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PRACTITIONER'S PERSPECTIVE

Scientists' responsibilities towards evidence-based conservation in a Small Island Developing State

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Introduction

Much has been written about bridging the implementation gap, also known as the 'great divide' or the 'knowledge–action boundary' (e.g. Gibbons *et al.* 2008; Arlettaz *et al.* 2010; Cook *et al.* 2013). Most of these authors make valid and needed points concerning the application of science to conservation management, including the proposal of conceptual frameworks or changes to the structure of the research system. Recommended measures range from collaborative exercises for identifying important research questions, which, when addressed, will provide the evidence base for effective conservation policies (Rudd 2011; Braunisch *et al.* 2012), to creating an institutional platform to engage individuals from across the knowledge–action boundary (Cook *et al.* 2013). While such recommendations for higher-level structural changes are desirable, they are rarely in sync with the constraints of conservation scientists (e.g. Soulé 1985; Balmford *et al.* 2003), which call for rapidly achievable outcomes with limited resources. As a consequence, the recommendations of many well-intentioned researchers end with publication (Fazey, Fischer & Lindenmayer 2005), despite the fact that publication alone is usually ineffective in triggering management changes (Pullin & Knight 2005). Here, largely following the model proposed by Gibbons *et al.* (2008), we show, using a successful case study from the Seychelles, how researchers and practitioners have worked together to change strategy and policy for conservation of an endangered species based on scientific evidence. Further, the example expands on the responsibility of researchers by demonstrating immediate actions that can be taken by scientists to improve uptake of their research results. Such steps can be highly effective, and practical guidelines can be drawn from this example by other researchers hoping to more effectively bridge the gap between their research and management.

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Island biodiversity and conservation

Small Island Developing States (SIDS) hold a disproportionately large amount of the world's threatened biodiversity relative to their size (Kier *et al.* 2009). To maintain and protect this biodiversity, governments of SIDS must prioritize conservation and carefully balance the interest of protecting the environment with economic development, population growth and the sustainable use of environmental resources (Teelucksingh, Nunes & Perrings 2013). To effectively protect and manage threatened biodiversity and assess the ability to achieve conservation outcomes, evidence-based practices are required (Sutherland *et al.* 2004). Many SIDS, however, have limited resources and capacity to provide the evidence on which conservation decisions should be based. This is the case in the Seychelles, part of the Madagascar and Indian Ocean Islands biodiversity hotspot (Conservation International, http://www.cepf.net/resources/hotspots/Pages/default.aspx, accessed 16 September 2014), an IUCN Centre of Plant Diversity and a WWF Global 200 Eco-region, where the skills and capacity available in a small total human population size of *c.* 90 000 people imposes serious constraints on the country's ability to meet its obligations from national and international conservation agreements for the protection of its biodiversity. Seychelles recognized this constraint early and established long-term collaborations with research institutions in developed countries to improve the scientific basis for biodiversity management, partly to compensate for the lack of in-country environmental education at university level prior to 2011 (Dogley

2010). Here, we illustrate how we used research and the exchange of knowledge and ideas to help combat poaching and overexploitation of an endangered flagship and economically valuable plant species in the Seychelles.

Conserving a keystone species in the Seychelles: a case study

The iconic coco de mer palm *Lodoicea maldivica* Gmelin is endemic to the Seychelles. The palm, which is most famous for producing the largest seeds of any plant in the world, currently occurs on two small islands. The coco de mer is a keystone species and ecosystem engineer (Edwards, Fleischer-Dogley & Kaiser-Bunbury, unpublished data), sustaining a large variety of vertebrate and invertebrate species, which are directly dependent on palm forest habitat dominated by coco de mer (e.g. Noble *et al.* 2011; Reuleaux *et al.* 2013). The species is also economically important, partly due to the high market value of the nuts, which are sold to tourists as souvenirs, but also due to the direct and indirect revenue generated by the coco de mer forest of the Vallée de Mai, a UNESCO World Heritage Site, which is the most visited tourist attraction in the Seychelles. The value of the nuts and relative rarity of adult female palms (the coco de mer is dioecious) have led to legal and illegal overexploitation. Poaching primarily targets the kernel of both mature nuts, sold as an aphrodisiac in the Chinese medicine market, and of immature nuts, as a delicacy for local consumption. Export of whole nuts as souvenirs is strictly regulated by the Seychelles government. Other threats to the coco de mer include fire, soil erosion and invasive alien species (Fleischmann *et al.* 2005; Rist *et al.* 2010; Kaiser-Bunbury *et al.* 2014). While fire is the most acute and severe short-term threat, overexploitation of nuts ultimately limits coco de mer recruitment in existing and newly planted populations, thereby compromising long-term conservation of the species.

The coco de mer populations at the Vallée de Mai and Fond Ferdinand on Praslin and on Curieuse island make up more than 70% of all remaining coco de mer trees on the two islands. The other trees are scattered across Praslin and do not form any forest stands (Fleischer-Dogley *et al.* 2011). The three populations are managed by two parastatal organizations; the Seychelles National Parks Authority (SNPA; Curieuse) and the Ravin de Fond Ferdinand Nature Reserve and a public trust, the Seychelles Islands Foundation (SIF; Vallée de Mai). Together with the Ministry of Environment and Energy (MEE) and the general public that manage coco de mer trees on public and private land, these organizations are the main stakeholders responsible for the protection and sustainable use of coco de mer.

With increasing demand for regulated nut and unregulated kernel sales between 2002 and 2007, the MEE, together with key stakeholders, identified the need for a revision of the legislation and the protection status of the coco de mer to ensure long-term viability of the main populations. Despite the ecological and economic significance of the species, very little general knowledge on its biology and ecology existed at that time on which to base conservation management decisions. Decisions based on the experience of individual practitioners or on anecdotal information can be highly risky (Sutherland *et al.* 2004), especially for a country with very limited resources, rapidly increasing demand for this scarce natural resource and the slow life history of the coco de mer. Whether management decisions actually benefit the species and the palm forest ecosystem may take 60–80 years to confirm (the length of time it takes for juvenile palms to mature), but earlier indicators of success could include germination success, expanding coco de mer distribution and population increases of associated fauna.

Bringing scientists and practitioners together

To address the gap in knowledge, SIF initiated the establishment of a coco de mer working group partnering international academic scientists, practitioners and policymakers. The aim of the working group was to overcome common impediments to the use of science in policymaking, such as the lack of alignment of research with information needed (Fazey, Fischer & Lindenmayer 2005), shortage of financial resources and capacity to conduct research and implement findings (Young & Van Aarde 2011), bureaucratic restrictions (Cook *et al.* 2013), general scepticism towards the use of science in decision-making (Young & Van Aarde 2011) and suspicions concerning sharing of data and information between stakeholders.

The working group met to jointly identify the information needed for effective management. The scientists among the group then developed a plan aligned with these requirements which outlined research recommendations for coco de mer, covering population dynamics, ageing and sexing methods, age structure, mortality, reproduction, genetic variability and critical ecosystem processes that sustain the resistance of coco de mer forest against invasive species. As a priority in 2009, we initiated long-term monitoring schemes on growth of different age classes, reproduction and mortality. In parallel, we consolidated the available data from the different management organizations on coco de mer population size, distribution and dynamics. To collect ecological data, we trained local field staff and interviewed Seychellois parabotanists and practitioners, with the objectives of gauging baseline knowledge to inform the scientists, and identifying knowledge gaps. Technical expertise, such as genetics and population modelling skills, was actively sought in the form of collaborations with academic researchers.

From 2010 onwards, we published peer-reviewed articles on the population ecology, genetics and sustainable harvesting strategies of the coco de mer (Rist *et al.* 2010; Fleischer-Dogley *et al.* 2011) and the importance of coco de mer-dominated palm forest for the associated fauna

(Noble *et al.* 2011; Reuleaux *et al.* 2013). We used the published results to support conservation actions. For example, the number of mature female trees was particularly low across the three populations (total of 2246 trees; 13·4% of all trees in the populations; Fleischer-Dogley *et al.* 2011), which, together with an extremely low rate of reproduction (1·17 nuts year^{-1}; Edwards, Fleischer-Dogley & Kaiser-Bunbury unpublished data) and heavy legal and illegal (poaching) exploitation pressure (Rist *et al.* 2010), prompted IUCN to upgrade the coco de mer Red List status to Endangered in 2011. Based on a population model considering different harvesting scenarios, we recommended that management should aim for natural recruitment of at least 20% of annual nut production of coco de mer to increase effective population size and long-term sustainability of the populations (Rist *et al.* 2010; Fleischer-Dogley *et al.* 2011). These and other specific recommendations derived from the research were summarized by our team of scientists in collaboration with the working group and submitted to policymakers at the MEE, with the offer of further advice throughout implementation to ensure the necessary operational capacity.

Evidence-based management

Based on these recommendations, SIF, the managing authority of the largest intact coco de mer forest, established an incentive-driven stewardship scheme of planting coco de mer nuts under natural conditions. Under this scheme, local field staff are awarded a monthly payment for every nut found that remains on the forest floor. Senior research staff (who are not eligible for stewardship payments to avoid conflicts of interest) check all nuts once a month to GPS nut locations and verify their presence and status for the payments. Field staff leave the nuts in the location they are found but hide them under leaf litter to minimize poaching risk. The payments continue until the nuts have germinated (6–18 months after falling from the tree). The stewardship scheme incentives alone have therefore cost approximately €30 per nut to date. The scheme reduces the risk of post-planting poaching and fosters among the field staff a sense of responsibility for, and identification with, the ecological value of the coco de mer and thereby promotes forest regeneration. Since its onset 18 months ago, some 200 nuts (*c.* 30% of the annual crop) have germinated under the scheme in the Vallée de Mai (SIF unpublished data). Legal harvesting of nuts from the forest has been reduced to levels as low as *c.*25% of the harvesting rates prior to the start of the scheme. Poaching currently accounts for *c.* 30–50% of annual known nut production of the population. To ensure sustainability of the scheme and long-term conservation of the species, SIF employs a three pronged approach: (i) visitors pay entrance fees to the Vallée de Mai to experience a coco de mer forest and the fees pay for the regeneration of the forest; (ii) SIF runs an extensive education and outreach campaign on the threats to coco de mer forest, aiming at reducing poaching pressure from the local community; and (iii) to deter poachers, the government of Seychelles and SIF instigated the listing of coco de mer kernel on CITES Appendix III, which provides the international legal requirements to restrict trade in the kernel. On a national level, the present Coco de Mer Management Decree is being reviewed to substantially increase the penalties for poaching and thus providing a stronger deterrent against coco de mer poaching. SIF works closely with the police to provide and gather evidence of poaching incidents in the Vallée de Mai. The government has also severely restricted the export of coco de mer kernel, and single export permits are granted only after rigorous documentation checks. In combination, these measures will reduce poaching pressure in the long term and contribute towards the sustainability of the stewardship scheme. *Ex-situ* germination of nuts has been considered but deemed unsuitable under the current ecological, biological and administrative constraints due to high costs, limited resources and unsustainable long-term commitment by a large set of stakeholders.

Overall, it is too early to determine conservation success of the measures put in place; outcome will be dependent on successful implementation of a regeneration programme in all main coco de mer populations, ideally resulting in recruitment of >20% of the annual nut production in each population, a substantial reduction in poaching, and balancing the supply and demand of legally harvested nuts for the tourism market. Our integrated programme of research, however, has already produced several positive outcomes of science informing conservation practices, from policy changes to active management interventions. There are several reasons for these successes. First and foremost, a platform was established for all partners, which ensured mutual understanding, clear communication of research and management objectives and equal level of commitment to the objectives by partners. Through this approach, all collaborators were fully integrated in the entire process, including identifying information requirements for decision-making, planning and conducting the necessary research, and the political and practical implementation of the recommendations. This involvement required that each group had to step out of their defined 'realm' and actively participate, seek responsibility and engage beyond their regular mandates. For example, results, as published by academic scientists in peer-reviewed journals, rarely reach practitioners; therefore, publications are only a first, although critical, step towards closing the 'implementation gap'. In our case, scientists actively facilitated the mainstreaming of research results into management and public awareness by interpreting these results in the most appropriate language for each audience. We published newspaper articles, newsletter items, social media posts and, most importantly, wrote letters to policymakers and politicians translating the

scientific findings into targets, practical recommendations and national benefits in non-technical language. We followed up the letters with meetings for all partners to discuss possible means of implementation under the financial, legal and operational constraints of a SIDS. Finally, the scientists in our group were involved in providing creative guidance, advice and training throughout the implementation stage and beyond, which fostered a strong sense of integration and trust between the scientists and local partners. With the emerging and urgently needed research findings, practitioners and policymakers were more receptive to new management strategies and practices (thereby freeing themselves from inflexible traditional management approaches). Furthermore, management organizations remain prepared to adapt their conservation practices if the research is integrated into the work programme and enables the full participation of staff in the research and decision-making process, which creates ownership of results and outcomes.

The bigger picture: a promising approach for other SIDS and beyond?

Biodiversity is crucial to the economic and societal well-being of many SIDS, for example through tourism and fisheries (Teelucksingh, Nunes & Perrings 2013). Flagship species, such as the coco de mer, bring not only direct and indirect economic benefits, but also critical ecosystem services, such as prevention of soil erosion and protection of watersheds. Governments of SIDS have a vested interest in maintaining biodiversity due to their high dependence on it, which, combined with their smaller and generally more accessible structure, increases the chances of rapid follow-up and implementation of evidence-based conservation recommendations. To raise awareness of this dependency on biodiversity and the sustainable management of the environment, the UN declared 2014 the International Year of Small Island Developing States. It is clear that the process we describe here may take longer, require more compromises, or be incomplete or unfeasible in some situations. This might be especially true if: (i) the platform for information exchange between scientists and practitioners is not anchored within an institutional framework; (ii) practitioners do not or only partially subscribe to the principle of evidence-based decision-making; (iii) only a small cross section of practitioners with limited capacity to implement change engage in the process; and (iv) resources to implement the recommendations cannot be made available. Nevertheless, the example of developing and implementing evidence-based conservation strategies for the coco de mer could set a precedent for species- or habitat-related conservation actions in SIDS and other countries. Coco de mer conservation in the Seychelles showcases a successful example of boundary science (cf. Cook *et al.* 2013), which describes research that advances scientific understanding while contributing to decision-making and implementation. Our experience of bilateral knowledge transfer between scientific research and management (evidence-based policy and policy-relevant science; Cook *et al.* 2013) can be adapted by other countries with similar circumstances to help address conservation challenges.

The way forward: the responsibility of the researcher

To better implement research results into conservation management, we summarize below actions that we have found to be imperative to a successful joint venture between scientists and practitioners. The list includes steps that can be taken by both scientists and practitioners, as well as funding agencies.

1. Successful collaborations require, as a first step, the identification of a common goal for all involved.

2. Academic scientists working abroad, particularly if conducting research in developing nations with threatened biodiversity, should commit to long-term research programmes and full engagement with practitioners (see also Gibbons *et al.* 2008), despite the difficulties of obtaining funding for long-term research.

3. Since practitioners and policymakers lack access to scientific papers or the technical expertise to decode them (Cook, Hockings & Carter 2009), researchers ought not to view the research process as ending with publication, but to ask themselves what they can do after publication to facilitate interpretation of their research results to the target audience to encourage implementation of their recommendations. At the very minimum, a concise summary to the relevant in-country authorities presenting the research findings and recommendations should be viewed as an integral part of applied ecology and threatened biodiversity research. This is a tiny time commitment in comparison with publishing a paper but is more likely to yield far-reaching results with greater impact.

4. Students of conservation biology at Masters and PhD level should be routinely trained in communication of results to different audiences, participatory approaches and community/stakeholder engagement, and supervisors should encourage their students to develop a mindset of committing to collaborating agencies and following up results appropriately to maximize impact and uptake of recommendations.

5. Engagement and longer-term commitment should be actively encouraged and incentivized by research funding agencies by aligning their reward systems to the needs of conservation management.

6. Equally, practitioners and policymakers must seek and embrace the opportunities that arise from research collaborations, be aware of the funding limitations and publication requirements within the fields of applied ecology and conservation, be willing to engage and be open to new ideas and approaches supported by science.

7. Researchers and institutions should establish and make appropriate use of a series of measures to facilitate

collaborative research, which might include signing of a Memorandum of Understanding (MoU) or research agreement that outlines the expectations of the research and each partner's roles, rights and responsibilities; promoting the value of converting scientific literature into appropriate formats for its application across institutions and audiences; offering training of local stakeholders; and providing opportunities for information exchange.

In summary, scientists at all levels have an individual responsibility to: (i) go beyond the existing research framework by feeding back their results to relevant institutions; and (ii) encourage and guide uptake and application of their results. Under such a scenario, there is a high potential for mutually beneficial collaborations and true advancement in the conservation of biodiversity.

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Data accessibility

Data have not been archived because this article does not contain data.

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Biosketch

Christopher N. Kaiser-Bunbury combines research on ecological networks with biodiversity conservation on islands and has headed the coco de mer working group since 2008. **Frauke Fleischer-Dogley** is a conservation biologist with a PhD in sustainable management of the coco de mer. As the CEO of the Seychelles Islands Foundation (SIF), she initiated the set-up of the working group and is responsible for the management of Seychelles' two UNESCO World Heritage Sites, the Vallée de Mai and Aldabra Atoll. **Didier Dogley** is currently the Special Advisor to the Minister of Environment and Energy and was formerly Principal Secretary of the Department of Environment. He has been instrumental in advancing Seychelles' conservation policy for the last decade. **Nancy Bunbury**, a conservation biologist and practitioner, manages research and conservation projects for SIF.

