. In some ways perhaps, this is akin to imagining the people our parents were before we were born. What were their childhood dreams and aspirations? Did they come true, or fall by the wayside? What of our boss or teacher, what are they like when at home eating dinner with their family? We can never truly know someone until we understand the elements which comprise their complicated, messy, fascinating lives. In the same way, we can never truly understand the important elements of any organism's existence until we recognise the multidimensional nature of it. Nor can we easily predict how far reaching changes to one small part will be... if your mother had argued with her parents that afternoon, if she had never attended that dance, then perhaps she may never have met your father, and you would not be here to read this now...

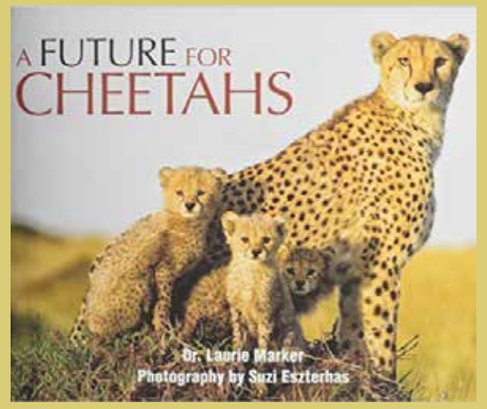
At present, the hummingbirds are listed by the International Union for Conservation of Nature (IUCN) as 'of least conservation concern'. However, numbers are decreasing, and the reasons for this are still unclear. Evidence from one study in Alaska has shown this species to be affected by timber harvesting, being completely lost from the study site after felling had occurred. Who would guess that felling a small stand of trees in Alaska could mean that the bird feeders at a house in Mexico remained unvisited? And what of the role that hummingbirds play as pollinators? The birds have been shown to be of critical importance in certain ecosystems, as their warm blood enables them to be active during the cold months of early spring when invertebrate pollinators are yet to emerge, thus ensuring the pollination and seed-set of early flowering plants which are important food sources for a variety of species. If hummingbird feeders are no longer put out in California, will this affect the body condition of bears in British Columbia? Think about this carefully and I am sure you will see how the answer could be yes.

We take the species we see, particularly the common ones for granted. But they live complicated lives, and we should not underestimate the far reaching effects that environmental damage at a local scale may have. Equally, we should never underestimate the power and influence we can have ourselves. Small gestures for conservation can have significant effects, and we are all part of the great web of life.

*1 By a 747 jet flying at 400 miles an hour

Matt Creasey is a PhD Researcher at Centre for Ecology and Conservation, University of Exeter, UK, mjsc201@exeter.ac.uk.

Running out of time?



CHEETAHS EVOLVED SOME FIVE MILLION YEARS AGO--BUT ARE THEIR DAYS NUMBERED?

"Everyone who comes to Africa on a safari wants to see a cheetah."

For those who are visiting savannah regions, this is undeniably true. Compared to the likelihood of seeing one of the rarer felines, such as a caracal or a genet, chances are fairly decent that the average tourist will encounter a cheetah at some point during his or her trip. The cats will probably be quietly lounging in the sun, resting or digesting, though some lucky visitors may be treated to glimpses of a hunt, or of a mother taking care of her young.

However, as Dr Laurie Marker writes in her book *A Future for Cheetahs*, cheetah populations are struggling, and humans—tourists and residents both—are one of the major reasons why. Dr Marker, founder and executive director of the Cheetah Conservation Fund (CCF), has over three decades of experience working with cheetahs, and injects her book with her considerable biological, sociological, and management knowledge.

A Future for Cheetahs starts with an introduction to the biology of cheetahs, then moves on to a survey of contemporary cheetah research. The remainder of the book analyses cheetah-human conflicts, in situ conservation efforts, and the use of sanctuaries and other captive environments, all with the aim of predicting the cats' future.

The scope of *A Future for Cheetahs* is impressive; even cheetah aficionados are likely to learn something new. Although there is more breadth than depth, the many gorgeous photos are an excellent accompaniment to the text, providing additional insights about cheetahs, their habitats, and their encounters with humans. In fact, the beautiful images are probably the best part of the book, stealing a bit of thunder from writing that is not always as clear, elegant, or even grammatically correct as you might like—especially given that the book costs a not insignificant $45 (a portion of which goes to the CCF).

Those who have glanced at the fairly sizeable list of cheetah conservation partners on page 208 might be surprised that the CCF consistently takes center stage, with the photos and text both suggesting that Dr Laurie Marker is the hero of the story. Although this may very well be true, and while the important work of the Cheetah Conservation Fund should by no means be overlooked, the somewhat self-congratulatory phrasing does become a little tedious.

That said, *A Future for Cheetahs* is to be commended for showcasing all of the hard work that is involved in wildlife conservation—the blend of veterinary science, ecosystem management, political maneuvering, captive breeding, campaigning, and more. Detail-oriented readers will also be pleased with the appendix, which provides extra data associated with cheetah biology, scientific methodologies, and conservation plans.

The book ends with an honest assessment of the cheetah's future: Marker writes that "at the current pace, the cheetah is not going to live into too many more generations." However, as she points out earlier in the book, this is a remarkable species that has successfully recovered from two previous population declines. Conservationists have at their disposal an impressive array of tools that can be deployed to save these magnificent cats. One such tool is the power to educate the public through outreach, and another is to raise money for vital conservation initiatives. *A Future for Cheetahs* is certainly an admirable bid to achieve both of these important goals.

A Future for Cheetahs
Dr Laurie Marker; With photographs by Suzi Eszterhas

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Caitlin Kight is an editor, writer and educator affiliated with the University of Exeter's Penryn Campus, caitlin.r.kight@gmail.com, http://www.caitlinkight.com.

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