# Practitioner and scientist perceptions of successful amphibian conservation

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**Article Impact Statement:** Conservation scientists and practitioners perceive success differently; thus, a clear definition of *success* up front improves results.

## Abstract

Conservation requires successful outcomes. However, success is perceived in many different ways depending on the desired outcome, which can vary according to numerous factors. We analysed perceptions of success among 355 scientists and practitioners working on amphibian conservation from over 150 organisations in more than 50 countries. Respondents identified four types of success: species and habitat improvements (84% of respondents); effective programme management (36%); outreach initiatives such as education and public engagement (25%); and the application of science-based conservation (15%). The most significant factor influencing overall perceived success was reducing threats. Capacity building was rated least important. Perceptions were influenced by experience, professional affiliation, involvement in conservation practice, and country of residence. More experienced conservation practitioners associated success with improvements to species and habitats, and less so with education and engagement initiatives. Whilst science-based conservation was rated as important, this factor declined in importance as the number of programmes a respondent participated in increased, particularly amongst those from Less Economically Developed Countries. The ultimate measure of conservation success – population recovery – may be difficult to measure in many amphibians, difficult to relate to the conservation actions intended to drive it, and difficult to achieve within conventional funding timeframes. The relaunched Amphibian

Conservation Action Plan provides a framework for capturing lower-level processes and outcomes, identifying gaps, and measuring progress.

## Introduction

Although the roots of conservation biology can be traced back over many decades, the field emerged as a scientific discipline over thirty years ago (Soulé 1985), and continues to evolve (Kareiva & Marvier 2012). Those aspects of conservation associated with success (hereafter: 'perceptions of success') are also evolving, leading to different views on what comprises success. Despite considerable global efforts to conserve biological diversity (Rands et al. 2010), conservation success is rarely defined, measured, and communicated (Saterson et al. 2004). The purpose of conservation may be framed in multiple ways, impacting the measurement of success (Mace 2014). Uncertainty in defining success can confound efforts to assess the value and relative level of achievement of conservation projects, and in conservation the diversity of definitions of success (e.g. Kleiman et al. 2000; Young et al. 2014) can cause confusion in assigning goals, and vice versa.

Nature is increasingly valued in terms of ecosystem services that benefit people (Mace 2014), emphasising conservation achievement alongside enhanced human well-being (Kapos et al. 2010; Carpenter et al. 2009; Ostrom 2009). Community Based Conservation projects (as classified by Souto et al. 2014) associate success with supportive social processes that encompass the needs, values and awareness of local stakeholders and the general public (Clark & Wallace 1998; Mascia et al. 2003), such as development of sustainable livelihoods, and improved welfare of local stakeholders (du Toit et al. 2004; Davies et al. 2014). This anthropocentric focus on measuring conservation success has been dubbed the "*new conservation*", with economic development and poverty reduction replacing species and habitat interventions (Soulé 2013).

Conservation success relates to the impact of different components (Kapos et al. 2008, 2009, 2010). This includes both (1) measures of process (e.g. species and site management, capacity building, political lobbying, financial indicators, resource utilisation,

milestones, research, learning by local communities, operational capability); and (2) measures of purpose-related outcome (e.g. population recovery, recovered habitats, sustained support in local communities, legal statutes, sustained human benefits, poverty alleviation). If these are not aligned, then an organisation might, for example, achieve research goals at the expense of local support or to the detriment of non-target species. Alternatively, the programme may operate smoothly, yet fail to deliver its desired outcomes, as observed in many instances (Kleiman et al. 2000; Black & Groombridge 2010; Black et al. 2011; Martin 2012).

In this study we explore the perceptions of success held by amphibian conservation scientists and practitioners. Our aim is to investigate the range of views on the nature of success, and the factors that may influence different perceptions. Amphibians are a large and widespread group experiencing significant declines (Stuart et al. 2004, 2008). They are also the subject of concerted and long-term conservation efforts (e.g. Griffiths & Pavajeau 2008; Smith & Sutherland 2014; Young et al. 2014), and there is a substantial group of practitioners and scientists focusing on their conservation (AArk 2016; ASA 2016; ASG 2016).

## Methods

### Data collection

We interviewed five key informants engaged in a range of amphibian conservation activities at the 2012 Amphibian Conservation Research Symposium. Subsequently we developed a pilot questionnaire based on these interviews and disseminated it amongst delegates of the 15th African Amphibian Working Group meeting in 2012. Pilot data informed the revision and improvement of the questions included in the final questionnaire. The questionnaire (Supplementary Information) was delivered to respondents in two formats: hard copies distributed at the 7th World Congress of Herpetology (7WCH), August 2012; and an identical online version (www.surveymonkey.com), available August 2012 to February 2013 and

disseminated to the IUCN SSC Amphibian Specialist Group. A targeted sampling strategy was employed, selecting potential respondents with relevant expertise, with chain-referral sampling encouraged (Newing 2011) to maximise sample size and breadth of respondents. Respondents were asked to provide details relating to five explanatory variables: their institution type; country of residence; whether they identified themselves as a conservation practitioner; whether or not they also conducted research; number of years of experience in conservation science and/or practice; and number of ongoing conservation programmes (see Supplementary Information (S2) for all definitions).

## Measuring perceptions of success

We initially asked respondents: *'How do you perceive "success" in a conservation programme?'* (hereafter "open-ended question" – question 12 of questionnaire (SI)). We subsequently coded answers to permit quantitative assessment (Newing 2011). Using a five-point ordinal scale (1 = not important, to 5 = highly important, with 0 = not applicable), respondents then scored a series of statements describing aspects of perceived success in conservation (hereafter "Components" – question 15 of questionnaire (SI); Table 1). These are categorized in Kapos et al. (2008, 2009, 2010) as: Species & Site Management; Sustainable Resource Use; Education & Awareness; Capacity Building; Research; and Government Policy. From the same list, respondents then picked their "top 3" statements, thus providing a measure of popularity. Permission to conduct this study was granted through ethical reviews from the 7WCH and the University of Kent.

## Data analysis

We analysed data using R version 2.14.2 (R Core Team 2012); all analyses preserved the anonymity of respondents. Answers to the open-ended question were coded by dividing each full answer into a series of segments that noted discrete aspects of success (hereafter "points"). Each point was coded according to a defined list assembled post-data collection (Newing 2011), and codes were allocated between four major categories: (1) "Species & Habitat" points described direct improvements in species populations and/or habitats resulting from *in situ* or *ex situ* conservation interventions; (2) "Programme Management" points related to general programme structure, management and strategy; (3) "Education &

Engagement" points included public education and awareness activities, and/or fostering local community/stakeholder support and involvement; and (4) "Research & Evaluation" points addressed species and habitat-related scientific research needs and/or the evaluation of programme outcomes. The proportion of each respondent's answer across each category was calculated by dividing the number of points made per category by the total number of points made. The proportion of responses for each of the four main categories were modelled separately as a function of five discrete explanatory variables: Institution (Academic/Non-academic); Country (Less Economically Developed Countries (LEDCs)/More Economically Developed Countries (MEDCs) (IMF 2014)); Conservation Practitioner (involved in practical conservation activities: Yes/No); Experience (in years, encompassing conservation science and/or practice); and Conservation Programmes (number ongoing). We modelled each variable and all two-way interactions using Generalised Linear Models (GLM) with binomial error structure. A quasi-binomial error distribution was employed when models were over-dispersed (Crawley 2007). Starting with two-way interactions, models were simplified by removing the least significant factor. The resulting model was compared to the previous one using an F-test (quasi-binomial) or Chi-squared test (binomial) before factor deletion. If the variance explained by the model before and after removal was significantly different, the interaction or variable was retained (Crawley 2007). The final model was accepted when only significant factors remained.

We analysed importance scores given by respondents (0-5 scale) using GLM to investigate the perceptions of different Components, namely: Sustainable Resource Use; Education & Awareness; Capacity Building; Research; and Government Policy (derived from Kapos et al. 2010). Per statement, each score was converted to a proportion of the maximum score (i.e. 5) with the initial model structure and simplification as above. We did not include the Species & Site Management statement in this analysis because "*known threats*" could subsume aspects of the other Components, e.g. unsustainable resource use could constitute a threat requiring management. For all analyses, effect sizes for explanatory variables of interest are presented in addition to their significance values. Effect sizes were calculated using Nagelkerke's pseudo-$R^2$ (Nagelkerke 1991) and are interpreted according to Cohen's (1988) rule of thumb (0.1 = small, 0.3 = medium, 0.5 = large effect size).

## Results

### Questionnaire responses

The questionnaire was answered by 355 respondents: 96 completed a paper questionnaire and 259 completed an online questionnaire. The 7WCH sample comprised a higher proportion of respondents from academic institutions (7WCH = 60%; Online = 51%), and the online questionnaire attracted a greater proportion of respondents from LEDC countries (7WCH = 11%; Online = 30%). Overall, the questionnaire was answered by 89 LEDC-based respondents and 265 MEDC-based respondents (one respondent did not report country of residence) across 55 countries and 167 organisations. The online questionnaire attracted proportionally more conservation practitioners (7WCH = 38%; Online = 44%). Median years of experience were similar across the two samples: 6.5 years for 7WCH respondents (interquartile range [IQR], 4-19; *n* = 96); and 10 years for the online questionnaire (IQR, 6-20; *n* = 259). The median number of conservation programmes per respondent was one for both the 7WCH (IQR, 0-3; *n* = 96) and online sample (IQR, 0-2; range = 0-15; *n* = 259). The two sets of questionnaires were analysed as a single sample to ensure the largest possible range of respondents.

### Perceptions of success

The number of discrete points describing success in amphibian conservation ranged from one to nine per respondent, with 242 respondents making a total of 579 points. Responses described 19 different types of success covering both process and outcome measures (see Supplementary Information for further details) allocated between four categories: Species & Habitat (84%); Programme Management (35%); Education & Engagement (24%); and Research & Evaluation (14%).

The majority of Species & Habitat points (96%; 349 points from 203 respondents) referred to *in situ* species conservation improvements (e.g. population numbers, persistence, security, genetic diversity, and health) and their habitats (e.g. condition, size, connectivity, and

protection). The remaining 4% described *ex situ* conservation measures, whereby assurance colonies of species are maintained in captivity, especially in cases where *in situ* threats cannot currently be mitigated. Seventy-six percent of Programme Management points (113 points from 85 respondents) referred to considerations such as long-term funding, multi-stakeholder approaches, clear strategic planning, an adaptive "learning" programme framework, and effective personnel management, all of which relate to process. The remaining 24% of Programme Management points asserted that success equals the achievement of pre-determined programme goals. Education & Engagement points (77 points from 59 respondents) described public education and awareness initiatives (57%), or the development of local support, sustainable livelihoods, and local community/stakeholder involvement (43%). Research & Evaluation points (40 points from 35 respondents) mentioned scientific research on species and habitat as being crucial to successful conservation (63%), as well as the evaluation of programme outcomes through appropriate monitoring (37%).

Across the statements, the mean importance score out of five varied little (4.09 to 4.70), and mirrored the trend in the proportion of respondents selecting statements as being among their top 3, which exhibited a wider range. Species & Site Management was the most popular statement (84% of respondents chose among top 3 statements) and capacity building was the least popular (32%).

## Predictors and components of success

Conservation practitioners believed Species & Habitat improvements to be proportionally less significant in defining conservation success than non-practitioners. A significant interaction between the explanatory variables of Conservation Practitioner and Experience (GLM: $t$ = 2.0, SE 0.02, $p$ = 0.05, df = 241, $R^2$ = 0.023) suggests that more experienced conservation practitioners believe factors relating to Species & Habitat are more important than less experienced practitioners (Fig. 1), although the effect size of this interaction was small. Conservation practitioners also considered Education & Engagement to be more important in defining conservation success than non-practitioners. A significant interaction between the explanatory variables of Conservation Practitioner and Experience and the

importance of Education & Engagement in defining success (GLM: $t$ = -2.0, SE 0.03, $p$ = 0.04, df = 241, $R^2$ = 0.026) suggests a declining importance attributed to Education & Engagement by practitioners as experience increases (Fig. 1), but again the effect size for the interaction was small. In both cases (Species & Habitat and Education & Engagement), the perceptions of non-practitioners altered little with experience (Fig. 1). The proportion of points relating to Research & Evaluation was low. However, academic respondents involved in multiple conservation programmes made a greater proportion of points relating to Research & Evaluation than those based at non-academic institutions. The importance of this category increased with the number of conservation programmes for individuals from academic institutions, but decreased to zero for respondents based at non-academic institutions (GLM: $z$ = -2.0, SE 0.02, $p$ = 0.043, df = 241, $R^2$ = 0.056; Fig. 1). No significant relationships were found between any of the interactions or discrete explanatory variables and the proportion of Programme Management points made by respondents.

Scores for components associated with investing in the human aspects of a conservation programme (Sustainable Resource Use, Education & Awareness and Capacity Building – i.e. the components most analogous to the category "Education & Engagement") were negatively related to years of experience across all respondents: Sustainable Resource Use (GLM: $t$ = -3.9, SE 0.008, $p$ = < 0.001, df = 234, $R^2$ = 0.103); Education & Awareness (GLM: $t$ = -3.1, SE 0.008, $p$ = 0.002, df = 234, $R^2$ = 0.068); and Capacity Building (GLM: $t$ = -2.3, SE 0.008, $p$ = 0.02, df = 234, $R^2$ = 0.038; Fig. 2). In each case, the effect size of experience on response scores was small. For Research, a significant interaction was found between Country and Conservation Programmes; the importance of Research declines as the number of conservation programmes per person increases and this decline is particularly pronounced for those from Less Economically Developed Countries (GLM: $t$ = 2.5, SE 0.11, $p$ = 0.02, df = 234, $R^2$ = 0.046; Fig. 2). Government Policy scores were associated with a significant interaction between Institution and Conservation Programmes ($t$ = 2.2, SE 0.08, $p$ = 0.03, df = 234, $R^2$ = 0.034); as the number of programmes increases, scores increased for respondents from non-academic institutions, but declined for those from academic institutions (Fig. 2).

## Discussion

### *Perceptions of success*

Our results indicate a diversity of perceptions of success that are influenced by factors concerning the respondent's background. Previous studies have similarly recognised that conservation success comes in different forms (Brooks et al. 2006; Waylen et al. 2010), at different spatial scales (Sodhi et al. 2011), and across organisational elements (Mace et al. 2007). The achievement of *in situ* improvements in the status of species and habitats is overwhelmingly perceived as central to success in amphibian conservation. *Ex situ* conservation actions are advocated for amphibians when threat mitigation is impossible (Zippel et al. 2011), although they may not be suitable for all species (Tapley et al. 2015). Although *ex situ* measures can be crucial to averting extinctions (e.g. Lee et al. 2006), they may not be associated with long-term success unless populations are restored to the wild.

Programme management definitions of perceived success were related to effective organisation of financial and human resources, and the achievement of pre-stated goals. The sustained mobilisation of financial and technical resources (McCarthy et al. 2012), effective leadership (Williams et al. 2007; Black et al. 2011; Walls et al. 2016), and use of adaptive management and organisational learning (Clark 1996) have all been associated with success, particularly as conservation programmes become more interdisciplinary (Black & Copsey 2014; Pooley et al. 2014). Black & Groombridge (2010) investigated organisational measures of success in business management, and adapted them to conservation projects. The implementation strategy of a conservation programme is as crucial to its operational success as any of its component actions (Knight et al. 2006).

Education and engagement can unite conservation with improvements in human welfare and livelihoods (Davies et al. 2014; Souto et al. 2014). In our sample, outreach initiatives were only mentioned by 25% of respondents when defining conservation success. Although education and awareness initiatives have been employed, historically amphibian conservation has not been linked to development projects that encompass livelihood

provisions. However, this situation is changing (e.g. Bride et al. 2008; Lin et al. 2008), partly driven by donors increasingly supporting projects that also benefit people (e.g. Cunningham & King 2013). Consequently, outreach initiatives that benefit people are likely to become important outcome measures for future conservation interventions (Fisher et al. 2009).

Research and evaluation was related to success in terms of science-based conservation practice. Improving the impact of conservation has been linked to the promotion of evidence-based decision-making (Pullin & Knight 2001; Sutherland et al. 2004) and the regular evaluation of outcomes (Bottrill & Pressey 2012). Although not frequently mentioned, research and evaluation is instrumental in achieving verifiable improvements in species and habitats. Furthermore, when rated against other components of a conservation programme, research was second only to species and site management, indicating that it is of key concern in amphibian conservation (Table 1). The effects of conservation interventions can extend beyond project funding timescales (Kapos et al. 2008). The evaluation of short-term and intermediate-level success criteria may enable a project to progress step-wise towards long-term impacts (Margoluis & Salafsky 1998; Margoluis et al. 2009; Martin et al. 2012). Additionally, measures of success may require ongoing negotiation between stakeholders, rather than be prescribed *ex-ante* by external organisations (Sayer & Wells 2004).

## Predictors and components of success

Experience was a key predictor of perceptions of success in both academic and practitioner groups. More experienced practitioners tended to place greater emphasis on species and habitat improvements; less experienced practitioners tended to place more emphasis on outreach initiatives such as public education and engagement, with analogous perceptions of non-practitioners altering little with experience. Experience also influenced the importance attributed to human components of conservation. There was a trend for scores for education and awareness, sustainable resource use and capacity building to be negatively associated with experience. More experienced practitioners may regard true success in terms of the traditional goal of effective management of species and habitats (Murphy 1990). Professional experience is often linked to career progression. This may draw perceptions of success away from programme components, and towards wider organisational goals or

aspirations. Likewise, success from the ecosystem viewpoint can be displaced by internal priorities or self-interest, or disciplinary bias (Newing, 2010; Sandbrook et al. 2011). Although regarded as important, capacity building appeared to be the least popular component of success among our sample, and was only mentioned by a single respondent in the open-answer question. However, it is increasingly emphasised globally as a key concern in promoting biodiversity conservation, for example in the Convention on Biological Diversity Aichi Biodiversity Targets, under strategic goal E (CBD 2014). Capacity building can partly be achieved by bringing together local and international conservation practitioners and researchers, helping to strengthen local agencies to set and enact the conservation agenda (Knight & Cowling 2006; Smith et al. 2009). Capacity building may be currently seen (by practitioners and academics alike) as a wider organisational objective rather than as a project-specific goal. If funding bodies set expectations that capacity building is achieved as part of a sustainable future for continued conservation achievement, it can become a key outcome and therefore a requirement within project design.

Research and evaluation was valued more by academics than practitioners, particularly when they are involved with multiple programmes. In academic institutions, career progression depends substantially on publishing (Sutherland et al. 2011), and this may explain the greater emphasis on research. Although it varies between organisations, publishing may be less of a priority for practitioners (Arlettaz et al. 2010). Respondents from LEDCs that were involved with more programmes placed less emphasis on the importance of research. Wealthier countries view evidence-based decision-making as fundamental to success, whereas less-wealthy countries may prioritise other actions out of socio-economic need (Karlsson et al. 2007; Sunderland et al. 2009). Finally, importance scores for Government Policy were positively related to involvement in multiple programmes for practitioners, with a slight negative relationship for academics. Effective policy and legislation are germane to the attainment of many conservation objectives (Rands et al. 2010; Phillis et al. 2013), and are important indicators of changes within a local or national conservation context, but may be a low priority for academics (Arlettaz et al. 2010).

### *Defining success*

Success is a value interpretation (Büscher 2014) shaped by worldviews (Jones 2012), which may be influenced by personal experiences, geographic location, and training. Clearly, understanding the determinants of success requires an assessment of both processes and outcomes, which are both measureable. The most fundamental outcome in conservation is recovery of the species, measureable by population assessment. Indeed, measuring population recovery is the ultimate indication that other lower-level outcomes have been achieved, such as mitigation of threats and restoration of habitat. Nevertheless, lower-level processes and outcomes may require their own measureable indicators as checks and balances that programs are on track. For small, cryptic and often highly seasonal species that display natural population fluctuations, determining population recovery can be difficult and long-term (Keith et al. 2015). For amphibians – which have undergone rapid, catastrophic declines in some species and some regions – there may not be the time or resources to measure population recovery, and lower-level, interim measures of success may be needed to monitor progress. Likewise, some of the processes – such as education and capacity building – may be inherently difficult to measure in terms of their outcomes. Establishing that education has worked and that capacity has been built does not necessarily translate into the behaviour changes that may be needed to achieve threat mitigation and ultimately, population recovery. Failure to see concrete evidence of these processes leading to positive outcomes may explain the perception of their low importance, particularly among more experienced conservationists. Coupled with the issue that amphibians are often overshadowed by mammals and birds when it comes to conservation campaigning, perhaps it is not surprising that the amphibian conservation community seems to be sceptical about the importance of capacity building. Equally, the fact that much conservation research fails to inform conservation practice may feed perceptions that research is not a major factor in driving success (Griffiths & Dos Santos 2012).

In amphibian conservation there is a mismatch between the urgency for action and the time needed to implement well-designed programs. Such programs require actions that tackle both the environmental and social drivers of declines, and identification of measures of

success. Consequently, amphibian conservation programmes frequently focus on relatively low-risk components that can be reasonably achieved within the timeframe of a short-term grant. The Amphibian Conservation Action Plan (Wren et al. 2015) provides the framework for joining up these components, identifying the gaps, and monitoring progress.

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**Literature Cited**

AArk 2016. Amphibian Ark. [online] Available at: http://www.amphibianark.org/ (Accessed 12 December 2016).

Arlettaz RM, Schaub M, Fournier J, Reichlin TS, Sierro A, Watson JEM, Braunisch V. 2010. From publications to public actions: when conservation biologists bridge the gap between research and implementation. BioScience **60**:835–842.

ASA. 2016. Amphibian Survival Alliance: Our Story. [online] Available at: http://www.amphibians.org/about/our-story/ (Accessed 12 December 2016).

ASG. 2016. IUCN SSC Amphibian Specialist Group. [online] Available at: http://www.amphibians.org/asg/ (Accessed 12 December 2016).

Black SA, Copsey JA. 2014. Purpose, process, knowledge, and dignity in interdisciplinary projects. Conservation Biology **28**:1139–1141.

Black SA, Groombridge JJ. 2010. Use of a business excellence model to improve conservation programs. Conservation Biology **24**:1448–58.

Black SA, Groombridge JJ, Jones CG. 2011. Leadership and conservation effectiveness: finding a better way to lead. Conservation Letters **4**:329–339.

Bottrill MC, Pressey RL. 2012. The effectiveness and evaluation of conservation planning.

Conservation Letters **5**:407–420.

Bride IG, Griffiths RA, Meléndez-Herrada A, Mckay JE. 2008. Flying an amphibian flagship: conservation of the Axolotl *Ambystoma mexicanum* through nature tourism at Lake Xochimilco, Mexico. International Zoo Yearbook **42**:116–124.

Brooks JS, Franzen MA, Holmes CM, Grote MN, Mulder MB. 2006. Testing hypotheses for the success of different conservation strategies. Conservation Biology **20**:1528–38.

Büscher B. 2014. Selling success: constructing value in conservation and development. World Development **57**:79–90.

Carpenter SR et al. 2009. Science for managing ecosystem services: beyond the Millennium Ecosystem Assessment. Proceedings of the National Academy of Sciences of the United States of America **106**:1305–1312.

CBD. 2014. Aichi Biodiversity Targets. [online] Available at: http://www.cbd.int/sp/targets/ (Accessed 4 December 2014).

Clark T. 1996. Learning as a strategy for improving endangered species conservation. Endangered Species Update **13**:5–6, 22–23.

Clark TW, Wallace RL. 1998. Understanding the human factor in endangered species recovery: an introduction to human social process. Endangered Species Update **15**:2–9.

Cohen J. 1988. Statistical power analysis for the behavioral sciences (2nd ed.). Hillsdale, NJ: Erlbaum.

Crawley M. 2007. The R Book. John Wiley, New York.

Cunningham S, King L. 2013. Comment on “Evaluating indices of conservation success: a comparative analysis of outcome- and output-based indices.” Animal Conservation **16**:137–138.

Davies TE, Fazey IRA, Cresswell W, Pettorelli N. 2014. Missing the trees for the wood: why we are failing to see success in pro-poor conservation. Animal Conservation **17**:303–312.

du Toit JT, Walker BH, Campbell BM. 2004. Conserving tropical nature: Current challenges for ecologists. Trends in Ecology & Evolution **19**:12–7.

Fisher B, Bolt K, Bradbury R, Gardner T, Green J, Hole D, Naido R. 2009. Two cultures of conservation. Conservation Biology **23**:1069–1071.

Griffiths RA, Dos Santos M. 2012. Trends in conservation biology: Progress or procrastination in a new millennium? Biological Conservation **153**: 153-158.

Griffiths RA, Pavajeau L. 2008. Captive breeding, reintroduction, and the conservation of amphibians. Conservation Biology **22**:852–61.

IMF. 2014. International Monetary Fund, World Economic Outlook - Recovery Strengthens, Remains Uneven (Washington, April 2014).

Jones JPG. 2012. Getting what you pay for: the challenge of measuring success in conservation. Animal Conservation **15**:227–228.

Kapos V et al. 2008. Calibrating conservation: new tools for measuring success. Conservation Letters **1**:155–164.

Kapos V et al. 2009. Outcomes, not implementation, predict conservation success. Oryx **43**:336–342.

Kapos V et al. 2010. Defining and measuring success in conservation. Pages 73–93 in Leader-Williams N, Adams WM, Smith RJ, editors.Trade-offs in Conservation: deciding what to save. Wiley-Blackwell Publishing Ltd, Oxford, UK.

Kareiva P, Marvier M. 2012. What is conservation science? BioScience **62**:962–969.

Karlsson S, Srebotnjak T, Gonzales P. 2007. Understanding the North-South knowledge divide and its implications for policy: a quantitative analysis of the generation of scientific knowledge in the environmental sciences. Environmental Science and Policy **10**:668–684.

Keith D, Akçakaya HR, Butchart SHM, Collen B, Dulvy NK, Holmes EE, Hutchings JA, Keinath D, Schwartz MK, Shelton AO, Waples RS. 2015. Temporal correlations in population trends: conservation implications from time-series analysis of diverse animal taxa. *Biological Conservation.* **18**: 315-317.

Kleiman DG, Reading RP, Miller BJ, Clark TW, Scott JM, Robinson J, Wallace RL, Cabin RJ, Felleman F. 2000. Improving the evaluation of conservation programs. Conservation Biology **14**:356–365.

Knight AT. 2006. Comments: Failing but learning: writing the wrongs after Redford and Taber. Conservation Biology **20**:1312–1314.

Knight AT, Cowling RM. 2006. Into the thick of it: bridging the research-implementation gap in the thicket biome through the Thicket Forum. South African Journal of Science **102**:406–408.

Knight AT, Cowling RM, Campbell BM. 2006. An operational model for implementing conservation action. Conservation Biology **20**:408–419.

Lee SK, Zippel K, Ramos L, Searle J. 2006. Captive-breeding programme for the Kihansi spray toad at the Wildlife Conservation Society, Bronx , New York. Wildlife Conservation **40**:241–253.

Lin H-C, Cheng L-Y, Chen P-C, Chang M-H. 2008. Involving local communities in amphibian conservation: Taipei frog *Rana taipehensis* as an example. International Zoo Yearbook **42**:90–98.

Mace GM. 2014. Whose conservation? Science **345**:1558–1560.

Mace GM, Balmford A, Leader-Williams N, Manica A, Walter O, West C, Zimmermann A. 2007. Measuring conservation success: assessing zoos' contribution. Pages 322–342 in Zimmermann A, Hatchwell M, Dickie LA, West, C editors.Zoos in the 21st Century: Catalysts for conservation. Cambridge University Press.

Margoluis R, Salafsky N. 1998. Measures of success: designing, managing, and monitoring conservation and development projects. Island Press, Washington, D.C., USA.

Margoluis RC, Stem C, Salafsky N, Brown M. 2009. Design alternatives for evaluating the impact of conservation projects. New Directions for Evaluation **122**:85–96.

Martin TG, Nally S, Burbidge AA, Arnall S, Garnett ST, Hayward MW, Lumsden LF, Menkhorst P, McDonald-Madden E, Possingham HP. 2012. Acting fast helps avoid extinction. Conservation Letters **5**:274–280.

Mascia MB, Brosius JP, Dobson TA, Forbes BC, Horowitz L, McKean MA, Turner NJ. 2003. Conservation and the social sciences. Conservation Biology **17**:649–650.

McCarthy DP et al. 2012. Financial costs of meeting global biodiversity conservation targets: current spending and unmet needs. Science **338**:946–9.

Murphy D. 1990. Conservation biology and scientific method. Conservation Biology **4**:203–

204.

Nagelkerke N. 1991. A note on a general definition of the coefficient of determination. Biometrika **78**: 691–692.

Newing H. 2011. Conducting Research in Conservation: A Social Science Perspective. Routledge.

Newing HS. 2010. Interdisciplinary training in environmental conservation: definitions, progress and future directions. Environmental Conservation **37**:410–418.

Ostrom E. 2009. A general framework for analyzing sustainability of social-ecological systems. Science **325**:419–422.

Phillis CC, O'Regan SM, Green SJ, Bruce JEB, Anderson SC, Linton JN, Favaro B. 2013. Multiple pathways to conservation success. Conservation Letters **6**:98–106.

Pooley SP, Mendelsohn JA, Milner-Gulland EJ. 2014. Hunting down the chimera of multiple disciplinarity in conservation science. Conservation Biology **28**:22–32.

Pullin AS, Knight TM. 2001. Effectiveness in conservation practice: pointers from medicine and public health. Conservation Biology **15**:50–54.

R. 2012. R: A language and environment for statistical computing. R foundation for Statistical Computing. Austria: Vienna. Available: http://www.R-project.org.

Rands MRW et al. 2010. Biodiversity conservation: challenges beyond 2010. Science **329**:1298–303.

Sandbrook C, Scales IR, Vira B, Adams WM. 2011. Value plurality among conservation professionals. Conservation Biology **25**:285–294.

Saterson KA, Christensen NL, Jackson RB, Kramer RA, Pimm SL, Smith MD, Wiener JB. 2004. Disconnects in evaluating the relative effectiveness of conservation strategies. Conservation Biology **18**:597–599.

Sayer J, Wells M. 2004. The pathology of projects. Pages 35–48 in McShane TO, Wells MP, editors. Getting biodiversity projects to work: towards more effective conservation and development. New York: Columbia University Press.

Smith RK, Sutherland WJ. 2014. Amphibian conservation: global evidence for the effects of interventions. Exeter, Pelagic Publishing.

Smith R, Verissimo D, Leader-Williams N, Cowling RM, Knight AT. 2009. Let the locals lead. Nature **462**:280–281.

Sodhi NS, Butler R, Laurance WF, Gibson L. 2011. Conservation successes at micro-, meso- and macroscales. Trends in Ecology & Evolution **26**:585–94.

Soulé M. 2013. The “new conservation.” Conservation Biology **27**:895–897.

Soulé ME. 1985. What is Conservation Biology? BioScience **35**:727–734.

Souto T, Deichmann JL, Núñez C, Alonso A. 2014. Classifying conservation targets based on the origin of motivation: implications over the success of community-based conservation projects. Biodiversity and Conservation **23**:1331–1337.

Stuart SN, Hoffmann M, Chanson JS, Cox NA, Berridge R, Ramani P, Young BE. 2008. Threatened Amphibians of the World. Lynx Editions, Barcelona, Spain; IUCN, Gland, Switzerland; and Conservation International, Arlington, Virginia, USA.. 758 pp.

Stuart SN, Chanson JS, Cox NA, Young BE, Rodrigues ASL, Fischman DL, Waller RW. 2004. Status and trends of amphibian declines and extinctions worldwide. Science **306**:1783–6.

Sunderland T, Sunderland-Groves J, Shanley P, Campbell B. 2009. Bridging the gap: how can information access and exchange between conservation biologists and field practitioners be improved for better conservation outcomes? Biotropica **41**:549–554.

Sutherland WJ, Goulson D, Potts SG, Dicks LV. 2011. Quantifying the impact and relevance of scientific research. PLoS ONE **6**:e27537.

Sutherland WJ, Pullin AS, Dolman PM, Knight TM. 2004. The need for evidence-based conservation. Trends in Ecology & Evolution **19**:305–8.

Tapley B, Bradfield KS, Michaels C, Bungard M. 2015. Amphibians and conservation breeding programmes: do all threatened amphibians belong on the ark? Biodiversity and Conservation **24**:2625–2646.

Walls SC, Ball LC, Barichivich WJ, Dodd CK, Enge KM, Gorman TA, O’Donnell KM, Palis JG, Semlitsch RD. 2017. Overcoming roadblocks to recovery of declining amphibian populations in the United States. Bioscience **67**: 156-165.

Waylen KA, Fischer A, McGowan PJK, Thirgood SJ, Milner-Gulland EJ. 2010. Effect of local cultural context on the success of community-based conservation interventions.

Conservation Biology **24**:1119–29.

Williams J, Haak A, Gillespie N, Colyer W. 2007. The conservation success index: synthesizing and communicating salmonid condition and management needs. Fisheries **32**:477–492.

Wren SA, Angulo A, Meredith H, Kielgast J, Dos Santos L, Bishop P. 2015. Amphibian Conservation Action Plan. IUCN SSC Amphibian Specialist Group. http://www.amphibians.org/publications/amphibian-conservation-action-plan/ (Accessed 17 June 2017),

Young RP, Hudson MA, Terry AMR, Jones CG, Lewis RE, Tatayah V, Zuël N, Butchart SHM. 2014. Accounting for conservation: Using the IUCN Red List Index to evaluate the impact of a conservation organization. Biological Conservation **180**:84–96.

Zippel K, Johnson K, Gagliardo R, Gibson R, McFadden M, Browne R, Martinez C, Townsend E. 2011. The Amphibian Ark: a global community for ex situ conservation of amphibians. Herpetological Conservation and Biology **6**:340–352.

Table 1. Statements of success ordered by the percentage of respondents choosing the statement as one of their 'Top 3' that best describe success in conservation (% Popularity).

| Components of 'conservation success' | % Popularity | Mean score (SE)[a] |
|---|---|---|
| *Species & Site Management*: Reducing known threats to improve the response of conservation target species to conservation interventions | 84 | 4.70 (0.04) |
| *Research*: Applying appropriate research results to conservation practice | 53 | 4.51 (0.05) |

| | | |
|---|---|---|
| *Sustainable resource use*: Promoting sustainable resource use and minimising damaging practices by relevant stakeholders | 47 | 4.26 (0.06) |
| *Education & Awareness*: Increasing support for the conservation of a species among appropriate target audience(s) through a communication, education and public awareness strategy | 46 | 4.30 (0.06) |
| *Government Policy*: Implementing relevant policies and/or promoting legislation relevant to conservation aims | 38 | 4.18 (0.06) |
| *Capacity Building*: Increasing the quality and/or quantity of conservation action(s) through appropriate capacity building (training of project staff) | 32 | 4.09 (0.07) |

[a] Mean scores of importance are out of a maximum of 5, from 1 = Not important to 5 = Highly important in describing conservation success (n = 245).

**Figure 1. General perceptions of success in a conservation programme.** The relationship between types of success noted by respondents and different explanatory variables (*n* = 242).

(a) Species & Habitat: Interaction between conservation practitioners (solid circles, solid line) or non-practitioners (open circles, dashed line) and experience on the perceived importance of Species & Habitat measures to conservation success; (b) Education & Engagement: Interaction between conservation practitioners (solid circles, solid line) or non-practitioners (open circles, dashed line) and the extent of their experience in amphibian research and/or conservation practice on the importance of Education & Engagement on perceived conservation success; (c) Research & Evaluation: Interaction between the respondent's

institution type – non-academic (solid circles, solid line) or academic (open circles, dashed line) – and the number of their ongoing conservation programmes on the importance of Research & Evaluation on perceived conservation success. In each case, fitted lines are model predictions of the change in the response variable (y-axis) when all explanatory variables (x-axis) in the final simplified models are held at their mean values.

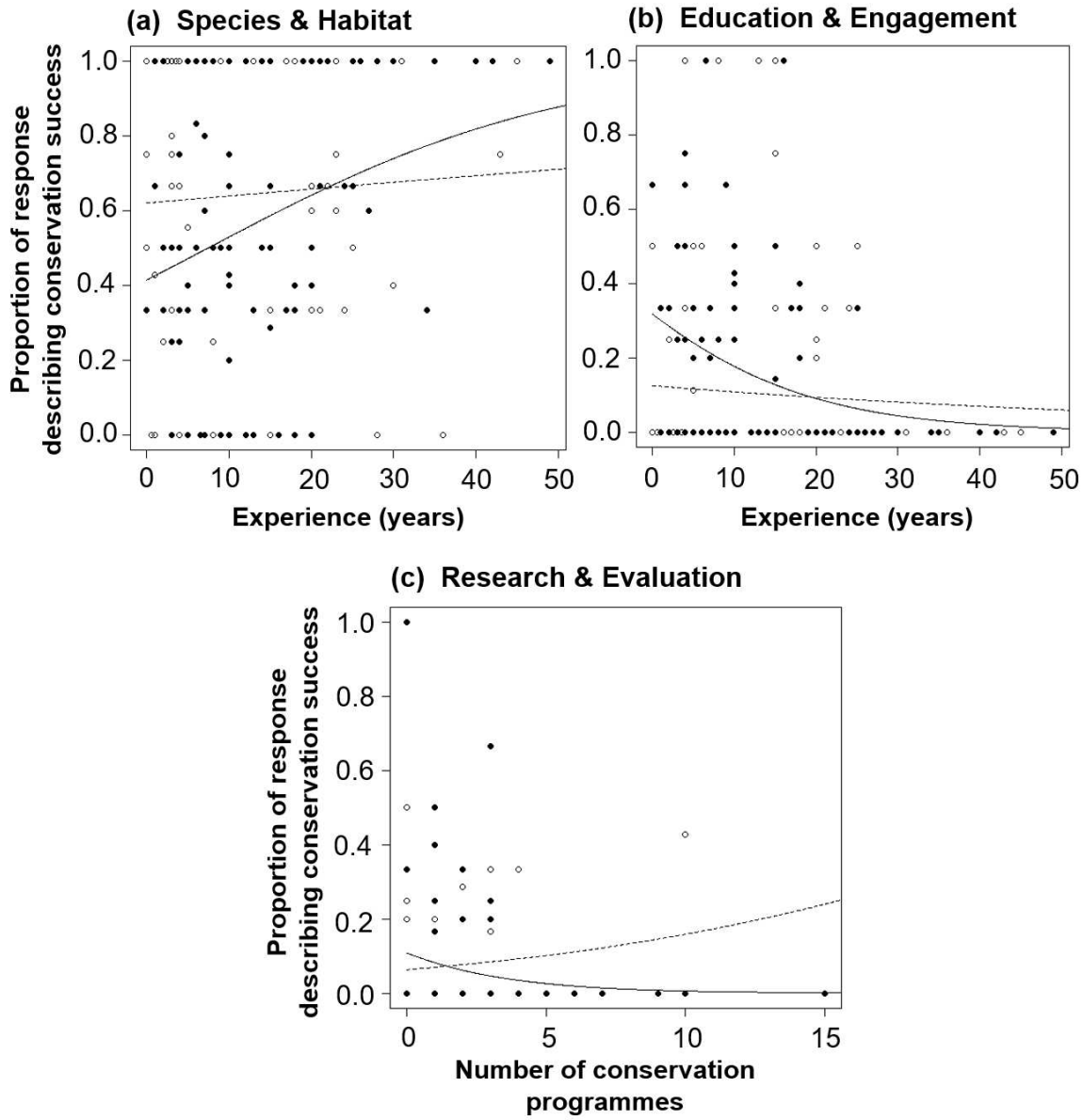

**Figure 2. Components of success in a conservation programme.** The relationship between scores of importance for components of success* and different explanatory variables (*n* = 235).

(a) Sustainable Resource Use: Relationship between experience and the importance score given to the conservation component “Promoting sustainable resource use and minimising damaging practices by relevant stakeholders”; (b) Education & Awareness: Relationship between experience and the importance score given to the conservation component “Increasing support for the conservation of a species among appropriate target audience(s) through a communication, education and public awareness strategy”; (c) Capacity Building: Relationship between experience and the importance score given to the conservation component “Increasing the quality and/or quantity of conservation action(s) through appropriate capacity building (training of project staff)”; (d) Research: Interaction between country (LEDC: open circles, dashed line; MEDC: crosses, solid line) and number of ongoing conservation programmes on the importance score given to the conservation component “Applying appropriate research results to conservation practice”; (e) Government Policy: Interaction between institution (Non-academic: open circles, dashed line; Academic: crosses, solid line) and number of ongoing conservation programmes on the importance score given to the conservation component “Implementing relevant policies and/or promoting legislation relevant to conservation aims”. *See Table 1 for all statements. In each case, fitted lines are model predictions of the change in the response variable (y-axis) when all explanatory variables (x-axis) in the final simplified models are held at their mean values.