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Conservation science relevant to action: A research agenda identified and prioritized by practitioners

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ABSTRACT

A wide gap between research and practice hinders the implementation of biodiversity conservation recommendations. As subjects studied by conservation scientists might bear little relevance for implementation, surveys have identified and framed research questions relevant to conservation in practice. No attempts to prioritize these questions have yet been published, although it would provide invaluable information for steering practice-oriented research. We surveyed Swiss conservation practitioners with the aim of identifying and prioritizing their needs in terms of useful scientific information. A first inductive survey of a selected subgroup generated a list of relevant research questions that were reformulated to be generalizable to all main Swiss ecosystems. The resulting compiled questionnaire was submitted through an online platform to all officially registered practitioners who were asked to rate the importance to their own field of expertise of each question, to nominate possibly omitted, subsidiary questions and to specify "hot topics" typically relevant to their field. Most respondents operated in several ecosystems, which facilitated the identification of general and ecosystem-related research priorities. Generally, questions related to economic, societal and stakeholder conflicts were found to be more important than conceptual questions. Questions concerning single-species were rated higher than ecosystem-related questions. Subsidiary questions and hot topics were subsumed and integrated into a final catalogue of research questions. By identifying and framing scientific questions of both general practical relevance and specific regional importance, this study provides a practice-oriented research agenda and a basis for developing conjoint activities with the intention to bridge the gap between conservation science and action.

1. Introduction

Despite the commitment of most governments to reduce the rate of ecosystem degradation and species loss, the world is facing a historically unprecedented biodiversity crisis. The failure to reach the Biodiversity Convention countdown targets by 2010 can only exacerbate the contention that conventional conservation biology is ineffective for saving, promoting or restoring biodiversity (Possingham, 2000; Whitten et al., 2001). Much criticism is directed towards the great divide that exists between "scientific publications and public actions" in this field (Arlettaz et al., 2010), with the discipline of conservation biology having largely failed to produce results that are practical and applicable in reality (Balmford and Cowling, 2006; Knight et al., 2006, 2008). Although the quantity of publications in the field of conservation biology and restoration ecology is steadily growing (Arlettaz and Mathevet, 2010; Fazey et al., 2005), research continues to contribute only marginally to concrete management of species and ecosystems (Hulme, 2011; Pullin et al., 2004).

Several factors have been postulated to explain what hinders the spread of a real culture of evidence-based conservation and the translation of scientific results into applicable guidelines (e.g. Roux et al., 2006). Although there is consensus within the scientific community that it is the responsibility of scientists to "advise as objectively as possible on where uncertainty is greatest, and where knowledge is sufficient to act" (Morton et al., 2009), many conservation scientists are not seriously committed to implementation, so their management recommendations lack applicability and tend to neglect crucial economic or societal constraints (Arlettaz et al., 2010; Knight et al., 2008). Furthermore, scientific information does not flow efficiently to practitioners and policy-makers who often

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have limited access to peer-reviewed literature and also lack the time to read scientific papers (Pullin et al., 2004). Practitioners and policy-makers are also often insufficiently motivated to commit resources to gathering scientific information because of their perception that conservation scientists omit genuinely relevant subjects (Fazey et al., 2005). One solution could be to better package the output of scientific conservation research via more effective communication media, such as through internet platforms for evidence based conservation, that provide information in a condensed and synthesised way, such as systematic reviews or meta-analyses (Keene and Pullin, 2011; Pullin et al., 2004; Pullin and Stewart, 2006; Sutherland et al., 2004). This information flow remains unidirectional, however, which has recently led to a series of initiatives (reviewed in Sutherland et al. (2011)) that have aimed to identify research questions of particular relevance to conservation practitioners and policy-makers, with the hope of redirecting research activities to enhance the applicability of scientific results.

Sutherland et al. (2006) conducted the first of what have come to be known as ‘‘100 questions exercises’’ (Cooke et al., 2010) to identify the issues deemed by practitioners and policy-makers in the UK to be most important for environmental protection. In that study, policy makers and practitioners from 37 organizations and academia were asked to select, from a list of 2291 questions supplied by 761 researchers, the 100 most relevant. The resulting paper has received broad interest among governmental agencies and NGOs. In a second study, Sutherland et al. (2009) repeated the process with senior representatives from the world’s major conservation organizations, professional scientific societies and universities, with the intention of establishing an agenda of research questions that would have the greatest positive impact on conservation practice worldwide. Inspired by Sutherland et al. (2006), several studies have followed that have narrowed, rather than broadened, their focus and conducted regional and topical 100 questions exercises (e.g. Morton et al., 2009; Pretty et al., 2010; Rudd et al., 2010). Similarly to Sutherland et al. (2006, 2009), all these studies deliberately avoided rating or ranking the importance of the questions because the authors considered that this would have influenced the formulation towards broad and all-embracing questions, which are typically perceived to be more important (Sutherland et al., 2006, 2011). A further reason was that they expected rating or ranking to be strongly dependent on, and probably biased towards the specific expertise and interest of the respondent (Sutherland et al., 2011). However, in view of the limited available financial and time resources in conservation practice, the additional identification of priorities, particularly when specified in relation to an ecosystem type or research field, can yield helpful information for the generation of national or regional research agendas and decisions on the allocation of funding.

The objective of the present study was to use a bottom up approach asking practitioners and policy-makers to nominate the research questions that should be most urgently investigated in order to deliver evidence-based guidance for practice. As one of the first attempts to both identify and prioritize (i.e. rate and rank) the expectations of conservation practitioners towards science, we conducted a nation-wide survey of Swiss practitioners including policy-makers working in federal or cantonal administration (in the following subsumed as ‘‘practitioners’’). Despite its small size Switzerland is characterized by a wide range of ecosystem types (due to very contrasted topography) and a high human population density, which makes it fairly representative in the Central European context – not necessarily with regard to political framework conditions, but with regard to the conservation-related problems faced in a broad variety of ecosystems. By considering questions of both overall relevance and specific regional concerns, we aimed first at recognizing general biodiversity conservation research needs, while at the same time generating a concrete research agenda, aligned with the needs of practice, that will eventually provide Swiss conservation practitioners with more useful information to optimize conservation and restoration action and to influence policy makers in their field.

2. Methods

2.1. Research strategy

One of the main limitations of the studies of Sutherland et al. (2006, 2009) and Pretty et al. (2010) was the difficulty of ranking the questions without affecting, and probably biasing, the formulation process (Sutherland et al., 2011). As a solution to this problem we adopted a two-step strategy. In a first preliminary survey, a small group of conservation practitioners deemed to encompass all main professional activities in the field was invited to formulate a pool of questions. This step essentially replicates the first phase of the studies by Sutherland et al. (2006, 2009). We then synthesized these questions into a logically framed thematic questionnaire which, in a second step, was submitted to a larger, nationwide sample of practitioners who were invited to rate the relevance of each question for their individual field of work. To address the concerns of Cooke et al. (2010) that a group of experts cannot be reasonably expected to represent the full range of stakeholders, we also invited the respondents to the nation-wide inquiry to provide additional questions if they felt an important research topic was missing in the questionnaire. A second conceptual problem, typical of this type of inquiry (Sutherland et al., 2011), was to find the optimal balance between too general and too specific questions. The former are of higher public interest but less likely to be answerable by scientists, whereas the latter are scientifically focused but have a narrower practical relevance (Roux et al., 2006; Sutherland et al., 2011). We tried to achieve a compromise by framing the questions so that they were sufficiently general to be applicable to a broad range of species or ecosystems and by offering the respondents the additional opportunity, for each question, to name specific topics (hereafter ‘‘hot topics’’) that they considered to be of high relevance in their respective field of expertise. We present this dual approach in more detail below.

2.2. First phase: generation of the questionnaire

The aim of the inductive phase was to generate a set of questions, which should be as exhaustive as possible. Using a theoretical sampling strategy (Strauss and Corbin, 1990), in which participants were not selected for statistical representativeness but for maximum variety within the prescribed limits of the sample population (Morse, 1994), we selected 30 from the 584 registered active conservation practitioners in Switzerland (see Section 2.3) on the basis of their representing the widest possible range of professional activity and ecosystem expertise. These persons were categorized according to their affiliation (non-governmental organisation [NGO], private consultant agency, public administration) and their main focal ecosystem (forests, agro-ecosystems, wetlands, rivers, alpine and urban ecosystems), and at least one practitioner per possible combination was selected. The sample was supplemented with practitioners who could not be categorized in any of the combinations, which enabled us to include those engaged in less traditional practical conservation activities. The selected practitioners were asked to nominate research questions that they considered being important in their field of expertise and 21 question sets were supplied. The decision that a sample size of 21 respondents was adequate was made with reference to Sandelowski (1995), and in the knowledge that participants in the qualitative phase would be given the opportunity to supplement the list should any questions be missing.

The 21 question sets contained 86 questions, which were reduced using Jankowicz's (2004) co-recategorization procedure. Two groups made up of research team members, independently and in parallel, derived themes from the submitted research questions and classified each of the questions according to these themes. The results of the two groups were then compared by cross-tabulating the allocation of the questions to the themes. One team identified 15, while the other identified 16 themes, with 9 commonly identified and 28 questions commonly categorized by both groups. A new arrangement of themes was then negotiated in an iterative process until agreement was reached and all 86 questions were finally reallocated to 10 themes. The questions were then reworded so that closely related or redundant questions were subsumed and questions deemed to be too specific were rendered more generic with regard to focal taxa and ecosystems. The reformulated questions were carefully worded to minimize variation in their broadness that might otherwise have put too much emphasis on all-embracing questions (Sutherland et al., 2006, 2011). The resulting set of 44 questions, arranged into the 10 themes under 5 main categories (Table 1), were translated from English into German and French, the two main Swiss languages, and included in an online survey instrument.

2.3. Second phase: survey of Swiss practitioners

In April 2010, all registered Swiss conservation practitioners ($n = 584$) were invited by email to participate in the online survey. The sample included all members of the Swiss Association of Environmental Practitioners (SVU-ASEP), a professional organization where most practitioners in Switzerland are registered. To exclude persons exclusively dealing with technical aspects or abiotic components of environmental protection, we selected all members whose activity profile included at least one of the following keywords: fauna, flora, agricultural management, forest management, landscape planning or environmental management (for a list of keywords: www.svu-asep.ch). We complemented this sample with the mailing list of the Swiss Biodiversity Forum, an information platform for knowledge transfer in biodiversity conservation issues. Our sample encompassed persons dealing actively – but not necessarily exclusively – with biodiversity conservation, including members of applied research institutes working at the science-practice interface, but excluding purely academic researchers (i.e. university researchers). Each practitioner was provided with a personal link to avoid double posting and uncontrolled dissemination to non-target groups. Participants were asked, first, to rate on a Likert scale (Likert, 1932) ranging from 1 to 4 the importance of each individual question for their work and, second, to nominate one or more hot topics related to that question, which would be of particular importance in their field. With this we offered participants the opportunity to narrow the rather general questions down to questions specific to particular species and ecosystems as well as to specific conservation strategies. A neutral option (“I don't know”) was provided for cases where participants were undecided or indifferent towards a particular question. At the end of each thematic section, the participants were invited to nominate questions that were relevant to that section and sufficiently important that they should have been included (hereafter “subsidiary questions”, Table 2). Finally, practitioners were asked to specify their main type of activity and the ecosystem(s) in which they were mostly engaged. Email reminders were sent to the non-respondents two, and again three weeks after the initial invitation. Upon closure of the online survey, an e-mail was sent to all non-respondents inquiring about the reason why they did not participate.

2.4. Statistical analysis

The questionnaire was evaluated in two ways: first, the mean importance assigned to each question and each theme was assessed; second, we tested whether the assigned importance differed according to the ecosystem type in which the practitioner was most involved. Only fully completed questionnaires were evaluated. Cases where the respondent indicated that they could not rate the importance of a particular question were removed from the analysis for that question. When calculating the mean responses, we treated the Likert scale ratings as interval responses, which is justified since integers were assigned to the four possible responses (1: unimportant, 2: minorly important, 3: important and 4: very important). However, to identify ecosystem-related differences and/or biases in assessments of question relevance, an ordinal regression was carried out since it is free from the assumption of normal distribution. The “test of parallel lines” (Garson, 2011) was applied to test for the requirement that the effect of the independent variable (i.e. the ecosystem type the respondent works in) is similar across the different levels of the Likert-scale response. Since respondents could indicate that they work in more than one ecosystem, a binary predictor variable was used to distinguish between persons who work primarily in a particular ecosystem and the remainder of the sample. For this dichotomous variable a positive coefficient means that the former (i.e. the respondents primarily working in that ecosystem) are more likely to have higher scores on the importance rating. We used the Benjamini and Hochberg (BH) (1995) procedure with a False Discovery Rate (FDS) of 5% to account for multiple testing ($n = 44$ questions), as this method controls for type-1 error inflation without overly increasing the type-2 error (Waite and Campbell, 2006).

3. Results

3.1. Respondents

From the 584 practitioners who were invited, 190 (32.5%) commenced the online questionnaire and, of these, 145 (24.8% of the invited practitioners) completed it fully. The 45 participants (23.7% of those who started) who did not finish the questionnaire evaluated an average of 10 questions (min.: 1, max.: 36) and were discarded from the analyses.

The reasons offered by the remainder for not responding were: too busy ($n = 53$); too many such solicitations that cause too much trouble ($n = 12$); wanted to take part but forgot ($n = 15$); did not like the concept and/or the questions ($n = 5$); had already replied to another similar inquiry ($n = 2$). Furthermore, 307 conservation practitioners did not respond to either the survey or to the question about why they did not participate.

According to their individual profiles, 47 (32.4%) of the respondents were working for environmental consulting firms (compared to 29.6% in the full sample [FS]), 42 (29.0%, FS: 34.9%) were employed in the federal or cantonal administration and 24 (16.6%, FS: 19.4%) at an NGO. From the remaining 32 (22.0%, FS: 16.1%), 11 (7.6%, FS: 4.3%) were engaged as environmental consultants for energy, construction or engineering companies, 6 (4.1%, FS: 1.9%) in communication and knowledge transfer organizations, 5 (3.4%, FS: 3.3%) in education, 5, (3.4%, FS 3.6%) in applied research, and 2 (1.4%, FS: 0.9%) at private foundations. The remaining 3 did not mention their affiliation. The activity profile of the respondents (i.e. their distribution across the four main types of activity “environmental consulting firm”, “administration”, “NGO” and “others”, with $n > 20$), did not differ from the full sample (Chi-square test $p = 0.28$) so there was no evidence of self-selection bias with regard to professional activity. The fields of expertise of the respondents

Table 1
The questionnaire (n = 44 questions) synthesized from the first, inductive survey phase that was to be rated according to relevance in the second, nation-wide survey (mean, SD and rank indicated). Questions were regrouped into 10 themes that were classified within 5 upper categories. The 10 highest ranks are indicated with bold numbers.

No	(**Category**, *theme*, question)	Mean	SD	Rank
	Biodiversity requirements			
I	*Species ecology and demography*			
1	What are the main ecological factors responsible for the decline of a target species?	3.56	0.71	**1**
2	Which demographic component (reproduction, survival, etc.) of a target species is most affected by these factors?	3.03	1.02	12
3	What are the qualitative and quantitative requirements of a target species regarding ecological resources (e.g. food, breeding sites)?	3.34	0.93	**3**
4	What is the size of a minimum viable population for a target species?	2.95	0.99	15
5	What are the spatial requirements of a target species (e.g. home range size, dispersal distance, minimum habitat patch size and critical inter-patch distance, minimum viable area for population persistence)?	3.33	0.97	**4**
6	What is the effect of naturally returning or reintroduced species on the pre-existing native wildlife?	2.6	1.04	37
II	*Ecosystem dynamics and requirements for restoration*			
7	Given the change of abiotic conditions (climate, soil) over time: How can we identify the reference state of a particular ecosystem as an objective for restoration?	2.69	1.05	31
8	What size and spatial configuration of ecosystems is necessary to optimize biodiversity in a particular landscape (e.g. within a urbanized lowland area)?	2.96	1.05	14
9	What size and spatial configuration of habitats is necessary to optimize biodiversity in a particular ecosystem (e.g. habitat types in a riverbed ecosystem)?	2.86	1.12	24
10	What amount and spatial configuration of structures is necessary to optimize biodiversity in a particular habitat (e.g. proportion of snags in a forest)?	2.89	1.19	20
	Human impact on biodiversity			
III	*Global change and anthropogenic disturbance*			
11	What is the effect of climate change on species persistence in sensitive ecosystems (e.g. boreo-alpine species in the Alps)?	2.69	1.01	32
12	What are the evolutionary consequences (adaptive potential to change within species?) of the alteration of ecosystems by humans?	2.37	1.12	41
13	Do expanding land use and anthropogenic disturbance favor particular species groups at the expense of others?	2.87	1	23
14	What is the effect of human infrastructure installation (transportation) on ecosystem connectivity?	3.09	0.87	**10**
15	What are the effects of renewable energy development (e.g. wind farms, hydropower micro-factories) on biodiversity?	2.79	1.06	28
16	What are the effects of increasing outdoor human recreation activities on wildlife?	2.9	0.98	18
17	How does the abandonment of traditional land use (e.g. farmland abandonment in marginal areas in the Alps) affect biodiversity?	2.88	1.06	21
18	To which extent is the decline of particular species responsible for the decline of an entire community? (keystone function)	2.24	1.2	44
IV	*Invasive species*			
19	What characteristics make a species become invasive?	2.55	1.03	39
20	In which ways are indigenous species affected by neobiota?	2.63	1.1	35
21	Which invasive species can be efficiently combated?	2.84	1.18	26
22	Which is the optimal time point of the colonization/settling process to start to combat invasive species?	2.73	1.24	30
	Biodiversity assessment			
V	*Tools and techniques*			
23	What are the best techniques for efficient and reliable species/communities/ecosystems monitoring?	3.26	0.94	**7**
24	What are the best criteria for selecting surrogate species (e.g. indicator, umbrella species)?	2.88	1.07	22
25	What are the pros and cons, and limitations of surrogate organisms (indicator and umbrella species) for overall biodiversity management?	2.67	1.07	33
26	How can we assess functional biodiversity?	2.36	1.29	42
27	What are the best techniques for cost-efficient evaluation of the effectiveness of implemented conservation and restoration measures?	3.14	1.05	**9**
	Biodiversity management			
VI	*Management strategies*			
28	How can exploited ecosystems be optimally managed for promoting biodiversity under economic constraints?	3.43	0.83	**2**
29	How can the promotion of biodiversity-relevant ecosystem components (e.g. dead wood) be integrated in land use management?	3.08	1.08	11
30	How to manage exploited ecosystems to buffer them against the negative effects of climate change?	2.26	1	43
31	How to mitigate the effects of disturbance by outdoor human recreation on wildlife?	2.86	1.03	25
32	What methods are effective to control invasive species?	2.81	1.12	27
VII	*Decisions and priority setting*			
33	How to define priority areas and targets for biodiversity conservation (endangered species and ecosystems) under dynamic ecosystems change?	2.9	1.15	19
34	What is the best strategy to integrate small areas or populations for promoting large-scale biodiversity?	2.66	1.17	34
35	How can the red lists be optimized for prioritizing species and habitat conservation measures?	2.57	1.14	38
36	How and when to decide to reinforce populations or reintroduce species?	2.52	1.03	40
VIII	*Knowledge transfer: from science to implementation, and from practice to research*			
37	How to efficiently bridge the research-implementation gap?	3.03	1.06	13
38	How to make the (gray and peer-reviewed) literature broadly accessible to practitioners?	2.78	1.02	29
39	How to direct research towards needs expressed by practitioners?	2.94	1.05	16
	Biodiversity policy			
IX	*Political processes*			
40	How to efficiently convey biodiversity issues to the broad public and society?	3.3	0.92	**5**
41	What is the optimal approach to reconcile the needs of conservation and the ongoing human demand for land use?	3.28	0.94	**6**
42	How to convince the public not to opt for societal choices that are detrimental to biodiversity?	2.94	1.1	17
X	*Incentives*			
43	How can a success-oriented distribution of environmental subsidies (e.g. in agriculture and forestry) best deliver for biodiversity?	3.15	1.12	**8**
44	How to label the biodiversity impact of a product to the consumer?	2.63	1.05	36

covered all Swiss ecosystem types, with a majority (n = 88, 61%) involved in conservation activities in more than one ecosystem (Table A1). This allowed the identification of both general and ecosystem-related research priorities.

3.2. Question importance

The mean importance assigned to the questions varied considerably, both between and also within themes. The highest ranked

Table 2
Supplementary questions, submitted by the participants of the nation-wide survey, assigned to the original themes (Table 1). Questions addressing research issues in economy and social sciences were grouped under a new header (XI: economy and social impact).

No	*Theme*, question
	II. Ecosystem dynamics and requirements for restoration
S1	What are the preconditions for establishing new populations?
S2	What is the actual extinction rate of species in the different habitats listed in this survey?
	III. Global change and anthropogenic disturbance
S3	What are the effects of pollutants or nitrogen on ecosystems?
S4	What is the impact of agricultural machinery on biodiversity outside ecological compensation areas and protected areas?
	VI. Management strategies
S5	What are the place and role of genetic conservation, especially ex situ?
	VII. Decisions and priority setting
S6	What level / amount of biodiversity is possible and desirable in a particular place?
	IX. Political processes
S7	How can the long-term impact/enforcement of political decisions aimed at supporting biodiversity be ensured?
S8	How can conflicts between user groups/stakeholders be successfully solved?
	X. Incentives
S9	(S9) What is the effectiveness of incentives and what determines acceptance of incentives?
	XI. Economy and social impact
S10	Which ecosystem services are relevant for Switzerland: how can they be valued and preserved?
S11	How much is the Swiss society willing to pay for biodiversity?
S12	How do socio-economic conditions (e.g. income, consumption rate, education, age structure, etc.) affect biodiversity (conservation)?
S13	What does biodiversity conservation cost, and how can it be financed?

themes were political processes (3.17; ranking score as in Fig. 1 and Table A 2) and species ecology and demography (3.14), whilst the lowest ranked themes were decisions and priority settings (2.66), invasive species (2.69) and global change and anthropogenic disturbance (2.73). The five other themes tightly grouped together with means between 2.85 and 2.89.

We recorded several ecosystem-specific differences in question rating based on the respondent's own field of activity (Fig. 1 and Table 3). To better illustrate patterns in the data we show both statistically significant findings (BH-adjusted q-value <0.05, indicated with asterisks $*$) and marginally significant trends ($0.05 \leqslant q$-value < 0.1), because an accumulation of ecosystem-related trends within one theme could point towards thematic (not just question-related) priorities. Agro-ecologists assigned a greater importance to questions about spatial requirements of target species (Q5), effects of land abandonment (Q17*), strategies for restoring habitat or population networks (Q34), accessibility of scientific literature to practitioners (Q38) and conservation incentives (Q43*, Q44), but less so to the effect of outdoor recreation on wildlife (Q16) than did practitioners working in other ecosystem types. Alpine ecologists considered issues of landscape ecology (Q8) to be less important than did other practitioners, while species-specific population-related target values (Q4), the effects of land abandonment on biodiversity (Q17) and conflicts between wildlife and expanding anthropogenic land use (Q13*) were deemed more important. The same Q13 also tended to be of more importance to urban ecologists who, in addition, reported habitat fragmentation caused by the development of transportation infrastructure (Q14*) and questions related to neobiota (Q19, Q20*) to be particularly important. Forest ecologists found the effect of outdoor recreation on wildlife (Q16) to be more important than did practitioners in other ecosystems and showed a specific interest in integrating biodiversity-relevant ecosystem components into land use management (Q29). River ecologists reported issues around ecosystem restoration (Q7), conflicts between wildlife and expanding anthropogenic land use (Q13), impact on biodiversity of developing renewable sources of energy, especially hydropower (Q15*), and tools for prioritizing conservation measures (Q35) to be of prime importance. Finally, practitioners working in wetlands showed no ecosystem-specific interests, but found questions concerning the use of surrogate species (Q25) to be less important than other practitioners.

3.3. Hot topics

We received a total of 506 nominations under the hot topics option, with 322 (64%) of them addressing 299 different subjects, attributable to 43 out of the 44 general questions of the inquiry (see Appendix B). However, participants frequently used the hot topics option to submit comments such as stressing the importance of a particular question irrespective of any theme, commenting on extant management strategies or complaining about political, economic or societal constraints without naming a specific topic. These comments ($n = 184$; 36%) were excluded from the analysis.

The retained, relevant hot topics varied from very general to very specific. The number of hot topics submitted per question (both in terms of total number, and reduced number after redundant hot topics between different respondents were grouped) was positively correlated with the scored questions' mean importance (Spearman's rank correlation $r_s = 0.62$ and 0.67, respectively, $p < 0.001$). This suggests that questions of greater interest for practitioners were also characterized by higher expectations regarding specific research outcomes. Given that the questions had been phrased to be as similar in broadness as possible, this result is unlikely to reflect a tendency to add more topics to broader questions. Interestingly, hot topics provided to supplement ecological or management-related questions (themes I–VI; Table 1) were worded as questions, whereas topics referring to questions pertaining to knowledge transfer and political processes (themes VIII and X) were rather framed as expectations or suggestions. The most frequently raised issue among themes I–VI was the design, optimization and management of ecological compensation areas and ecological networks, mainly in agro-ecosystems. Hot topics provided to supplement questions from themes VIII and X mostly addressed communication and collaboration between science, practice and politics.

3.4. Subsidiary questions

The respondents supplied a total of 97 subsidiary questions. Since the opportunity to append new questions was offered at the end of each theme during the course of the online inquiry (and therefore before respondents had completed the questionnaire), many of the extra questions were similar to questions that were

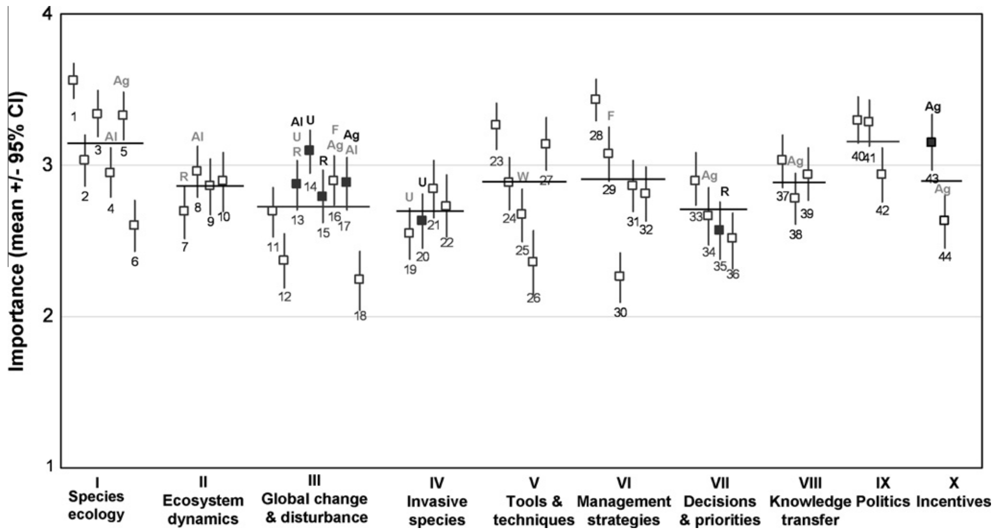

Fig. 1. Rating of the 44 questions, grouped to 10 themes (see Table 1 for extensive definitions; here headings are abbreviated) with regard to their importance (mean ± 95% confidence interval). The horizontal bars indicate the average importance as calculated from all questions within a topical section. Open symbols indicate questions in which importance differed significantly (ordinal regression, Benjamini–Hochberg FDR = 5%, $q < 0.05$, see Table 3 for details) between the practitioners primarily operating in one particular ecosystem (Al = alpine, Ag = agro-ecosystems, F = forest, R = rivers, U = urban, W = wetland) and the remaining respondents. Trends ($0.05 \leqslant q < 0.1$) are indicated with gray letters.

Table 3
Questions in which importance differed between the practitioners primarily operating in one particular ecosystem (number indicated in parentheses) and the remaining respondents identified by means of an ordinal regression. Significant differences after Benjamini–Hochberg adjustment (False Discovery Rate of 5%, $q < 0.05$) are indicated in bold; trends ($0.05 \leqslant q < 0.1$) are shown in plain letters.

Theme	Question	Ecosystem type (*N*)	Unadjusted *p*-value	*q*-Value	Estimate coefficient ± SE
I. Species ecology and demography	Q4	Alpine (35)	0.008	0.050	0.992 ± 0.375
	Q5	Agro-ecosystems (69)	0.028	0.068	0.754 ± 0.343
II. Ecosystem dynamics and requirements for restoration	O7	Rivers (42)	0.011	0.054	0.876 ± 0.344
	Q8	Alpine (35)	0.024	0.068	−0.825 ± 0.367
III. Global change and anthropogenic disturbance	Q13	Alpine (33)	**0.002**	**0.018**	1.226 ± 0.387
		Urban (41)	0.025	0.068	0.781 ± 0.349
		Rivers (42)	0.044	0.088	0.695 ± 0.345
	Q14	Urban (43)	**0.001**	**0.011**	0.942 ± 0.215
	Q15	Rivers (42)	**0.001**	**0.011**	1.190 ± 0.352
	Q16	Forest (49)	0.013	0.057	0.827 ± 0.334
		Agro-ecosystems (72)	0.044	0.088	−0.631 ± 0.313
	Q17	Agro-ecosystems (71)	**0.001**	**0.011**	1.018 ± 0.318
		Alpine (35)	0.026	0.068	0.830 ± 0.373
IV. Invasive species	Q19	Urban (41)	0.037	0.081	0.710 ± 0.341
	Q20	Urban (39)	**0.003**	**0.022**	1.050 ± 0.359
V. Biodiversity management tools	Q25	Wetlands (60)	0.027	0.068	−0.714 ± 0.323
VI. Management strategies	Q29	Forest (47)	0.035	0.081	0.736 ± 0.349
VII. Decisions and priority setting	Q34	Agro-ecosystems (70)	0.010	0.054	0.837 ± 0.326
	Q35	Rivers (41)	0.024		0.782 ± 0.346
VIII. Knowledge transfer	Q38	Agro-ecosystems (69)	0.016	0.064	0.762 ± 0.317
X. Incentives	Q43	Agro-ecosystems (72)	**0.001**	**0.011**	1.187 ± 0.341
	Q44	Agro-ecosystems (69)	0.023	0.068	0.709 ± 0.312

included later in the questionnaire. After dismissing redundancies and subsuming related questions from the remaining subsidiary questions, 13 new questions appeared (Table 2). Nine of them could be attributed to 6 of the 10 pre-defined themes, but 4 addressed a new 11th theme, situated outside conservation biology *sensu stricto* (understood as a nature science) but pertaining to general conservation science, which was named "economy and social impact".

4. Discussion

There are recurrent and increasingly insistent calls to effectively bridge the divide that exists between conservation research and action (Arlettaz et al., 2010), particularly with regard to establishing a new culture of communication and collaboration between researchers and practitioners (Knight et al., 2008; Roux et al., 2006). A first step towards ameliorating the situation is to create a structure of bidirectional knowledge transfer between researchers and practitioners in order to progressively replace expert-based approaches with evidence-based conservation strategies (Pullin et al., 2004; Sutherland et al., 2004). This requires, first, improving the flow of information from applied research outcomes towards policy-makers and practitioners (Pullin et al., 2004), and second, to direct applied research towards the research gaps and needs identified by the practitioners themselves (Knight et al., 2008; Roux et al., 2006; Sutherland et al., 2006). Surveys, such as the one presented here, are, we think, conducive to this purpose, as they contribute to documenting and ranking practitioners expectations towards science. Yet, to deliver useful outcomes, inquiries have to cope with complex methodological challenges (e.g. Sutherland et al., 2011).

4.1. Sampling procedure and representativeness

The representativeness of the sample is the first, critical issue for drawing a realistic, unbiased picture about research priorities. In our case, this concerned two steps: the completeness of the initial set of questions and the representativeness of the ratings allocated by respondents. The first inductive phase was not intended to be representative but to establish an initial question pool. Nevertheless, the finding that an entire theme (economy and social impact) was absent from the pool of questions along with the identification of nine further supplementary questions during the second survey phase, underlines Cooke et al.'s (2010) concerns that even a carefully selected group of experts may miss field-specific relevant issues and highlights the desirability of allowing the list to be supplemented by a larger sample.

With a return rate of 32.5% and a completion rate of nearly 25% the second phase of our survey is within the range of what can be expected from a web survey (Kaplowitz et al., 2004). Nevertheless, both rates fall below those of related studies (e.g. Rosenberg et al., 2010; Rudd, 2011), which obtained 53% and 42% return rates, respectively. However, a low response rate is not necessarily linked with lower accuracy, when the sample is representative (Curtin et al., 2000; Holbrook et al., 2007). The comparison of the respondent's professional activities with the activity profile of the full sample indicates that all groups are sufficiently represented, with no evidence for self-selection bias. These findings, along with an even distribution of respondents across ecosystem types, render us confident that our results are representative of the targeted community.

4.2. General vs. specific questions: reconciling two diverging concepts

The great divide between science and practice in conservation biology may partly result from differences in "operational cultures and working philosophies" (Roux et al., 2006) between academics and practitioners, which are inevitably reflected in both the types of questions raised, and the way of formulating them. While academics operate in a field that calls for innovative research of global relevance, practitioners face pressure to develop local actions targeted towards particular species and habitats (Hulme, 2011). Questions framed by academics take the form of hypothesis testing, which requires reducing system complexity to a series of answerable research interrogations to provide a widely transferable outcome. In contrast, practitioners tend to frame more general and integrative research questions on a system as a whole although local implementation remains their main goal.

To overcome this dilemma, our initial inductive phase produced a set of rather broad questions that was complemented with a second phase of rating and specification. The advantage of the procedure adopted in this paper is twofold: first, the process around formulating and generalizing the questions that were included in the questionnaire was uncoupled from rating; hence the formulation of the questions was not affected by the necessity to rank them (Sutherland et al., 2006, 2011). Second, we obtained three different types of information: the generic question; its relevance for the practitioners; and specific hot topics of local relevance for practice. The combination of this information enables us to merge the interests and requirements of both conservation academics and practitioners in terms of identifying questions with both global relevance and local applicability, which are framed in such a way that they are amenable to scientific research.

4.3. General and ecosystem-bound research priorities

The questions inferred in the inductive survey phase largely addressed issues that had also been featured previously (e.g. Rudd et al., 2010; Sutherland et al., 2009). Specific regional and ecosystem-related differences and priorities were revealed by the rating and specification exercise in the second phase, with the Swiss example reflecting general European particularities and recent environmental trends.

There was a slightly distinct ranking of importance among the themes, with species ecology and demography, and political processes appearing to be more important than the themes labelled invasive species, and decision making and priority settings. The noticeable variation that appears within, rather than between, the themes suggests that importance was assigned for specific questions rather than for themes and that there was no observable learning effect during the process of filling in the questionnaire.

Swiss practitioners attached highest importance to questions that addressed species-specific knowledge and methods for reconciling biodiversity conservation with societal and economic constraints. The first preference seems to be paralleled by those of researchers, since scientific literature in conservation biology was found to be biased towards single-species studies compared to community-based or ecosystem-level approaches (Fazey et al., 2005). In the geographic context of the study, it may also reflect the European conservation tradition with its focus on small-scale species protection, often in human-managed ecosystems rather than on wilderness protection in more pristine ecosystems. The second aspect addresses a component that – although found to be highly important in similar surveys (e.g. Fleishman et al., 2011; Sutherland et al., 2006, 2009) – is lacking in most conservation studies: the consideration of the economic or societal drivers and constraints, which are prerequisite for successful implementation (Knight et al., 2006, 2008; Roux et al., 2006; Salafsky et al., 2002). On the contrary, questions dealing with theoretical or abstract concepts, such as evolutionary adaptive potential, keystone function, or functional biodiversity were considered to be least important. This finding is in line with With (1997) and Pickett et al. (1994) who criticize a lack of integration of ecological theory in conservation practice, a common problem that often arises because most conceptual studies are framed in very general terms, not being transferable into pragmatic examples or applicable guidelines, which represents a major impediment to implementation (Fazey et al., 2005).

Interestingly, the general ranking-pattern was rather consistent throughout the sample and was independent of the ecosystem in which the respondents were primarily engaged. However, there were some noticeable ecosystem-specific exceptions, most of which were linked to political or economic developments. First, issues around incentives were particularly important for practitioners working in farmland. This is not surprising given the widespread implementation of agri-environmental schemes in Europe, which have been for the most part only minorly effective for biodiversity, despite generous subsidies (Aviron et al., 2009). The great demand for improved knowledge in this area was also reflected by the contributed hot topics, where the optimization and management of ecological compensation areas and ecological networks in farmland were among the most frequently addressed issues. Second, questions pertaining to the effects of renewable energy production appeared particularly important in river ecosystems, reflecting the expansion and subsidization of the use of these as sources of energy following the political decisions in several Central European countries to rely less or even abandon nuclear energy. Finally, practitioners working in alpine ecosystems gave higher importance to questions that concerned changes in land-use Alpine ecosystems which are particularly impacted by economically driven land-use shifts. The replacement of unprofitable pasture-systems by tourism industry leads to vegetation encroachment followed by a progressive decline of the typical biodiversity of semi-open subalpine and timberline ecosystems (Maurer et al., 2006) while anthropogenic disturbance in recreation areas impacts on sensitive wildlife (Arlettaz et al., 2007; Braunisch et al., 2011; Patthey et al., 2008). All these examples highlight the direct influence of political and economic decisions on biodiversity status and management, and the consequential necessity to integrate economic and societal factors in conservation research.

Interestingly the questions relating to global change were generally rated as being of quite low importance, which contrasts with previous studies, such as that of Morton et al. (2009) who identified climate change as an issue of major environmental concern in Australia. The threat of climate change is perceived as more serious in low-populated, dry and desertic Australia, than in the densely-inhabited temperate context of Central Europe where anthropogenic land-use changes have long affected nature and may thus be perceived as a more immediate, and manageable, threat.

Through the identification of regional and ecosystem-bound priorities in biodiversity conservation, the present exercise provides valuable synthesised information for generating a practice-oriented national research agenda and for the allocation of funds accordingly. The chosen approach is not free of caveats, however. Although we believe that conservation themes classically popularized in the media affected our target group only marginally, allocation of importance to a particular question is inherently subjective and conservation practitioners are influenced by a variety of factors including their own context, experience and awareness of how the results of research may be applied. Emerging research fields which may be highly relevant for conservation, but are poorly advertised or explained by science, may thus be underrated by practitioners. This may for instance explain why conservation genetics was absent from the questions raised by practitioners during the first survey phase, and mentioned only once as a supplementary question in the nation-wide survey. Although the capacity for genetics to contribute to conservation has been established in the scientific literature, it has been shown to make an insufficient contribution to practical management (Moyle et al., 2003). Even when aware of the implications that genetic processes have for conservation, molecular methods are frequently perceived by practitioners as expensive and obscure with limited practical applicability (Howes et al., 2009). Better communication from scientists (Moyle et al., 2003) along with practical decision support systems that guide practitioners through the process of defining analytical questions and interpreting their outcome (e.g. Hogbin et al., 2000; Howes et al., 2009) may show the potential of molecular tools and enhance their perceived importance among practitioners.

4.4. Interdisciplinarity and collaboration with social sciences

The finding that practitioners consider the integration of social sciences into practical ecology to be important is in agreement with the results of previous studies by Sutherland et al. (2006, 2009) and Fleishman et al. (2011). Although not directly connected to conservation biology as a life science discipline but to conservation science more generally, this finding supports previous arguments that once conservationists have developed strategies to achieve a particular outcome, they also need a strategy to obtain the desired political decision or public support (Mathevet and Mauchamp, 2005). Morton et al. (2009) and Mathevet and Mauchamp (2005) argue that insufficient links between ecological research and the social sciences, including resource economics, governance and institutional design, constrain progress towards sustainable ecological management. While the number of interdisciplinary studies in which social sciences and ecology are included is increasing, disciplinary methods tend to be not deeply integrated, and hence have limited impact in practice (Evely et al., 2010).

4.5. Transfer and implementation

Orienting scientific efforts towards practice relevant questions and providing practising conservation biologists with these tools is an inherent duty of conservation biology (Soulé, 1986). However, for bridging the divide between science and practice, unidirectional knowledge transfer will not suffice: rather this requires improving commitment, communication and collaboration (Arlettaz et al., 2010; Roux et al., 2006), which was a point frequently raised in the hot topics and by the practitioners commenting on this study. New ways of bidirectional knowledge transfer must be developed, and ideally complemented by common activities, such as joint conservation research-implementation projects (Roux et al., 2006), to not only enhance exchanges of information, but also to enable understanding of the demands and constraints in the respective field. To facilitate the implementation of the results of this study into science, practice and politics, we propose establishing platforms with personnel who are both scientifically well trained in, and committed to evidence-based conservation philosophy and familiar with the tenets of conservation practice. The task would be, first, to synthesize and enhance bilateral information exchange between conservation researchers and practitioners and second, to organize and support conjoint conservation research-implementation activities around priority issues. This will foster the integration of these two groups so that they influence each other more deeply in the way they conceive their work, with their goals becoming aligned, thus contributing to bridge the gap between conservation science and action. Our hope is also that the present prioritization exercise of conservation relevant topics will be an inspiration for public and private funding agencies to allocate resources to useful biodiversity conservation research and action in Switzerland.

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Table A1
Number of practitioners engaged in conservation activities in a primary ecosystem type that were also involved in other ecosystem types. Upper matrix triangle: absolute sample sizes (*n* total = 145); lower triangle: corresponding percentages. Percentages do not sum to 100 since several practitioners work in more than two ecosystem types.

	Primary ecosystem	No other (%)	Forests	Agro-ecosystems	Wetlands	Rivers	Alpine	Urban	No other
Forests	49	27		24	25	15	17	13	13
Agro-ecosystems	72	22	33		39	26	23	23	16
Wetlands	60	8	42%	65%		27	28	20	5
Rivers	42	17	36%	62%	64%		15	16	7
Alpine	36	6	47%	64%	78%	42%		11	2
Urban	43	33	30%	53%	47%	37%	26%		14

Table A2
Importance assigned to each question (mean and standard deviation).

Theme (mean relevance, rank from high to low)	Question	N (total)	Mean	SD
I. Species ecology and demography (3.14, 2)	Q1	145	3.56	0.71
	Q2	144	3.03	1.02
	Q3	144	3.34	0.93
	Q4	145	2.95	0.99
	Q5	144	3.33	0.97
	Q6	144	2.60	1.04
II. Ecosystem dynamics and requirements for restoration (2.85, 7)	Q7	145	2.69	1.05
	Q8	145	2.96	1.05
	Q9	140	2.86	1.12
	Q10	143	2.89	1.19
III. Global change and anthropogenic disturbance (2.73, 8)	Q11	144	2.69	1.01
	Q12	145	2.37	1.12
	Q13	143	2.87	1.00
	Q14	144	3.09	0.87
	Q15	143	2.79	1.06
	Q16	144	2.90	0.98
	Q17	144	2.88	1.06
	Q18	143	2.24	1.20
IV. Invasive species (2.69, 9)	Q19	144	2.55	1.03
	Q20	142	2.63	1.10
	Q21	144	2.84	1.18
	Q22	142	2.73	1.24
V. Biodiversity assessment (2.86, 5)	Q23	144	3.26	0.94
	Q24	144	2.88	1.07
	Q25	144	2.67	1.07
	Q26	141	2.36	1.29
	Q27	144	3.14	1.05
VI. Management strategies (2.89, 4)	Q28	144	3.43	0.83
	Q29	144	3.08	1.08
	Q30	144	2.26	1.00
	Q31	143	2.86	1.03
	Q32	144	2.81	1.12
VII. Decisions and priority setting (2.66, 10)	Q33	143	2.90	1.15
	Q34	144	2.66	1.17
	Q35	144	2.57	1.14
	Q36	144	2.52	1.03
VIII. Knowledge transfer (2.85, 6)	Q37	144	3.03	1.06
	Q38	143	2.78	1.02
	Q39	142	2.94	1.05
IX. Political processes (3.17, 1)	Q40	144	3.30	0.92
	Q41	144	3.28	0.94
	Q42	144	2.94	1.10
X. Incentives (2.89, 3)	Q43	144	3.15	1.12
	Q44	143	2.63	1.05

Appendix A

(See Tables A1 and A2).

Appendix B. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.biocon.2012.05.007.

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Appendix A

Table A.1: Number of practitioners engaged in conservation activities in a primary ecosystem type that were also involved in other ecosystem types. Upper matrix triangle: absolute sample sizes (n total = 145); lower triangle: corresponding percentages. Percentages do not sum to 100 since several practitioners work in more than two ecosystem types.

	Primary ecosystem	No other	Forests	Agro-ecosystems	Wetlands	Rivers	Alpine	Urban	No other
Forests	49	27%		24	25	15	17	13	13
Agro-ecosystems	72	22%	33%		39	26	23	23	16
Wetlands	60	8%	42%	65%		27	28	20	5
Rivers	42	17%	36%	62%	64%		15	16	7
Alpine	36	6%	47%	64%	78%	42%		11	2
Urban	43	33%	30%	53%	47%	37%	26%		14

Table A.2: Importance assigned to each question (mean and standard deviation)

Theme (mean relevance, rank from high to low)	**Question**	**N (total)**	**Mean**	**SD**
I Species ecology and demography (3.14, 2)	Q1	145	3,56	0,71
	Q2	144	3,03	1,02
	Q3	144	3,34	0,93
	Q4	145	2,95	0,99
	Q5	144	3,33	0,97
	Q6	144	2,60	1,04
II Ecosystem dynamics and requirements for restoration (2.85, 7)	O7	145	2,69	1,05
	Q8	145	2,96	1,05
	Q9	140	2,86	1,12
	Q10	143	2,89	1,19
III Global change and anthropogenic disturbance (2.73, 8)	Q11	144	2,69	1,01
	Q12	145	2,37	1,12
	Q13	143	2,87	1,00
	Q14	144	3,09	0,87
	Q15	143	2,79	1,06
	Q16	144	2,90	0,98
	Q17	144	2,88	1,06
	Q18	143	2,24	1,20
IV Invasive species (2.69, 9)	Q19	144	2,55	1,03
	Q20	142	2,63	1,10
	Q21	144	2,84	1,18
	Q22	142	2,73	1,24
V Biodiversity assessment *(2.86, 5)*	Q23	144	3,26	0,94
	Q24	144	2,88	1,07
	Q25	144	2,67	1,07
	Q26	141	2,36	1,29
	Q27	144	3,14	1,05
VI Management strategies (2.89, 4)	Q28	144	3,43	0,83
	Q29	144	3,08	1,08
	Q30	144	2,26	1,00
	Q31	143	2,86	1,03
	Q32	144	2,81	1,12
VII Decisions and priority setting (2.66, 10)	Q33	143	2,90	1,15
	Q34	144	2,66	1,17
	Q35	144	2,57	1,14
	Q36	144	2,52	1,03
VIII Knowledge transfer (2.85, 6)	Q37	144	3,03	1,06
	Q38	143	2,78	1,02
	Q39	142	2,94	1,05
IX Political processes (3.17, 1)	Q40	144	3,30	0,92
	Q41	144	3,28	0,94
	Q42	144	2,94	1,10
X Incentives (2.89, 3)	Q43	144	3,15	1,12
	Q44	143	2,63	1,05

Appendix B

Specific “hot topics” submitted to each of the 44 research questions in the questionnaire. Topics submitted by more than one participant are indicated and the number of submissions given in parentheses.

I Species ecology and demography

Q1: What are the main ecological factors responsible for the decline of a target species?

Agricultural ecosystems:

1 Effects of intensification on agricultural ecosystems
2 Effects of overgrowth of pastures
3 Intensification of grassland at different altitudes: effects on insect diversity
4 Effects of irrigation of grasslands on the development of invertebrates
5 Effects of the eutrophication of poor meadows
6 Factors responsible for the decline of invertebrates and birds in agricultural ecosystems
7 Effects of the expansion of agrobusiness on biodiversity, also in developing countries

Forest ecosystems:

8 Factors responsible for the decline of the forest birds among the 50 priority species of the Swiss programme for bird conservation
9 Effect of forestry on different forest species
10 Reasons for the decline of biodiversity in the wooded pastures and subalpine forests of the Jura mountains
11 Relation between loss of dead wood, cavity trees, and breeding trees and the decline of birds in managed forests
12 Decline of forest species: effects and interactions of biotic, abiotic and anthropogenic factors

Industry, technical developments, infrastructure

13 Industrial environmental protection
14 Effects of new infrastructure and soil sealing in agricultural ecosystems
15 Effects of windpower plants
16 Impact of technical infrastructure (power lines, wind power plants, traffic)
17 Conflicts with birds in Urban areas
18 Habitat loss due to culvertization
19 Effects of forest soil compaction by heavy machinery
20 Effects of (minimum) discharge regimes in rivers and streams when using hydro energy
21 Effects of drainage of wetlands

Pollution

22 Effects of air pollution
23 Effects of lake pollution
24 Effects of pesticides in aquatic ecosystems on aquatic organisms

Others

25 Main factors for trivialization or decline of entire communities

26 Factors for species declines in areas with intact habitat conditions
27 Changes in ecological processes
28 Effect of fauna-flora interrelations in the decline of birds, butterflies, odonata, amphibians
29 Effects of climate change
30 Habitat fragmentation as a cause of biodiversity loss

Q2: Which demographic component of a target species is most affected by these factors?

Impacts on population dynamics

31 Main causes of reproduction failure, main causes of adult mortality
32 Threshold values for adult mortality and survival rates with regard to population viability
33 Developmental biology and dispersal behaviour of butterflies
34 What factors affect the development of fish-eggs in the river bed
35 How does reproductive success depends on trophic resources?
36 Effects of forestry and building projects during the reproductive season of hemerophilic species

Mitigation measures

37 Development of targeted measures to increase the survival rate of a target species
38 At which time (in the reproductive cycle of a population) do building projects have the least impact on a population?

Q3: What are the qualitative and quantitative requirements of a target species regarding ecological resources (e.g. food, breeding sites)?

39 Requirements of amphibians, birds and mammals in farmland
40 Requirements of insects in extensive meadows and water bodies
41 Relation between habitat structure and food availability
42 Habitat requirements of game species
43 Habitat requirements (patch size and structure) for reintroduced and recolonising species
44 Landscape connectivity for returning animal species: assessment and improvement of measures to mitigate fragmentation
45 Thresholds and target values for the planning of compensation measures: how much is neccessary?
46 Qualitative and quantitative requirements for optimally managing floodplains and riparian habitats
47 Qualitative and quantitative requirements for creating ecological (habitat-) networks and improving connectivity
48 Minimum discharge regimes and water level in streams (use of hydro-power) (2x)

Q4: What is the size of a minimum viable population for a target species?

49 MVP of indicator and umbrella species and interrelations with management
50 MVP of species typical in gravel-quarry ponds (e.g. yellow bellied toad (bombina variegata), sand martin (riparia riparia))
51 MVP of butterflies
52 MVP of game ungulates
53 MVP of endangered fish and crustaceeans (e.g. Roi du Doubs (zingel asper), lake trout (salmo trutta lacustris))
54 MVP of capercaillie in the Jura mountains and species of TWW (dry meadows and pastures)
55 Minimum number of habitat patches to preserve or restore a MVP of a target species?

Q5: What are the spatial requirements of a target species (e.g. home range size, dispersal distance, minimum habitat patch size and critical inter-patch distance, minimum viable area for population persistence)?

Species-specific requirements

56 Spatial requirements of small carnivores (mustelids)

57 Spatial requirements of red deer

58 Spatial requirements of alpine fish species, consequences for fishery

59 Spatial requirements of species of gravel-quarry habitats

60 Spatial requirements of species in urban ecosystems (where habitat loss is particularly high)

61 Dispersal/migration distances of fish (e.g. eel, salmon, lake trout (salmo trutta lacustris)), barriers to dispersal (weirs)

62 Knowledge about the dispersal capability of species (animals and plants)

63 Home range sizes in relation to varying density and availability of food resources : when is the foraging effort so high that breeding success is negatively affected?

64 Spatial requirements of species in relation to different habitat types

Spatial requirements and management decisions

65 Scientific basics for the creation of "green spaces" (semi-natural habitats) in urban areas

66 Minimum spatial requirements for constituting ecological networks through ecological compensation areas

67 Spatial requirements for establishing networks of wetland ecosystems

68 Given the spatial requirements of a species: is it possible / worth while to support a species in a given project? (e.g. creation of ecological networks) (2x)

69 Definition of management targets in relation to patch size: independent population or "stepping stone" in a metapopulation system?

70 Spatially-explicit information of species' spatial requirements (not just general, theoretical formulation)

Q6: What is the effect of naturally returning or reintroduced species on the pre-existing native wildlife?

71 Effects of reintroduction of amphibians in gravel-quarry ponds

72 Effect of large carnivores (lynx, wolf) on red-deer (3x), other native species (2x) and consequential effects on forest damages (browsing, bark stripping)

73 Effects of neophytes which are sold in garden centers and disperse from domestic gardens

74 Effects of neophytes in protected areas

75 Initial release of endangered fish and crustacean species in revitalized aquatic ecosystems

76 Effects of direct and indirect competition between native and reintroduced / returning species?

77 Where are the potential habitats for Neobiota in Switzerland and the Alpine range, which are the best ecological criteria for their delineation?

II. Ecosystem dynamics and requirements for restoration

Q7: Given the change of abiotic conditions (climate, soil) over time: How to identify the reference state of a particular ecosystem as an objective for restoration?

78 Reference state for riparian (riverbank-) habitats, particularly with regard to (re-)vegetation

79 Reference state for the renaturation of gravel quarries?

80 Definition of reference states under considerations of climate change

81 What is the altitudinal shift of plants and associated fauna under climate change?

82 How long after abandonment is an exploited landscape type (e.g. grasslands) restorable? (particularly: marshes and dry meadows)

83 To which extent (when?) is the restoration of a reference state of an ecosystem legally claimable?

Q8: What size and spatial configuration of ecosystems is necessary to optimize biodiversity in a particular landscape (e.g. within a urbanized lowland area)?

84 Optimal size and spatial configuration for ecological compensation areas in multifunctional farmland

85 Targets for the restoration of riparian habitats with regard to flood protection
86 Target values for the restoration of rivers
87 Importance and optimization of near natural gardens and parks for the biodiversity in urban areas
88 Designation of protected areas: quantitative and qualtitative targets regarding connectivity, composition and configuration of habitat types
89 What composition of habitat types makes an area particularly valuable for protection?
90 Spatial and compositional targets for compensation measures (for infrastructure projects)

Target values for ecological networks…
91 - of rare habitats
92 - of ecological compensation areas in farmland
93 - for connecting major and secondary tributaries, mitigating of barriers for migration
94 - for restoring and connecting former mining sites

Q9: What size and spatial configuration of habitats is necessary to optimize biodiversity in a particular ecosystem (e.g. habitat types in a riverbed ecosystem)?

95 Targets for compensation measures (2x): is replacement habitat adequate?
96 Ecological networks in farmland: habitat requirements of target species (2x)
97 Qualitative targets for the designation of protected areas and restoration projects
98 What is better: centralized or decentralized mining sites?
99 How to optimize river revitalization (e.g. the Rhône) in spatially constrained systems
100 Optimal size and spatial configuration of habitats in floodplain ecosystems
101 Optimal size and spatial configuration of forest reserves, patches of dead wood in a forest

Q10: What amount and spatial configuration of structures is necessary to optimize biodiversity in a particular habitat (e.g. proportion of snags in a forest)?

102 Required area and amount of forest structure elements (1x) and islets of old forest (1x) to promote forest biodiversity?
103 Necessary structure to optimize biodiversity in wooded pastures?
104 Optimal density and amount of small structures (hedges, stone-piles etc.) (2x)
105 Targets for compensation measures?
106 Ecological Quality Regulations: Minimum requirements for pastures, orchards, vineyards?
107 Proportion of un-mown grass (refuges) in a meadow?

III. Global change and anthropogenic disturbance

Q11: What is the effect of climate change on species persistence in sensitive ecosystems (e.g. boreo-alpine species in the Alps)?

108 Effect of climate change on bats?
109 Effect of climate change on the distribution range of black grouse?
110 Potential decline of boreo-alpine caddisflys (trichoptera), expansion of eurythermic species to higher altitudes
111 Effect of climate change on Alpine and cold-climate-adapted fish species, adaptive potential and consequences for fishery and management? (3x)
112 Effect of warming of rivers and streams on biodiversity?
113 Spread of oak in the lowlands (on plains)
114 Changes of the alpine treeline and development of bird species in treeline and above-treeline habitats?
115 Summer drought in forests: effects on tree species, which species are resistant?
116 Altitudinal up-shifts of forests and alpine habitats?

117 Effects of desiccation of agriculturally used soils and consequential effects of irrigation, abandonment, change of use?
118 Protected areas and networks: strategic recommendations for adaptations to climate change

Q12: What are the evolutionary consequences (adaptive potential to change within species?) of the alteration of ecosystems by humans?

119 Carrying capacity of habitats that are characteristic of stream and river ecosystems?
120 Increasing out-competing potential of invasive, exotic species
121 What are the potential costs, but also economical chances arising from species adaptation?
122 Ecosystem resilience: How can the genetic variability in ecosystems be measured, communicated to policy and integrated in conservation management?

Q13: Do expanding land use and anthropogenic disturbance favour particular species groups at the expense of others?

123 Effects of eutrophication
124 Trivialization of species (plant) communities (2x)
125 Impact of roads
126 Invasive Neophytes
127 Promotion of plant species by "chemical selection" in agriculture
128 Do habitat networks promote the distribution of undesired harmful species
129 Increase of reed in fens
130 Changes in species' distributions and abundance (e.g. red fox in urban areas; increase of corvids; decline of plants associated to cereals; decline of pioneer species and species of fallowland)
131 Changes in predator-prey relationships (e.g. red fox, carrion crow and ground-nesting birds in agricultural areas)

Q14: What is the effect of human infrastructure installation (transportation) on ecosystem connectivity?

132 Effect of roads / infrastructure as barriers or obstacles for dispersal between nodal areas of habitat networks?
133 (Species-specific) barrier effect of different types of transportation infrastructure?
134 Permeability of passages for fish and invertebrates
135 Effects of fragmentation for micro organisms?
136 Can roads/ road verges be used to for creating habitat networks?
137 Effectiveness of wildlife passages
138 Effect of forest roads on capercaillie

Q15: What are the effects of renewable energy development (e.g. wind farms, hydropower micro-factories) on biodiversity?

Wind energy:
139 Effect of wind turbines on habitat quality for endangered breeding birds
140 Wind turbines and problems of bird collisions (raptors, migrating birds)
141 Effect of wind turbines on bats
142 Problems for birds and bats arising from wind turbines on the ridges of the Jura massif
Hydro-energy:
143 Effects of hydro-power on biodiversity?
144 Critical amount of residual flow (minimum water level) when using hydropower stations? (2x)
Bio-energy (plants)
145 Use of wood (plantations, coppice wood) as bio-fuel: effect on biodiversity

146 Effect of the increased use of firewood on forest biodiversity

Q16: What are the effects of increasing outdoor human recreation activities on wildlife?

147 Effects of disturbance of cliff-nesting birds
148 Disturbance of mammals in forests
149 Effects of dogs
150 Effects of recreational hunting
151 Effects of restocking mountain lakes for fishing
152 Effects of disturbance on wild ungulates
153 Disturbance (of birds) in suburban farmland
154 Effect of human disturbance on invertebrates?
155 Effects of canyoning, tubing and kayaking on rivers
156 Relation between human disturbance and the extent of browsing damage, selective pressure on particular tree species?
157 How big are the impacts of disturbance really (e.g. with regard to species fitness)?
158 "Critical load" for human disturbance: do conservation measures (e.g. habitat restoration) make sense in areas with a high level of human disturbance?
159 Creation of refuges and reproduction zones in areas of intense human activity
160 Concepts for sustainable use of biodiversity for tourism, contribution of tourism to biodiversity conservation

Q17: How does the abandonment of traditional land use (e.g. farmland abandonment in marginal areas in the Alps) affect biodiversity?

161 Effects of forest encroachment in abandoned (upland) pastures (3x)
162 Nitrification and trivialization of meadow flora (e.g. in Ticino, Engadine) (3x)
163 Effects of abandonment of mowing or conversion of dry meadows into pastureland
164 Encroachment of reed meadows; encroachment of reeds in bogs

Q 18: To which extent is the decline of particular species responsible for the decline of an entire community? (keystone function)

(No topics submitted)

IV. Invasive species

Q19: What characteristics make a species become invasive?

165 What characteristics further the propagation of new invasive tree species (e.g. Ailanthus)
166 Invasive plants along revitalized streams and rivers
167 Tolerance of invasive fish and crustaceans to global warming or diseases
168 Effect of climate change on the expansion of neobiota

Q20: In which ways are indigenous species affected by neobiota?

169 Effects of Orconectes limosus, Signal crayfish (Pacifastacus leniusculus), Galician crayfish (Astacus leptodactylus), Crayfish plague, Fish stocking
170 Effects of gold fish, Rana ridibundus frog (Seefrosch)
171 Displacement of forage plants and endangered plants by neophytes
172 Mitigation measures against invasive species in protected areas and in core areas of ecological networks

Q21: Which invasive species can be efficiently combated?

How to combat...

173 - Buddleja
174 - Canada goldenrods (Solidago canadensis)
175 - Japanese knotweed (Fallopia japonica)
176 Preventive and curative measures against invasive species in renaturation and management projects
177 Non-chemical techniques to fight against invasive plants in nature reserves (protected areas)
178 Methods to combat invasive species in riparian ecosystems, forest edges, farmland and wasteland

Q22: Which is the optimal time point of the colonisation/settling process to start to combat invasive species?

179 What are the costs of combatting compared to non-combatting invasive species, at which time is combatting most effective?
180 When to combat Japanese knotweed (Fallopia japonica), Canada goldenrods (Solidago canadensis)?
181 Development of a risk assessment tools to proceed according to the national strategy for combatting invasive species

V. Biodiversity assessment / tools

Q23: What are the best techniques for efficient and reliable species/communities/ecosystems monitoring?

Species:

Cost-effective methods for monitoring…

182 - terrestrial mammals and bats
183 - returning large predators
184 Methods for volunteer-based monitoring schemes

Biodiversity:

185 Development of one single, simple measure (indicator) for describing biodiversity that replaces ambiguous species lists (2 x)
186 Development of qualitative instead of quantitative biodiversity indicators

Habitat conditions:

187 Landscape connectivity for returning animal species: assessment and improvement of measures to mitigate fragmentation
188 Monitoring the effects of habitat networks through ecological compensation areas in farmland

Q24: What are the best criteria for selecting surrogate species (e.g. indicator, umbrella species)?

189 Selection of target species for ecological networks within farmland
190 Which target species for which conservation measure / conservation target?

Q25: What are the pros and cons, and limitations of surrogate organisms (indicator and umbrella species) for overall biodiversity management?

191 In which contexts does the use of umbrella species make sense, where not?

Q26: How can we assess functional biodiversity?

192 In the context of agricultural pesticides and yield: what is the use and benefit of functional biodiversity?
193 Focus on habitat rather than species to avoid habitat destruction of unknown, sensitive species

Q27: What are the best techniques for cost-efficient evaluation of the effectiveness of

implemented conservation and restoration measures?

Cost-efficient measures...

194 - to measure and evaluate the success of compensation measures

195 - for planning and controlling the success of ecological network projects

196 - for controlling the success of political interventions and subsidies

VI. Management strategies

Q28: How can exploited ecosystems be optimally managed for promoting biodiversity under economic constraints?

197 How to promote diversification of habitats in farmland, preserve extensive meadows (2 x)

198 How to avoid forest exploitation, promote extensive forest management (2 x)

199 How to manage road banks in a biodiversity-friendly manner

200 How to manage ecotones (e.g. agricultural areas - gravel quarries)

201 How to optimize wildlife management to avoid selective browsing and bark stripping

202 How to develop and manage habitat networks (2 x)

203 How and where to block development in wildlife corridors, mitigate existing barriers and obstacles

204 How to optimize or make optimal use of the existing legislation (direct payments); ecological compensation areas; Ordinance on the ecological quality in farmland) (2 x)

205 How to promote and manage biodiversity in urban areas

206 How to reduce air pollution

Economic and ecological optimization of…

207 -species recovery and restoration programmes

208 - Breeding and restocking of endangered fish and crabs

209 Positive vs negative effects of machinery

Q29: How can the promotion of biodiversity-relevant ecosystem components (e.g. dead wood) be integrated in land use management?

210 What are the most relevant / most beneficial components in different ecosystem types?

211 Creation of small structures (e.g. hedgerows etc.)

212 Sustainable, dynamic management of old and dead wood in managed forests: what is the basic requirements (not eligible) and for which efforts shall forest owners be compensated?

213 Promoting biodiversity (including dead wood and snags) through novel forest management methods in the context of the developing wood-energy economy

214 Statutory amount of dead wood removal in/for power stations (?)

215 Develop a biodiversity-boosting attractive (for farmers) option-set for ecological compensation areas through smart financial incentives

216 How do biodiversity-enhancing ecosystem components benefit a land-user or society? (Develop alternatives to subsidies)

Q30: How to manage exploited ecosystems to buffer them against the negative effects of climate change?

217 Prediction of changes with regard to draining of marshes, peat mineralization

218 Shading (of streams), connection of rivers with side-streams, creation of deep water sites in renatured rivers

219 What are the effects of climate change on mountain spruce forests which are not totally native (partly planted), and how to manage them?

220 How can the protective effect of forest be maintained?

221 Adverse effects of adaptive management strategies for biodiversity?

Q31: How to mitigate the effects of disturbance by outdoor human recreation on

wildlife?

222 How to optimally delineate refuge zones?

223 How to guarantee that refuge zones are respected (e.g. particularly with regard to the use of quads, motocross, snow-mobiles)? (2x)

224 Visitor steering concepts in protected areas

225 Development of differentiated visitor steering concepts, e.g. zoning concepts with different forms of regulation?

226 How to develop and optimize targeted measures for temporal and spatial restrictions of activities (no general bans)?

Q32: What methods are effective to control invasive species?

227 Effective methods for controlling ambrosia

228 Cost-benefit calculations for different methods of combating (and non-combating) invasive species

VII. Decisions and priority setting

Q33: How to define priority areas and targets for biodiversity conservation (endangered species and ecosystems) under dynamic ecosystems change?

229 Definition of nationally important areas for biodiversity conservation in agricultural landscape (high value farmland regions)

230 Definition of priority areas and targets with regard to the new concept of forest reserves

231 Prioritization of endangered plants for conservation

232 Development of a nationwide strategy for the use of rivers and streams

233 Development of decision support systems for weighing interests of nature/biodiversity conservation vs development of green-energy sources

234 Are conservation measures for particular species worthwhile, in view of the ongoing changes of their habitat?

235 Where to promote wilderness, where to promote cultural landscapes?

Q34: What is the best strategy to integrate small areas or populations for promoting large-scale biodiversity?

236 How to develop ecological networks, how to define and promote nodal zones and "stepping stones"? (2 x)

Q35: How can the red lists be optimised for prioritizing species and habitat conservation measures?

237 Red lists should not be changed for reasons of comparability. The question should therefore read: what additional instruments do we need next to the red lists to define priority species?

238 What particular (international) responsibility do we have in Switzerland for a species or habitat?

239 Harmonization of the methodology at international level (e.g. IUCN)

Q36: How and when to decide to reinforce or reintroduce species?

With regard to...

240 - Breeding of amphibians in gravel-mining ponds

241 - Existing programmes for breeding of fish and crustaceans

242 - Large carnivores

243 How to manage the respective ecosystems for these species?

244 How to integrate criteria of ecosystem resilience and genetic diversity in the decision process?

VIII. Knowledge transfer

Q37: How to efficiently bridge the research-implementation gap?

245 Involve multipliers which are in contact with both science and practice

246 Communication of scientific results in a clear language and in open-access journals and databases (2 x)

247 Make use of synergies between research and applied ecology: promote research projects on developing ecological networks in farmland (e.g. grassland project University of Bern)

248 Involvement of practitioners in the development of research projects

249 Promote knowledge transfer with regard to emerging federal policies: restoration of rivers and streams; urbanisation; renewable energy sources

250 Discuss the applicability of scientific recommendations with practitioners (e.g. members of the Swiss association of environmental practitioners)

251 Improve communication and collaboration between scientists and practitioners by using a "common language"

Q38: How to make the (grey and peer-reviewed) literature broadly accessible to practitioners?

252 Synthetic studies / publications for practice

253 Creation of internet- platforms that provide quick and easy access to research results on specific topics in understandable language (e.g. evidence-based website, waldwissen.net) (2 x)

254 Open-access journals and databases

255 Make available unpublished students' theses which include information relevant to practice

256 Workshops, direct personal and oral communication

257 Creation of networks of organizations (e.g. "Naturforschende Gesellschaft", association for nature science)

Q39: How to direct research towards needs expressed by practitioners?

258 In farmland ecology, use federal advisory agencies (e.g. Agridea) to have the needs of practitioners influence research (via forums, exchange groups, etc.)

259 Integration of practitioners' needs in research and research questions

260 Bidirectional exchange and discussion of questions and problems

261 Influence of practitioners on decisions about allocation of research funds or staffing

262 Presentation of scientific research (by scientist themselves!) in a popular way

263 Communication between scientists and practitioners in situ (e.g. in the field)

264 Instead of information about ecosystem functioning and structure, we need more information about the interactions between ecosystems and humans

265 Collaboration in projects

266 Collaboration with the Swiss association of environmental practitioners, which can mobilize experts in this particular topic

IX. Political processes

Q40: How to efficiently convey biodiversity issues to the broad public and society?

267 How to raise acceptance that certain areas are not only available for human recreation but also for promoting particular species?

268 How to find a common, understandable language to communicate biodiversity issues?

269 How to fight against the common view that unmanaged and ageing forests represent a threat for biodiversity?

270 How to increase awareness of the biodiversity issues among farmers?

271 How to optimize the use of media, associations etc.?

272 Participatory planning processes

273 Answering questions from the broad public (e.g. by telephone, e-mail)

274 How to optimally conduct awareness-raising campaigns? How successful are they?

Q41: What is the optimal approach to reconcile the needs of conservation and the ongoing human demand for land use?

275 Spatial requirements of streams and rivers

276 Visitor steering concepts

277 Attitude of man with regard to various ecosystems; identify elements perceived positively and negatively, use them in the management of sensitive habitats

278 Conflicts between nature conservation and agriculture

279 How to communicate nature conservation as a social and economic opportunity for the future?

280 Issue of urbanisation vs farmland preservation (2 x) and basis for species conservation

281 Spatially explicit fundamentals for landscape planning, regulations for land use

282 Fundamentals for the management of winter sports

Q42: How to convince the public not to opt for societal choices that are detrimental to biodiversity?

283 At which level which kinds of decisions are made (individual, consumer, voter, employee, etc.)? Which level optimally address a specific issue?

284 Correlation between agricultural products (commodities) and farmland habitat quality

285 Are the current political instruments still suitable?

286 How to convince the politicians...?

287 In the field of transportation and individual mobility: how to communicate nature-friendly behaviour in a positive way (communicate positive effects for both the user and biodiversity)

X. Incentives

Q43: How can a success-oriented distribution of environmental subsidies (e.g. in agriculture and forestry) best deliver for biodiversity?

288 Consider the selection and use of seeds of wild plants

289 Concepts for subsidizing non-management (natural dynamics, protection of natural processes)

290 Concrete, measurable biodiversity-related goals are required for an optimal allocation of funds in forest ecosystems (current targets are too related to single species, no comprehensive concepts available)

291 Funding for biodiversity-friendly urban development projects

292 Show the effects of agricultural policies on biodiversity independently of the monitoring scheme of the federal administration

293 Effective, attractive, non-compulsory, voluntary option-sets (see above) for enhancing farmland biodiversity

294 Advancement of the direct payment system (3 x) considering research gaps in the evaluation of nitrification

295 What are the negative effects of subsidising electricity from small hydroelectric power stations on biodiversity?

Q 44: How to label the biodiversity impact of a product to the consumer?

296 Food labels: Which label actively and effectively promotes biodiversity and how is this communicated to the public?

297 Develop labels indicating the pollution of streams with micro-pollutants (problem of proliferative kidney disease in fishes)

298 Labels for hydro-energy stations ("clean energy")

299 Develop suitable monitoring systems quantitatively appraise the ecological impacts of processes and products (eco-balance)