From Publications to Public Actions: When Conservation Biologists Bridge the Gap between Research and Implementation

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There is a vigorous debate about the capacity of conservation biology, as a scientific discipline, to effectively contribute to actions that preserve and restore biodiversity. Various factors may be responsible for the current great divide that exists between conservation research and action. Part of the problem may be a lack of involvement by conservation scientists in actually conducting or helping implement concrete conservation actions, yet scientists' involvement can be decisive for successful implementation, as illustrated here by the rapid recovery of an endangered hoopoe population in the Swiss Alps after researchers decided to implement the corrective measures they were proposing themselves. We argue that a conceptual paradigm shift should take place in the academic conservation discipline toward more commitment on the part of researchers to turn conservation science into conservation action. Practical implementation should be regarded as an integrated part of scientific conservation activity, as it actually constitutes the ultimate assessment of the effectiveness of the recommended conservation guidelines, and should be rewarded as such.

Keywords: the great divide, theory-implementation gap, evidence-based conservation, social commitment, conservation in practice

Guidelines and recommendations for practical manage-ment of threatened ecosystems, habitats, and species are common in the rapidly growing scientific literature on conservation biology (Young 2000, Fazey et al. 2005, Joseph et al. 2009). Too rarely, however, are these guidelines effectively implemented (Gelderblom et al. 2003, Cowling 2005, Balmford and Cowling 2006, Knight and Cowling 2008, Knight et al. 2008), and there is increasing acknowledgment of a great divide between conservation science and action (Pfeffer and Sutton 1999, Opdam et al. 2002, Anonymous 2007). Several reasons have been postulated for the existence of this divide.

First, practitioners often do not get the relevant information they need to enact appropriate conservation action. They may have limited access to the scientific literature as a result of financial constraints (Pullin and Knight 2005), or they may have little time to devote to reading scientific articles, which are often published in a foreign language. Moreover, practitioners may not make a distinction between peer-reviewed and conventional publications, and therefore might lack the necessary background to appraise the information critically. Recently launched Web sites for evidence-based conservation have attempted to solve to this problem (see Pullin and Knight 2003, Sutherland et al. 2004, Pullin and Stewart 2006) by processing and delivering the requested information in a filtered way to enhance its utility for practitioners. It is difficult to determine the usefulness of these platforms as the number of systematic reviews and meta-analyses available still remains relatively small, and the language obstacle has not yet been overcome.

Second, conservation researchers often study issues that are simply not relevant to conservation practice, or focus on "easy" conservation problems that result in recommendations that are viewed as trivial by practitioners (McNie 2007). An absence of consultation with practitioners is seen as one of the principal reasons most conservation science lacks applicability (Balmford and Cowling 2006, Haseltine 2006, Knight et al. 2008). A related issue is that a large amount of ecological and biological research is opportunistically published in the conservation literature, even when it cannot inform conservation action (Fazey et al. 2005). The recommendations outlined in this type of scientific paper are often vague and not pragmatic, and not surprisingly, practitioners are confronted with "solutions" where social and economic contexts are not properly appraised, cost-effectiveness of management options is not evaluated, and management prescriptions are not quantitative or spatially explicit (Prendergast et al. 1999).

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Third, a lack of economic, social, and political support may eventually jeopardize any chance of implementation (Roux et al. 2006), even when there is a good match between the expectations of practitioners and the recommendations delivered by researchers. This seems to be one of the most commonly cited obstacles when scientists and practitioners have worked together to put conservation guidelines into action (Jacobson and McDuff 1998, Salafsky et al. 2002, Keane et al. 2008). The problem in this case is clearly beyond the competence of conservation practitioners and scientists, and therefore not central to the "knowing, but not doing" issue addressed here.

A fourth factor, and one that is not often discussed in the literature (as if involvement should be restricted to advising about policies; e.g., Lach et al. 2003), is the absence of commitment by the researchers themselves to engage in conservation implementation. Professionally, academics are essentially evaluated on their research performance; that is, their publication record. Almost all conservation researchers based in academia are focused on this metric for their career progression, with the extremely competitive academic scene providing little room for parallel activities. As a result, many conservation researchers are diverted from the ultimate goal of conservation biology: to increase the probability that ecosystems, species, and populations survive into the future (Soulé 1986). Scientists are currently not specifically rewarded, from an academic viewpoint, for any commitment that would improve the status of biodiversity (Chapron and Arlettaz 2008).

This article focuses on this fourth factor of the research-implementation gap by providing an example of how the actions of conservation scientists based in an academic environment proved to be decisive in a successful conservation action.

The hoopoe (*Upupa epops,* Linnaeus 1758) has become rare in many parts of Central and Western Europe. In Switzerland, the species occurs mostly in Valais, where a small, isolated population had been declining in the middle of the Alps throughout the 20th century (figure 1; Arlettaz 1984). In the late 1990s, a study was launched in an attempt to elucidate the mechanism responsible for the decline; the study resulted in the generation of a set of evidence-based conservation guidelines (Arlettaz et al. 2000). Herein, we describe the formidable demographic response of the hoopoe population following the application of these theoretical guidelines into tailored conservation actions. By writing this article, our hope is to demonstrate that the involvement of scientists at the conservation action stage, in close collaboration with state agencies and local land users, may sometimes be extremely rewarding—at least from a species-conservation perspective. We use this study as evidence that it may be time to consider implementation itself as an essential part of the conservation science process, as it represents a real test of the recommendations made by conservation scientists in their publications. We believe that such an approach, one that includes scientists in the implementation phase, would be highly beneficial to biodiversity and to conservation science, augmenting the credibility of the discipline (Ehrlich 2002, Lach et al. 2003).

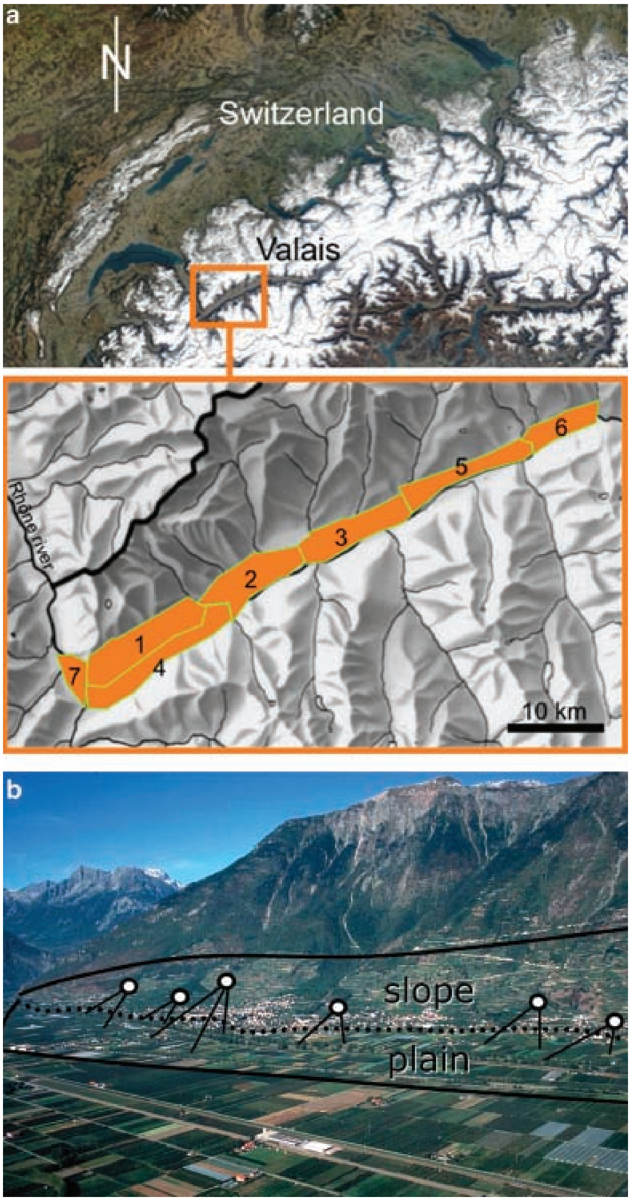

Figure 1. (a) The location of the different study zones (in the canton of Valais, southwest Switzerland; thick line: border to canton of Vaud) that have been sequentially equipped with nestboxes between 1999 and 2003. (b) View of the landscape in the western part of zone 1, where hoopoes have been monitored since 1979. Full line: boundary of the western part of the perimeter; broken line: interface between the foothill slope and the plain. Dots indicate traditional nest sites occupied before the massive nestbox campaign (see figure 2). Arrows show the typical commuting flights that formerly took place between the nest sites on the foothill slope and the main foraging grounds on the plain.

Evidence-based recommendations

The project was conducted on the plain of the upper Rhône valley (Central Valais, SW Swiss Alps; 46°2'N 07°4'E; figure 1). Covering 64 square kilometers (km^2), the study area consisted of a segment of the plain (1.6 × 40 km) that is primarily devoted to industrial farming, in particular fruit tree plantations, vegetables, and vineyards (460 to 520 meters altitude; Arlettaz 1984).

Systematic surveys of the hoopoe population conducted since 1979 (Arlettaz 1984, Arlettaz et al. 2000) revealed a dramatic population decline (Arlettaz et al. 2000). A subsequent research project identified the lack of breeding sites on or close to the plain of the valley as the principal factor limiting hoopoe population growth (Fournier and Arlettaz 2001). The authors showed that hoopoes were constrained to breeding on the foothill slopes because only there were suitable nesting cavities available. Although suitable breeding cavities were also once widely spread on the plain, they no longer exist because of the almost complete eradication of hedges and tall trees (figure 1). They also showed that the diet of the local hoopoe population consisted primarily of mole crickets, *Gryllotalpa gryllotalpa* (Linneaus 1758), a very energetically profitable prey that occurs in soft, sandy alluvial soils on the plain, but not in the stony soils of vineyards on the nearby foothill slopes. Fournier and Arlettaz (2001) therefore suggested providing nesting sites on the plain, which would short-cut the long provisioning trips of the adults between the main food reservoirs on the plain and the breeding cavities situated far away on the adjacent foothills. As a mid- and long-term solution they recommended the restoration of the agricultural matrix on the valley plain by planting hedges to rehabilitate woodpecker populations—woodpeckers create the holes in which hoopoes nest. As a short-term measure they also advised the installation of nestboxes on the plain. They tested the suitability of the latter measure by installing artificial breeding sites in 1998 (Arlettaz et al. 2000), on trees ($n = 29$) or inside agricultural buildings and sheds with only the access hole visible from outside ($n = 11$). The latter nestboxes were a better alternative because they were almost invisible to passersby, and most buildings were locked, which limited the risk of human disturbance. Moreover, these nestboxes were better protected from weather and had almost no evidence of decay. The artificial sites were readily used by hoopoes, so Arlettaz and colleagues (2000) recommended the installation of a large number of nestboxes on the plain.

Practical implementation

The implementation phase was carried out between 1999 and 2003; success control measures and monitoring continue to date. Following the evidence-based recommendations drawn by Fournier and Arlettaz (2001) and the successful pilot test carried out in 1998 (Arlettaz et al. 2000), hundreds of nestboxes were installed on the plain between 1999 and 2003, mostly in agricultural shacks, barns, and other farm buildings not inhabited by humans. To speed up the process, given the critical status of the hoopoe population and our awareness of a potential implementation gap or delay, we (RA, JF, and AS) decided to do the job ourselves, backed by the Swiss Ornithological Institute and with the assistance and support of local farmers, landholders, and citizens. Two state agencies of the canton of Valais (the Office of Agriculture, and the Office of Forest and Landscape) were convinced by the encouraging preliminary feasibility tests (Arlettaz et al. 2000) and provided a substantial financial contribution to the project. As mole crickets are a pest to market gardening (e.g., cauliflowers, asparagus), we presented the project as an attempt to reduce the impacts of mole crickets in an ecosystem-friendly way; this approach allowed us access to most of the farmers' facilities.

We installed 712 nestboxes in successive steps, starting from the area where the first suitability test was conducted in 1998 (zone 1; figures 1 and 2), then proceeding mostly eastward in successive zones (151 nestboxes in zone 1 in 1999; 107 nestboxes in zone 2 in 2000; 105 and 106 nestboxes in zones 3 and 4, respectively, in 2001; and 117 nestboxes in zone 5 in 2002; figures 1 and 2). Finally, in 2003, we equipped the marginal zones at the eastern and western periphery of the regional hoopoe geographic distribution (76 and 30 nestboxes in zones 6 and 7, respectively; figures 1 and 2) to examine the spatial extension of the response of hoopoes to the nestbox scheme.

During the year before we installed the nestboxes in a given zone we conducted surveys in spring, from April to June (Arlettaz et al. 2000). Hoopoe presence was indicated by their distinctive, far-carrying calls, especially early in the season when mating occurred. Later, observation of chick-feeding adults commuting with prey in their beaks was the best way to locate nest sites. These, conducted before nestbox installation, served as controls of pretreatment population status. After installation, nestboxes were checked every fortnight during the breeding season (beginning of April through the end of July) for hoopoe presence. We visited occupied nestboxes more regularly to document reproduction.

The demographic response of hoopoes to the applied corrective measures was estimated through the annual number of broods and fledglings in the entire study area. As a metric, brood number was preferred over the number of breeding pairs because hoopoes often engage in up to two or occasionally even three breeding attempts per year. Annual population growth rate ($\lambda = N_{t+1}/N_t$) was thus calculated from the number of broods. As the proportion of adults engaging into a second or third brood was constant during the course of the study, this most likely represents a reliable approximation of the true growth rate.

Outcome

In the first zone, the recolonization by hoopoes took place within two years of nestbox installation (right panel, 1998–1999 in figure 2). The initial test carried out in 1998 immediately initiated the move (indicated by arrows in figure 2), which was completed as early as 1999. The surveys run in parallel indicated an absence of breeding outside the zone containing the nestboxes from 1999 until 2005, either on the slope or on the plain. Between 2006 and 2008, a few casual singers ($n \leq 5$) were again heard on the slope, probably as a result of a progressive saturation of the suitable habitat on the plain.

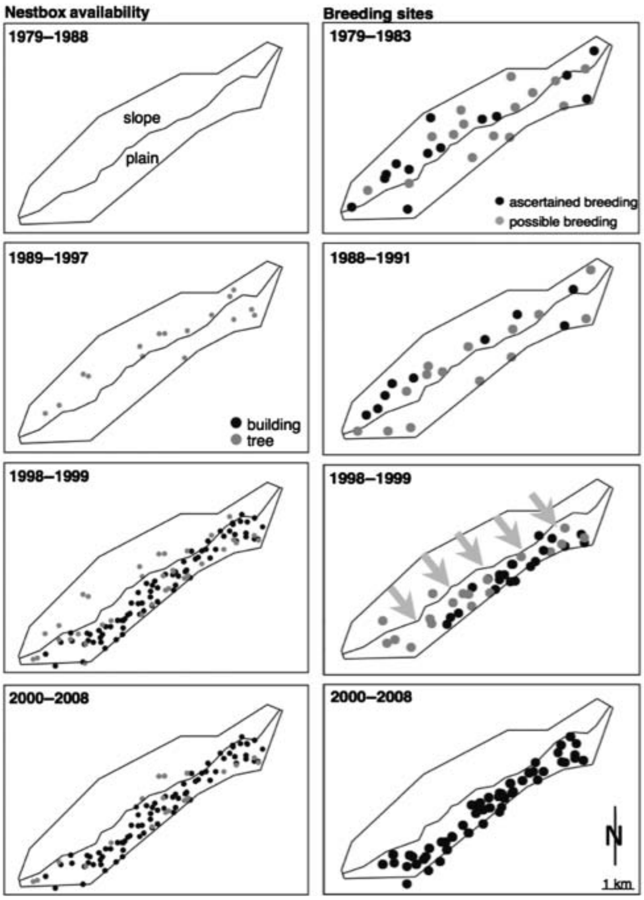

Figure 2. The effect of providing a large number of nest sites on the plain in zone 1 from 1999 onward. The population was surveyed regularly between 1979 and 2008, with absence of data for 1984–1987 and 1992–1997. The response of the local hoopoes was immediate and massive (see arrows) as traditional nest sites on the foothill slope were readily abandoned for the nestboxes on the plain. Black dots are locations where breeding was identified and gray dots are locations where breeding possibly took place. Population monitoring focused principally on nestbox occupancy after 2000 because checks had shown that nonnestbox sites were no longer occupied (no data on possible or probable broods are thus available after 2000).

When the same nestbox measures were implemented in the other zones that contained suitable foraging habitat (zones 2–5, see figure 1), there was also an immediate recolonization by hoopoes. In peripheral areas (the eastern and western ends of the study area, zones 6 and 7), where habitat is less favorable, only a small number of (unsuccessful) breeding attempts were recorded. Using cumulative data from the preimplementation surveys, we estimated that the Valais hoopoe population must have delivered approximately 20 broods a year before the wide-scale installation of the nestboxes. The average yearly population growth rate during the course of the study was 32% (figure 3). This rate represents an almost sixfold increase in population size over a few years (from around 20 broods in the prenestbox period of 1998–2001 to 118 broods in 2007), with about 90% of the asymptotic growth reached in 2004, followed by a slower increase and finally some slight decrease in population size and growth rate (–7%) in the last two years (figure 3).

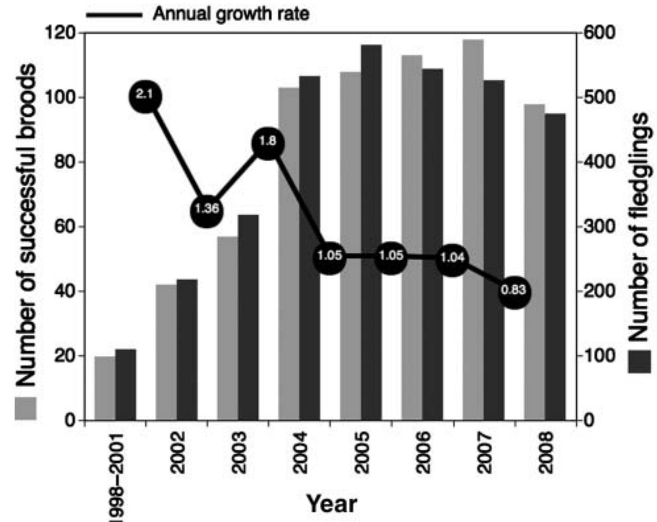

Figure 3. Demographic parameters of the hoopoe population in the entire study area since 1998, including yearly number of successful broods (broods with ≥ 1 fledgling), fledglings, and population growth rate. The period 1998–2001 provides a baseline estimate (preexperimental control) obtained from field surveys.

Involvement of scientists in conservation practice can make a difference

This case study illustrates how the practical involvement of researchers, in close collaboration with local stakeholders (cantonal state agencies and landholders), led to the rapid recovery of an endangered animal population. Without this engagement of scientists in practical implementation, conservation measures (Fournier and Arlettaz 2001) would probably never have been implemented on such a wide scale and at such a rapid pace, and the local hoopoe population would have continued to decline. This example supports the contention that the involvement of conservation scientists in practice can make a real difference to a conservation outcome. Similar success stories exist but are rare in the peer-reviewed literature (e.g., Catry et al. 2009, Rannap et al. 2009, Saalfeld et al. 2009), but the key difference in this example is that the scientists carried out the conservation actions themselves. By doing this, they could prevent the classic gap between the time conservation science is completed and the moment conservation action is implemented (as commonly seen in conservation projects throughout the world; e.g., Whitten et al. 2001).

Crucial for the rapid and massive restoration of the Valais hoopoe population was the availability of a detailed, evidence-based set of conservation recommendations (Fournier and Arlettaz 2001). By identifying the lack of suitable nesting opportunities as the principal cause of hoopoe decline in the study area, suitable guidelines could be generated and applied (Arlettaz et al. 2000). Not surprisingly, the subsequent massive installation of nestboxes caused a sudden spatial shift of breeding pairs of hoopoes from the foothill slopes to the valley plain (figure 2). The sudden close proximity of suitable breeding opportunities to optimal foraging grounds led to a significant increase in reproductive output (Arlettaz et al. 2000, 2010).

One of the most unexpected findings was how quickly and readily hoopoes occupied the new artificial breeding sites. We expected a slow, progressive switch from the foothill slopes down to the plain, as we assumed that hoopoes had first to develop a new "searching image" for suitable nest sites, which could come from a positive nestbox experience by nestlings during their infancy. The fact that the vast majority of nestboxes were rather inconspicuous (to a human eye), with just a small entrance hole (55 millimeters diameter) visible from the outside, was also of concern. However, the immediate occupation of the nestboxes indicated a posteriori that the absence of suitable nesting sites close to the rich foraging grounds on the plain had been very distressful for the local hoopoe population. As nestboxes can represent only a temporary rescue solution, we are now approaching farmers and regional authorities for assistance in restoring agricultural matrices that, in the future, will provide the tall trees and hedges that can attract woodpeckers that will then excavate the most suitable cavities for hoopoes. The development of a close relationship with the local farming community through the nestbox project will very likely prove invaluable for implementing this second phase.

A key factor for the success of the project was its integrated political and social dimension: First, the tremendous support from regional authorities, and second, an incredible enthusiasm—after some initial skepticism—of the local farmers. Here, the public perception of scientists as politically neutral may have contributed to overcoming the acceptance problems usually faced by nongovernmental conservation bodies. During the implementation phase of this project, we were often surprised at the requests of some farmers to install more nestboxes in nonequipped shacks and barns. While inquiring about their motivation, we learned that it was not the ecosystem service provided by hoopoes (the Valais hoopoes presently consume at least 150,000 mole crickets during a breeding season, whereas the costs of treating 1 hectare of vegetable culture with an anti-mole-cricket insecticide amounts to about €1300 per hectare). Instead, the farmers' main motivation was the opportunity to observe these birds during their daily field activities, which highlighted that conservation action can lead to unexpected paradigm shifts among different stakeholders, such as landowners, once the tangible effects of implementation become discernible.

We recognize that this case study represents a very simple situation, as the Valais hoopoe restoration project took place in a wealthy, developed country and featured a charismatic flagship species that was well studied (Arlettaz 1984, Arlettaz et al. 2000, Fournier and Arlettaz 2001). Furthermore, the corrective measures were cheap and required implementation in a relatively small area (64 km^2). It was also a pretty clear win-win situation for biodiversity conservation and local stakeholders, without any major obstacle or need for compromise. For most endangered populations, the context is often more complicated, at least at a first glance. For instance, for several threatened species, it is not the lack of nesting sites but the nonavailability of other key (e.g., foraging) resources during reproduction that remains the crux, and providing these resources can be in direct conflict with human activity. Nevertheless, we believe that this project is an important example of what can be achieved if scientists get involved with the practice of conservation from time to time. There are probably hundreds of situations around the world similar to this example that would require just a small effort by scientists yet would lead to improving the population status of an endangered species. Many such rather simple cases may not yet have been recognized, so a further important task of conservation biologists might be to identify projects with a favorable cost-benefit ratio in which to opportunistically invest their time and effort. Of course, appropriate appraisal concerning species conservation requirements and negative factors at play in population declines remains the crux for formulating evidence-based recommendations that are still lacking in many conservation contexts. This again calls for the development of a real culture of evidence-based conservation among practitioners to bridge the other side of the research-implementation gap (Pullin and Knight 2003, Sutherland et al. 2004, Pullin and Stewart 2006).

Notwithstanding the recent growth of evidence-based conservation and the efforts of many conservation biologists who actively try to implement their research with teams of practitioners on the ground (e.g., Smith et al. 2006, Klein et al. 2008, Joseph et al. 2009), we believe that the lack of commitment to conducting conservation actions demonstrated by many conservation scientists in academic arenas certainly contributes to the well-recognized failure of conservation biology to deliver results in countering biodiversity erosion (Ehrlich and Pringle 2008). In fact, this can be seen as a lost opportunity to learn because implementation of corrective guidelines, as illustrated by our example, is nothing but the ultimate test of the actual relevance of the recommendations made by conservation scientists. As such, control experiments represent an essential way to assess conservation and restoration achievements (Stephens et al. 2002). We therefore agree with Memmott and colleagues (2010) that these actions must be regarded as a requisite part of the integral conservation scientific process as schematically illustrated in figure 4. In this figure, we present the research-action continuum, taken from an academic perspective, and show that conservation issues and challenges raised by practitioners should influence the way conservation scientists set priorities for defining their research topics (Sutherland et al. 2006).

Conservation biology needs to develop new paradigms that systematically elicit fruitful collaborations between the two extreme poles of the conservation continuum—conservation research and conservation action (Whitten et al. 2001, Scott et al. 2008). The future of effective conservation science depends on the ability of conservation academics to build upon these new interdisciplinary pathways. The development of cross-institutional conservation programs, led by integrated conservation teams including all stakeholders, certainly represents one solution to this problem (Jacobson and McDuff 1998, Salafsky et al. 2002, Seidl et al. 2003, Haseltine 2006, Roux et al. 2006, Keane et al. 2008). Only integrative conservation projects that address real issues of biodiversity erosion and foresee pragmatic conservation action as their ultimate endeavor (*sensu* figure 4b) will enable us to efficiently slow the pace of the ongoing sixth mass extinction.

We do not advocate here that all scientists should systematically do all the practical conservation action themselves. In most situations, a deep involvement of scientists would be an inefficient investment of limited time and financial resources and a waste of expertise. Instead, we call for the academic community to adopt new rules that at least tolerate (and at most promote) the

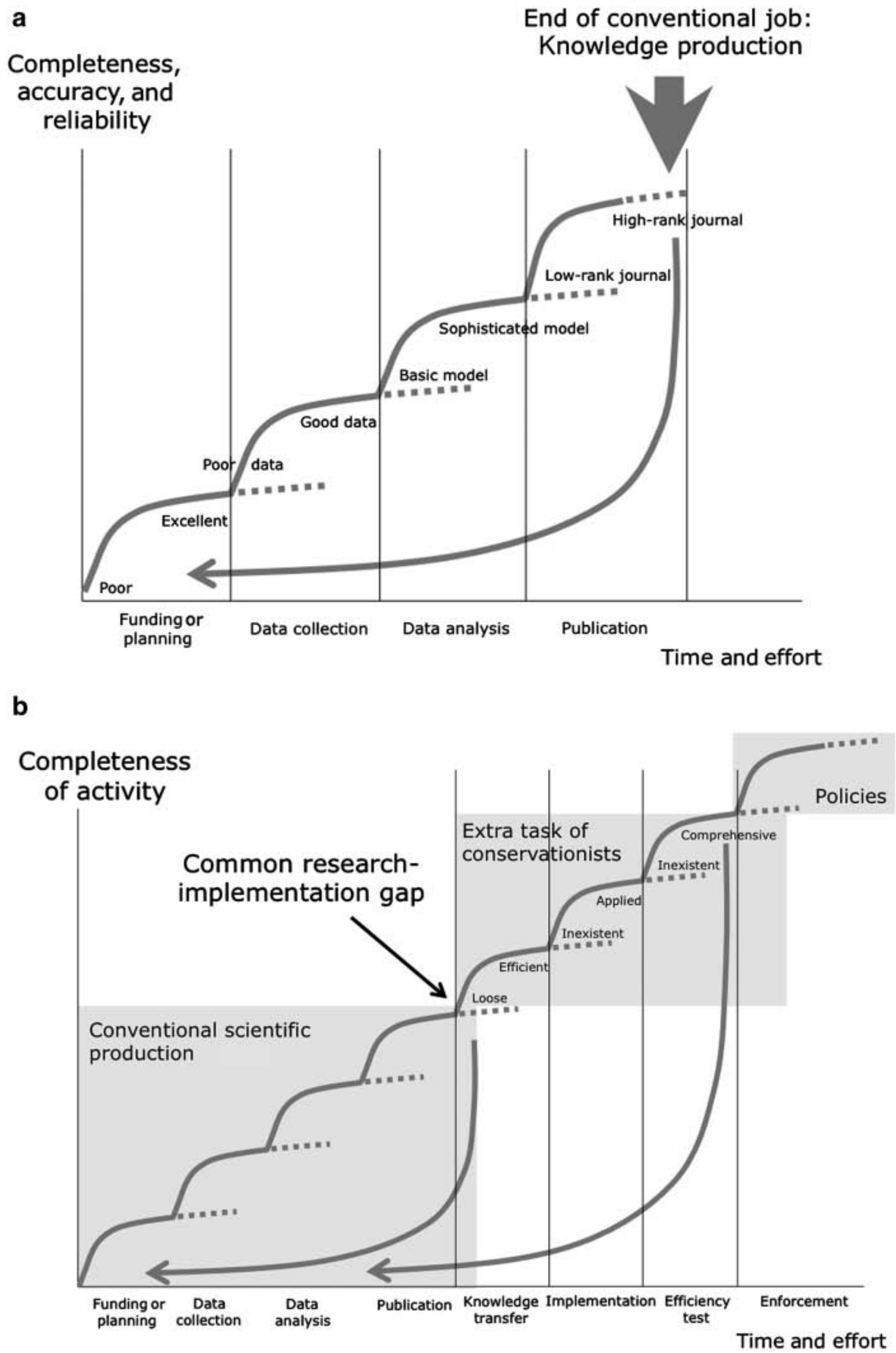

Figure 4. Comparison between (a) conventional scientific research activity, which focuses primarily on knowledge production (publications); and (b) the tasks of conservation scientists who should use implementation as a real-scale test of the validity of their recommendations. The various steps of the research-action continuum, with the main identified gap, are represented as diminishing returning curves for accuracy, completeness, and reliability of the different activities, with respect to invested time and effort. The perspective here is that of academics involved in the research-action process. The backward arrows indicate the circular nature of the process, with the outcome of conservation research and implementation influencing the next round of scientific questioning and actions.

commitment of conservation scientists to practice. Although many breakthroughs and paradigm shifts in applied conservation have stemmed from theoretical rather than empirical research (e.g., systematic conservation planning, Vane-Wright et al. 1991, Margules and Pressey 2000; evidence-based conservation, Pullin and Knight 2003, Sutherland et al. 2004, Pullin and Stewart 2006), the discipline must recognize that a diversity of personal scientific attitudes and positioning is needed along the research-action gradient (figure 4). There is no reason to incessantly discourse on promoting the diversity of life in all its forms and to discount diversity of opinions, strategies, and practical involvement in action when it comes to defining the correct positioning of individual professionals in our corporation. In our opinion, conservation academics will be able to easily position themselves along a research-action gradient (Blockstein 2002), typical of all integrative applied sciences, spanning from pure theoretical to applied-empirical research toward implementation action (figure 4), which itself can take different forms from practical fieldwork (as presented here) to close collaboration with practitioners to purely advisory activities (Haseltine 2006, Scott et al. 2008).

Arguably the most problematic issue is that the current rules for evaluating the performance of conservation scientists are unbalanced and focus mostly on pure theoretical performance, with total disregard for practical implementation. We propose that academics in a field of conservation science should be evaluated by a less crude estimate than their publication records (Lane 2010). We propose a grading system, inspired by bibliographic metrics; a type of "public action" impact factor (Chapron and Arlettaz 2008). Such a metric could be developed to rank conservation academics by their applied performance. Until such novel performance indices are available, we simply advocate that conservation academics, at least those who have a permanent position, conduct additional efforts toward the realization of the corrective measures they propose in their scientific publications, and therefore contribute to maintaining the research-implementation continuum (Cowling 2005). A small effort, such as the one illustrated here, can make a huge difference for biodiversity.

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