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„Assisted colonization – usefulness, risks, acceptance and implementation”

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1. Introduction

1.1 Current state of assisted colonization

Effects of global climate change on species and ecological systems are becoming increasingly pervasive (Dawson et al., 2011; Urban, 2015) and bring about changes in species physiology, phenology, and distributions, in interspecific interactions as well as in disturbance regimes, which subsequently lead to modifications in ecosystem functions (Parmesan, 2006; Lawler, 2009; Grimm et al., 2013; Chao et al., 2018). These novel pressures act on top of other anthropogenic impacts e.g. habitat loss and degradation, water extraction, toxic contaminants, and invasive alien species (Grimm et al., 2013), which are already threatening the survival of roughly a quarter of extant species (Ma et al., 2018; Díaz et al., 2019). In response to all these unprecedented environmental changes, species are increasingly shifting their ranges (Parmesan et al., 2003; Root et al., 2003).

Thus, climate change and other anthropogenic pressures create a huge challenge for species conservation to identify tools that allow ensuring species survival in the Anthropocene (Loss et al., 2011; Wessely et al., 2017; Genovesi et al., 2020). In general, the survival of species under rapid environmental change will depend on the interplay of *in situ* adaptation and their capacity to track environmental changes in space, i.e. to colonize regions that have become newly suitable (McLachlan et al., 2005). In situations were *in situ* adaptation is unlikely, translocation of organisms by assisted colonization may represent an option (Hällfors et al., 2017; Lloyd et al., 2019) and has already been proposed as a novel conservation tool to complement current conservation strategies (Hällfors et al., 2014). Assisted colonization, also known as assisted migration, managed relocation or benign introduction, is commonly understood as intentional movement and release of an organism outside its native range to avoid extinction of populations of the focal species (IUCN/SSC, 2013). Originally, this conservation tool has been proposed for species whose suitable climatic space is projected to disappear entirely during the next decades in their current range (Hällfors et al., 2017), but for which suitable climatic conditions outside their current range are modelled. In these cases, future survival may depend on the ability to colonize newly suitable climatic space (Minteer et al., 2010; Ste-Marie et al., 2011). Assisted colonization aims to actively support range shifts towards newly suitable regions in which the species are expected to move and survive due to climate change (Hällfors et al., 2014). Thus, it has been proposed to represent an effective climate change adaptation strategy (Thomas, 2011).

In 2013, the IUCN published official guidelines for reintroduction of species. There, assisted colonization and associated risks and opportunities are presented and discussed for the first time in a global conservation guidance document (IUCN/SSC, 2013). Assisted colonization is carried out primarily where protection from current or likely future threats in the current range is deemed less feasible than at alternative sites. The term includes a wide spectrum of operations, from those involving the movement of organisms into areas that are both far from the current range and separated by unsuitable areas, to those involving small range extensions into contiguous areas (IUCN/SSC, 2013). Feasibility assessment should include a balance of the conservation benefits against the costs and risks of both the translocation and alternative conservation actions (IUCN/SSC, 2013).

Assisted colonization has become a subject of substantial controversy in the conservation community. Contested issues are for instance the potential scope and feasibility, the risks

associated with the likelihood of translocated species becoming invasive, carrying diseases and parasites as well as the risk of disrupting historical evolutionary and ecological processes (Hoegh-Guldberg et al., 2008; Ricciardi et al., 2009; Schwartz et al., 2009; Seddon et al., 2009; Minteer, 2010; Loss et al., 2010; Probert et al., 2019). Besides, even if assisted colonization is preceded by careful risk assessment, it is possible that there are unintended and unpredictable consequences (Ricciardi et al., 2009, 2014), mainly because the impacts of introduced species vary over time and space under the influence of local environmental variables, interspecific interactions and evolutionary change (Ricciardi et al., 2009; Gray et al., 2011). Therefore, some conservationists recommend focusing on traditional conservation actions such as expanding protected areas or improving habitat connectivity as an alternative (Hunter, 2007; Vitt et al., 2009; Javeline et al., 2015).

However, other conservationists argue that assisted colonization involves risks that can be contained (Sax et al., 2009). For example, it has been argued that containment of native species risk of extinction can be achieved as long as the focal species are being translocated within the same broad geographic region and the target areas have no local endemics (Thomas, 2011). According to Minteer (2010) "*the consequences of doing nothing would be far worse*" than using a species protection strategy that has certain limitations. Along these lines, assisted colonization can be seen as an adaptive management option where humans fill the gap between species migration capability and the expected velocity of climate change (Ste-Marie, 2011).

Moreover, assisted colonization is a complex topic that encapsulates scientific, societal and normative issues (Aubin et al., 2011). Thus, the debate on assisted colonization has become bi-partisan and highly opinionated (Aubin et al., 2011; Burbidge et al., 2011). In addition, financial, logistical and legal aspects are important and contentious issues for implementing assisted colonization (Hunter, 2007). Assisted translocation of candidate species will require sufficient public support and assistance and the availability of funding (Hoegh-Guldberg et al., 2008; Hunter, 2007). Further, analyses are needed to understand the potential impacts of species translocations and their benefits and risks (McLachlan et al., 2007).

1.2 Surveying expert opinions on assisted colonization

To assess opinions held of specific issues of environmental management, surveys of specific expert target groups have been proven effective (Donlan et al., 2010; Javeline et al., 2013; Braun et al., 2016; Pe'er et al., 2017, 2019). Such surveys allow to collect the current knowledge and opinions on specific issues, and if directed towards experts, they allow to provide a synthesis of views held by this target group. For instance, an expert survey on extinction risk and climate change adaptation for biodiversity reported that assisted colonization may be a partial solution for reducing climate-induced extinction risks and that participating conservationists were open to its perceived benefits, especially in restricted circumstances (Javeline et al., 2015). In that broader survey, an impressive number of responses were obtained from ecologists, evolutionary biologists, and conservation biologists. Thus, it is a useful starting point for our survey focussed on assisted colonization.

1.3 Hypotheses and research questions

Some of the early assisted translocation were implemented to resolve human-animal conflicts, to supplement game populations, and for conservation reasons (Fischer et al., 2000). In recent years, an increasing number of assisted colonization events have been implemented worldwide. This involves the relocation of swamp tortoise in Australia (*Pseudemydura umbrina*) (Seddon et al., 2015), the conifer *Torreya taxifolia* in the United States (McLachlan, 2007), and two butterfly species (*Melanargia galathea* and *Thymelicus sylvestris*) in the United Kingdom (Willis et al., 2009).

The aim of this study is to assess the views of conservation experts experienced in assisted colonization by means of an online survey. My questions are dealing with the four key issues usefulness, risks, acceptance, and implementation. Only experts were invited to participate in the survey, who had authored scientific articles on assisted colonization in international journals. To examine potential reasons for differences in expert views, I set up two specific hypotheses:

Hypothesis 1: Despite the global species extinction crisis, scientists with different backgrounds (e.g. countries of origin, focal study species) hold different opinions regarding for which threats (e.g. climate change, habitat destruction) assisted colonization is an appropriate conservation tool. Thus, it is assumed that assisted colonization is perceived to have a different relevance in specific contexts.

Hypothesis 2: I hypothesize that experts who spend more working time in the science or implementation of assisted colonization are more in favour of this conservation tool.

2. Methods - Survey design and analysis

2.1 Sampling frame and implementation

I considered authors of publications on this topic in international scientific journals. I collected all scientific publications that have dealt with assisted colonization and collected the contact details of the authors. This was done the following way:

(i) at the start of my investigation in October 2018, I researched and evaluated scientific articles using the term "assisted colonization" and synonyms in Scopus (www.scopus.com). I used the following search terms:

Assisted migration/ Assisted colonization	Conservation strategies
Relocation	Moving species
Translocation of species	Climate change and threats to species
Benign introduction	Risks climate change species
Reintroduction species	Climate change impacts on species

(ii) after selecting articles by the keywords listed above, a further selection was made based on titles and abstract, i.e. articles that dealt with the topic assisted colonization were selected. In addition, "snowballing" was used (Wohlin, 2014). Based on the reference lists of the selected articles, additional articles were identified that corresponded with the research criteria mentioned above.

(iii) In the next step, the e-mail addresses of the lead authors and co-authors and their affiliations were extracted from the articles or researched on the internet.

Overall, the final sample consisted of 264 authors (incl. co-authors) of articles on assisted colonization. They authored 89 articles that were affiliated with 23 countries. Most of these countries lie in the geographical regions of North America, Europe and Oceania. Researchers from these three regions made up 95% of the total sample (Fig. 1a).

2.2 Survey design and analysis

In April 2019 and May 2019, a web-based survey (www.soscisurvey.de) of expert views about assisted colonization was conducted. The survey questions were based on previous original research on assisted colonization. For the individual survey questions, Likert-style survey items (Likert, 1932) were used – i.e. statements or questions that respondents evaluate from a provided bipolar response scale. Additionally, participating experts could provide open answers and suggestions to some questions.

Overall, the questionnaire contained nine questions with several answer options. The survey questions and statements were divided into six different categories: usefulness; risks; risk avoidance; acceptance; implementation; and summary statements. At the end of the questionnaire, several personal questions were asked to assess relevant characteristics of the population of responding experts. In the survey the term "assisted migration" was used instead of "assisted colonization". After some respondents had referred to the definition in the IUCN guidelines, assisted migration was here replaced with assisted colonization. The entire questionnaire can be found in the annex.

2.3 Data analyses

First, a descriptive analysis of the collected data was carried out to graphically illustrate how experts responded to the survey questions. Therefore, the response behaviour of the participating experts in presented in percentage distributions for the Likert-scale categories.

For the verification of the two hypotheses concerning the answering behaviour of the experts, the statistics software SPSS were used, and various statistical tests were applied.

Hypothesis 1, i.e. for assessing whether scientists from different parts of the world have differing opinions regarding the question "For which kinds of threats to species, assisted colonization is an effective tool?", the participating experts were assigned to the geographical regions of North America, Europe, Oceania, Asia and South America. I tested for significant differences (p-value < 0.05) among the medians of the different groups using a Kruskal-Wallis-one-way ANOVA (McKight et al., 2010).In the event that a significant difference could be identified among groups, Mann-Whitney- U post hoc tests were performed to

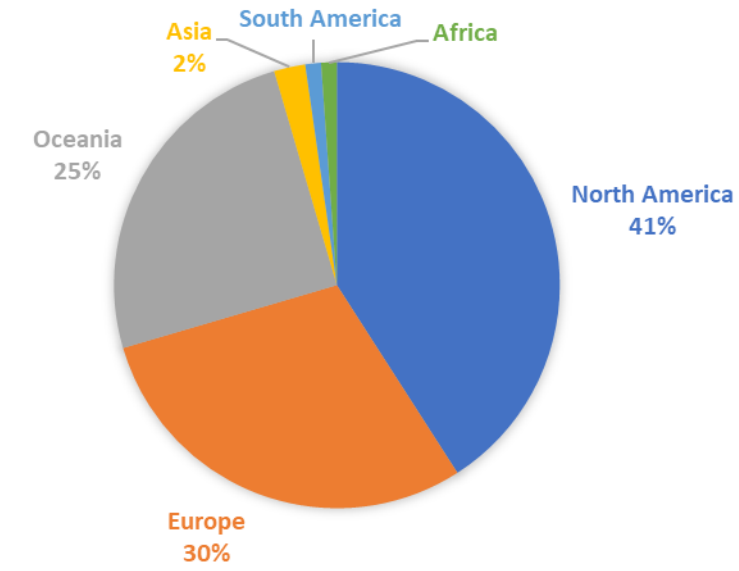
determine which of the groups differed significantly from the others (Best et al., 2010; Bortz et al., 2010).

In case of **Hypothesis 2**, i.e. for assessing whether working background affects the view of experts on assisted colonization, two questions were selected from the summary statements and examined in more detail: (i) “Assisted colonization should be recognized as an effective tool for species conservation but with potential risks that need to be carefully addressed” and (ii) ”Assisted colonization should only be implemented if exhaustive assessments are made that conclude that it will not cause a decline in the conservation status of any species native to the target area”. For this purpose, I used the proportions of respondents’ work time allocated for each of the five activities (i.e. research on assisted colonization, climate change impacts, and biodiversity, applied conservation management and conservation policy; see annex) as predictors and conducted correlation analyses using the Spearman rank correlation coefficient.

3. Results

3.1 Respondents and their main work fields

Of 264 invited experts on assisted colonization, 48 (18.2%) participated in the online survey and were assigned to the five geographical regions of North America, Europe, Oceania, Asia and South America (Fig. 1b). Of these, 33 were male, 11 were female, and four respondents gave no information about their sex. The participating experts used an average of 13.2% (±17.0 SD) of their work time in the past five years to conduct research on implementation of assisted colonization, further 17.4% (±17.2 SD) to conduct other kind of research on climate change impacts on biodiversity, and further 26.9% (±23.3 SD) for yet other kind of research on biodiversity and nature conservation. They applied further 18.3% (±20.1 SD) of their work time for applied conservation management and dedicated 9.2% (±13.3 SD) to conservation policy. A majority of the experts (59%) stated that they mainly worked in forests, 33% worked in grasslands, 26% in mountains, 10% in marine and urban areas respectively, 8% in coastal, freshwater and tundra ecosystems, respectively, and 6% in agricultural ecosystems. Some of the experts stated several ecosystems they worked in.



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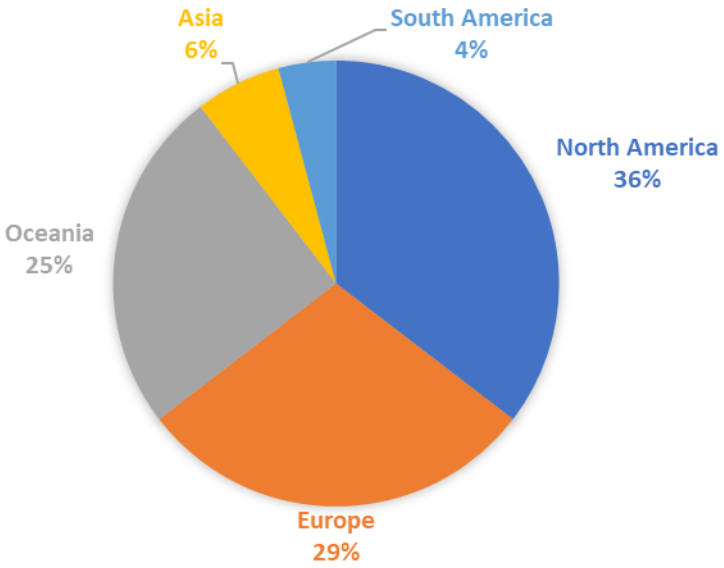


(b)

Fig. 1 : Geographical affiliation of (a) the authors of scientific articles (n = 264) on assisted colonization (assignment of the lead authors and co-authors was done based on Internet research at which institute they carried out their research), and of (b) the authors of scientific articles who took part in the survey (n = 48) on assisted colonization.

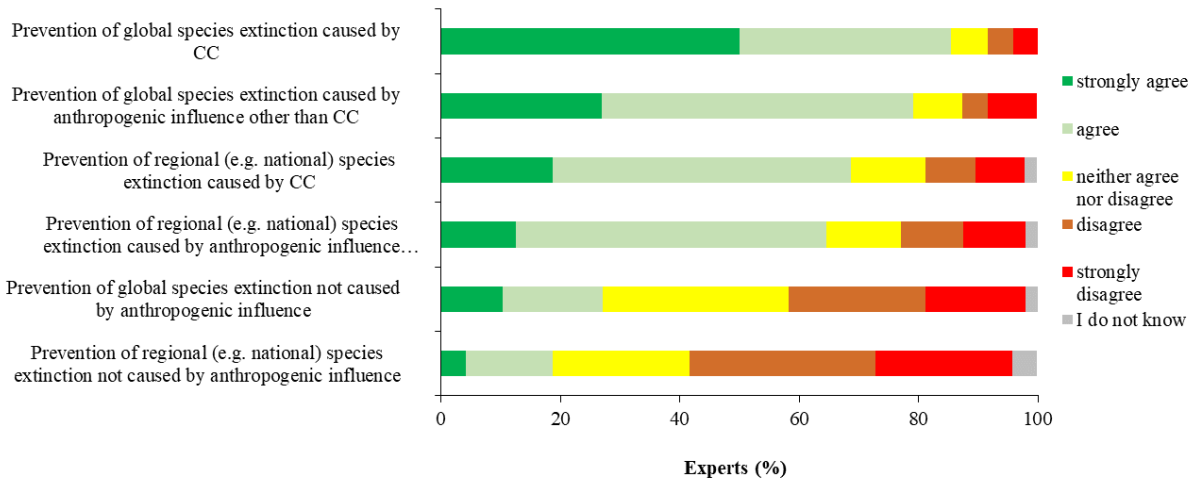
3.2 Usefulness of assisted colonization

The vast majority of the participating experts strongly agreed or agreed that assisted colonization should be applied to prevent global species extinction when caused by climate change (85%) and when caused by anthropogenic pressures other than climate change (e.g. fragmentation, habitat loss, competition, predation, pathogens) (79%) (Fig. 2a). Lower values (i.e. 68% and 64%) were obtained for agreement with preventing regional (e.g. national) species extinction caused by climate change, and caused by anthropogenic pressures other than climate change, respectively. By contrast, experts showed little agreement for applying assisted colonization for preventing global (27%) or regional (20%) species extinction caused by natural causes (e.g. rarity, endemism) (Fig. 2a).

In case of suitable criteria to identify species for assisted colonization, 91% of the experts strongly agreed or agreed on "species whose extinction risk could not be reduced despite the implementation of conservation strategies other than assisted colonization". A further 79% strongly agreed or agreed that the extinction risk (i.e. Red List status) of species should be considered as a criterion (Fig. 2b).

The criteria related to small climatic niches, long generation time when compared to the velocity of climate change, keystone species or species that are relevant for ecosystem functions and for ecosystem service provision received >62% agreement among the respondents (Fig. 2b). Low genetic variation and phylogenetic uniqueness were considered least relevant for assisted colonization (37% and 41% agreement) (Fig. 2b).

Some remarks of the experts were related to the aspects of the species' potential to become invasive in a new region, as well as evidence for non-invasive "behaviour". One expert suggested an additional criterion for assisted colonization: very limited dispersal capacity to reach suitable habitat.



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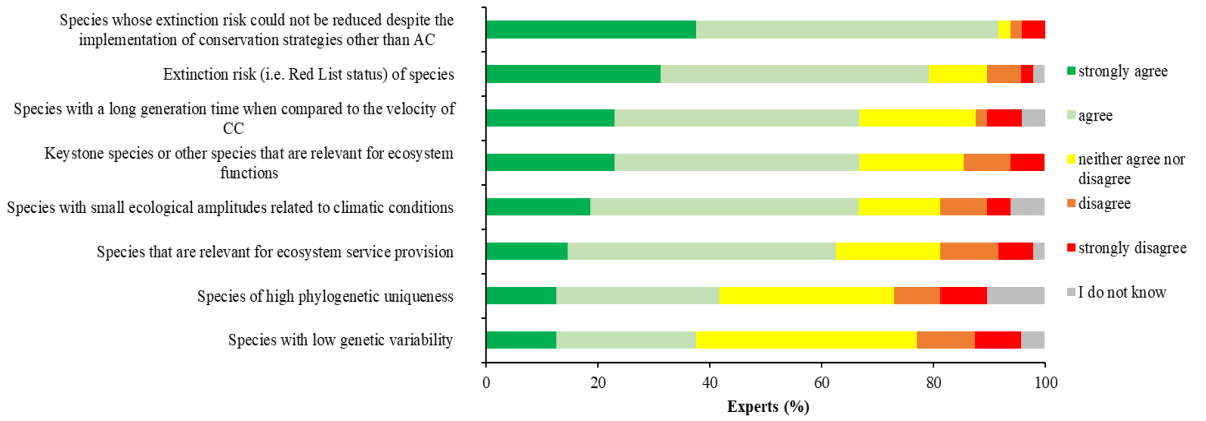

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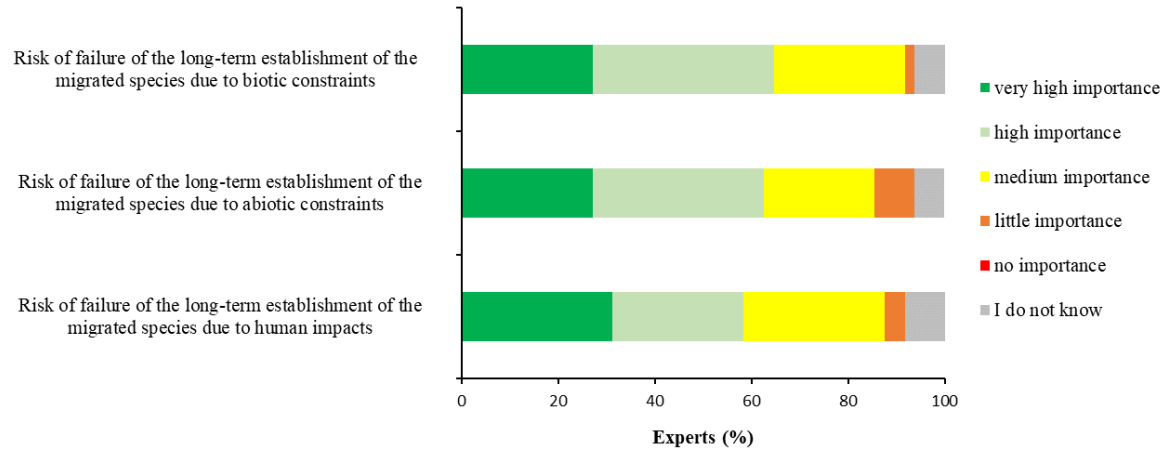
Fig. 2: Answers (n = 48) to the questions (a) "For which kinds of threats to species, assisted colonization (AC) should be applied?, and (b) "Which should be the criteria to identify species for assisted colonization?"

3.3 Risk and risk avoidance of assisted colonization

The potential risks of failure of the long-term establishment of translocated species were universally considered important (Fig. 3a). More than half of the experts considered all three risks to be important or very important and only a minor fraction of the respondents considered them of little importance. Participating experts ranked the potential risks according to their importance as follows: biotic constraints (competition, predation, parasitism) (64%), followed by abiotic constraints (62%) and human impacts (60%) (Fig. 3a).

Likewise, the majority of experts estimated specified risks for the native biota of the target area to be high importance (Fig. 3b). The respondents ranked the potential risk as followed: transmission of diseases (71%), increased competition with native species (60%), displacement of native species (58%), changes in ecosystem functioning as well as in species interactions and food webs (56%), increased herbivory and predation (54%), changes in ecosystem service provision (48%).

Additional risks were specified in the open question, such as loss of economic and cultural values and changed aesthetics of the recipient region, the risk of opportunity costs (e.g. withdrawing funding from more effective conservation actions), and it will be important to consider that islands and insular environments are places most at risk when implementing assisted colonization.



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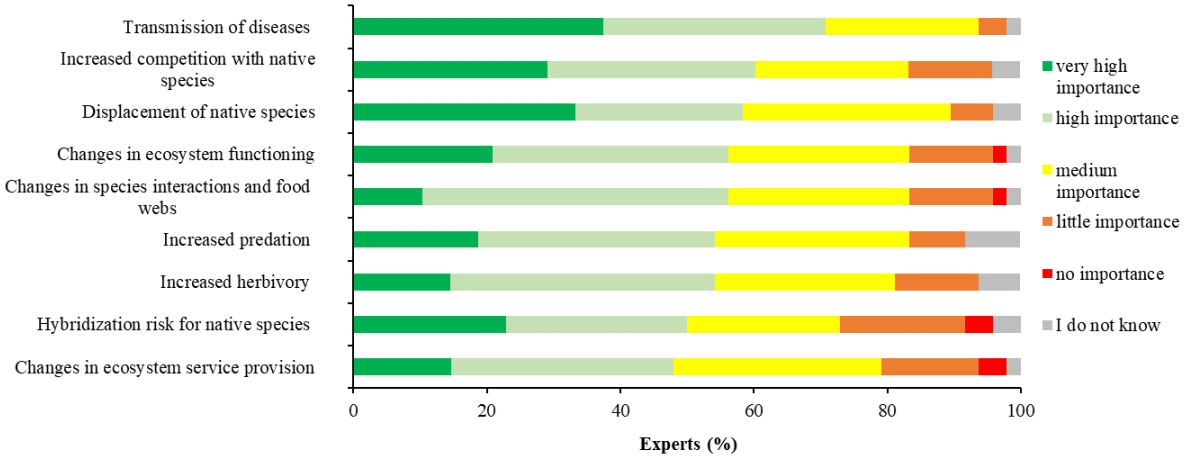


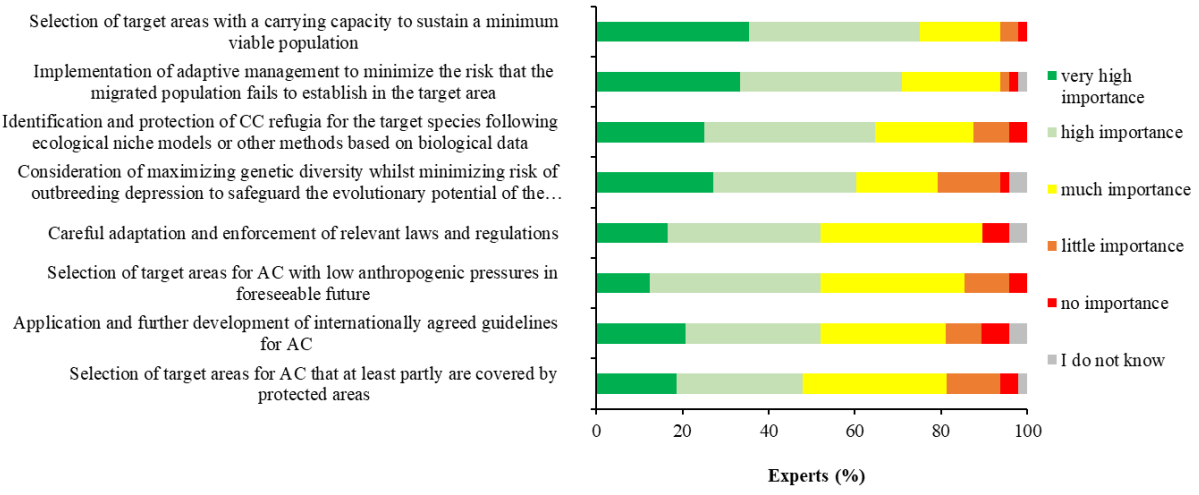
(b)

Fig. 3: Answers (n = 48) to the question (a) "How would you consider the importance of the following potential risks of failure for implementing assisted colonization?", and (b) " How would you consider the importance of the following potential risks of assisted colonization for native biota of the target area?"

On reducing risk of failure, 75% of the participating experts held the opinion that selecting a target area with a carrying capacity to sustain a minimum viable population is very important (Fig. 4a), closely followed by measures to implement adaptive management to minimize the risk of failing to establish in the target area (70%). Further relevant means of risk reduction were identification and protecting climate change refugia for the target species (62%) and maximizing genetic diversity whilst minimizing risk of outbreeding depression (60%) (Fig. 4a). Least relevant to the experts was selecting target areas for assisted colonization that at least partly are covered by protected areas (47%) (Fig. 4a).

When it comes to risk avoidance for native biota in the recipient region, 74% of the respondents meant that the most important aspect was monitoring of the target region and areas adjacent to it to identify negative impacts if they occur (Fig. 4b). Other measures, i.e. implementation of adaptive management to minimize the risk for the biological community of the target area and comprehensive and standardized assessment of the potential risks to the

biological community of the target area before implementation still gained high importance (66% and 62%) (Fig. 4b). Some of the experts mentioned that root fungal associations as well as plot scale studies to provide insights for effective implementation of assisted colonization also should be considered as risk avoidance measures.



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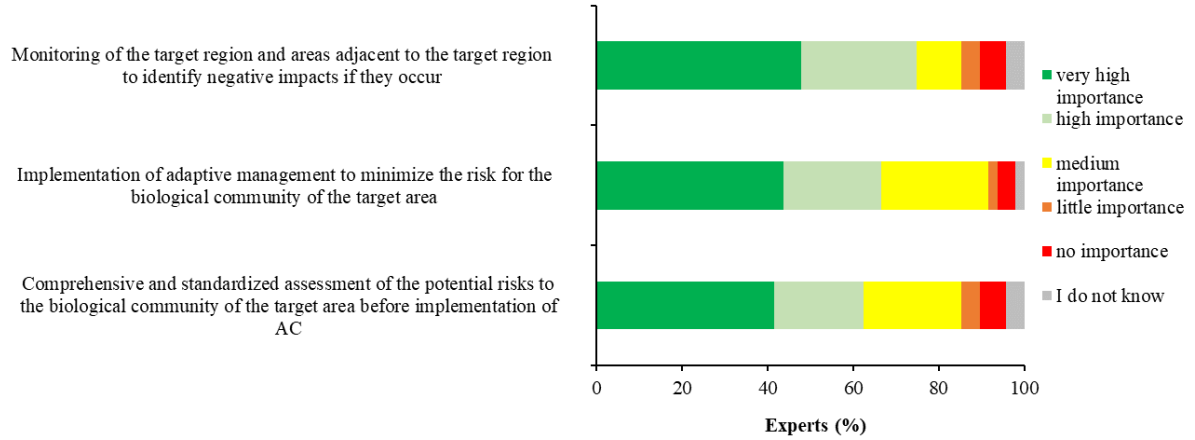


(b)

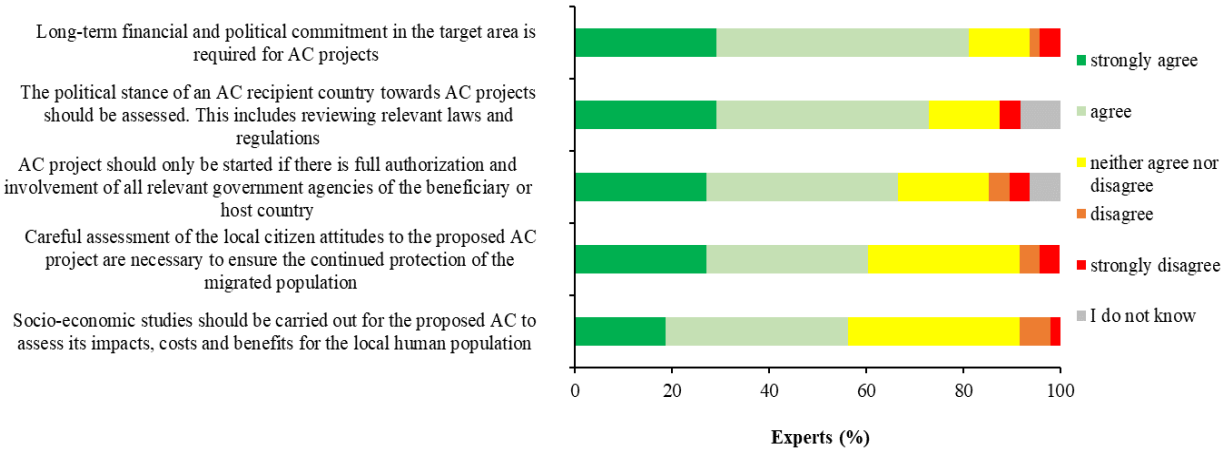
Fig. 4: Answers (n = 48) to the question (a) "How would you consider the importance of the following measures to reduce the risk of failure", and (b) "How would you consider the importance of the following measures to avoid risks for native biota and ecosystems?"

3.4 Acceptance and implementation of assisted colonization

A total of 81% of the experts strongly agreed or agreed that long-term financial and political commitment in the target area is required for assisted colonization projects to be successful (Fig. 5a). A high level of agreement (72%) was shown for the statement that the political

stance including relevant laws and regulation on assisted colonization projects should be assessed (Fig. 5a). Also, all other statements reached >56% agreement (Fig. 5a).

In case of responsibility for the implementation and related decisions of assisted colonization projects, 83% of the respondents strongly agreed or agreed that government agencies (national to sub-national) should be in charge (Fig. 5b), while it was also widely stated that inter-governmental and multi-national agencies (e.g. IUCN) should take responsibility (77%) (Fig. 5b). Other stakeholders mentioned by the participating experts were scientists, sub-national government land managers, indigenous peoples, farmers, other landholders, and miners (in the case of restoration sites).



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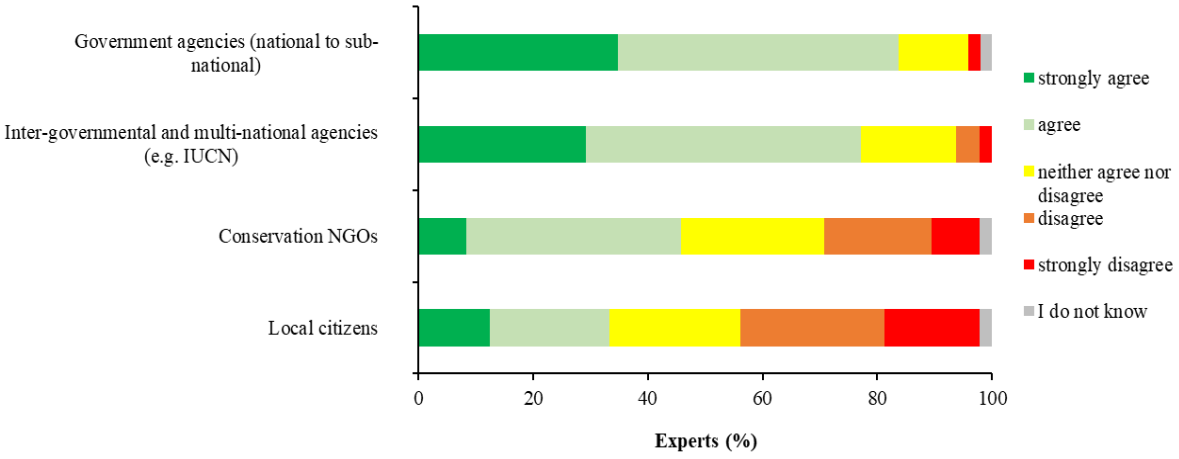

(b)

Fig. 5: Answers (n = 48) to the question (a) "Please specify the level of agreement with the following statements regarding acceptance of assisted colonization and socio-economic, societal and legal requirement", and (b) "Who should be responsible for the implementation of assisted colonization projects and related decisions?"

3.5 Summary statements on assisted colonization

A total of 82% of the participating experts strongly agreed or agreed that assisted colonization should be recognized as an effective tool for species conservation but with potential risks that need to be carefully addressed (Fig. 6). In contrast, the overwhelming majority of experts (83%) denied that assisted colonization is ethically questionable and should be avoided altogether (Fig. 6).

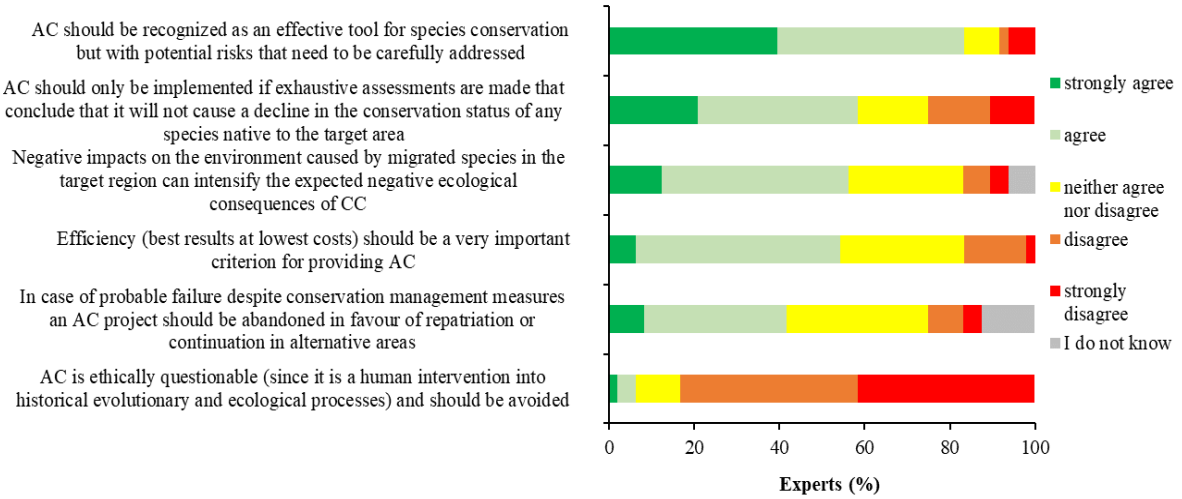

Fig. 6: Answers (n = 48) to the question "Please specify the level of agreement with the following statements"

3.6 The role of geographic origin on the perception of usefulness and risks of assisted colonization (Hypothesis 1)

There was a statistically significant difference among the answers from respondents of the different continents on the usefulness of assisted colonization for (i) the prevention of global species extinction caused by anthropogenic pressures other than climate change, and (ii) for the prevention of regional species extinction caused by climate change. The p-value of the Kruskal-Wallois test for (i) was 0.046 and the subsequent Mann-Whitney-U test showed that South Americans (median Likert = 2) agreed significantly less than North Americans (p-value 0.043) and Oceanians (p-value 0.032) (median Likert = 4 in both cases) that assisted colonization is useful when globally endangered species are threatened by anthropogenic pressures other than climate change. On (ii), the Kruskal-Wallis test, yielded a p-value = 0.032 and according to the Mann-Whitney-U post-hoc test, Oceanians (median Likert = 4.5) agreed significantly more (p-value = 0.007) than European (median Likert = 3.5) that assisted colonization should also be considered for prevention of regional extinctions.

3.7 The role of respondents' work time on the perception of usefulness and risks of assisted colonization (Hypothesis 2)

Regarding the dependence of favouring assisted colonization on working time spent on related topics, only one of the ten analyzed correlations was statistically significant. Working time in "research on biodiversity and nature conservation (excluding research on assisted colonization and climate change impact on biodiversity)" was negatively correlated (Spearman Rho = -0.32; p-value = 0.029) to the agreement with the statement "Assisted colonization should be recognized as an effective tool for species conservation but with potential risks that need to be carefully addressed".

4. Discussion

4.1 General views on the usefulness of assisted colonization

The expert survey conducted in this study provides a synthesis of the views of world leading experts on assisted colonization. Building on their knowledge, pros and cons of assisted colonization were highlighted in regards of the aspect's usefulness, risks, acceptance, and implementation.

Overall, the vast majority of participating experts in the present survey were in favour of this conservation strategy and considered assisted colonization as a useful strategy to prevent global species extinction caused by climate change and other anthropogenic pressures. However, the experts were also aware of the possible risks that this strategy could entail such as translocated species not being able to establish or threaten the persistence of native biota and that assisted colonization only should be applied under certain circumstances. Interestingly, there was a clear difference in the appropriateness of assisted colonization for mitigating natural versus anthropogenic pressures on species. Apparently, the level of acceptance of assisted colonization seems to have risen recently, and likely the publication of the IUCN guidelines (IUCN, 2013), which provide recommendations for every relevant aspect such as risk assessment, regulatory compliance, release strategy, and monitoring and management, played an important role. Respondents agreed that to prevent the failure of a translocation, it is inevitable that certain precautions are met such as a completed risk assessment, the creation of an adaptive management plan, and detailed monitoring of the target area. Likewise, long-term financial and political support in the target area, as well as relevant legislation is required to implement assisted colonization projects. In view of this, the majority of experts believe that these should be best decided by government- and inter-governmental agencies.

This survey showed that ethical questions about assisted colonization are considered clearly less important, most likely because protecting endangered species from extinction is considered to be of paramount importance. Nevertheless, ethical considerations in biodiversity conservation in general and assisted conservation in particular require a broad societal discussion (Minteer et al., 2005a, b, 2008).

4.1.1 Opportunities of assisted colonization

Most of the participating experts stated that assisted colonization is an appropriate conservation measure to prevent global species extinction caused by climate change and other anthropogenic pressures (e.g. fragmentation, habitat loss, pathogens). The prevention of global species extinction threatened by climate change seems to be the main reason for justifying assisted colonization. Particularly in the last few years, climate change and its impacts on biodiversity have become an urgent global concern (Williams et al., 2003; Deb et al., 2018). However, the experts of the present survey considered assisted colonization not only to overcome anthropogenic barriers (e.g. urban or agricultural regions) that hinder distribution shifts required to match climatic requirements of populations (Javeline et al., 2015), but also to prevent extinction caused by other anthropogenic pressures than climate change. This finding indicates that the unfolding global extinction crisis is caused by a cocktail of several pressures (IPBES, 2019; Otero et al., 2020), of which climate change is just one ingredient.

Previous studies have shown that other conservation strategies (e.g. expanding protected areas, the establishment of corridors, ex situ conservation) are preferred to assisted colonization (Javeline et al., 2015). This view is generally supported by the respondents of this survey. However, these conservation strategies might not be effective enough to cope with climate change in a strongly fragmented landscape (Wessely et al., 2017). Thus, there is an urgent need to critically assess all conservation strategies (Genovesi et al., 2020).

I found that conservation biologist who mainly work on conservation strategies other than assisted colonization were more likely to disagree with assisted colonization. This finding shows that opinions on assisted colonization differ among subgroups of the surveyed experts, and it indicates that other relevant stakeholders may hold different opinions as well.

I also detected differences between European and Oceanian expert views on whether the prevention of regional species extinction caused by climate change is useful, as Oceanians were more in agreement with this statement than Europeans. This is probably related to Oceania's distinct insular biogeography, which results in a particularly large number of highly threatened species. This situation created an urgency for applying and testing novel conservation measures (Short, 2009; Burbidge et al., 2011; Seddon et al., 2015).

In further consideration of the usefulness of assisted colonization, the analysis showed that a substantial proportion of respondents considered the use of assisted colonization only appropriate when it is applied to highly threatened species (79%) that cannot be effectively protected by other conservation strategies (91%). This was also exemplified by Thomas (2011) and the example of the *Pyrenean desman*, a species that might get extinct in its native range but could survive in regions that the species is not able to reach without human assistance. Although this strategy does not seem to be the first choice (Javeline et al., 2015), related to as specific species, it might be the only way to save it (Minteer et al., 2010).

According to the results, the protection status of a species seems not the only relevant criterion. Other criteria that were considered relevant such as small climatic niches, poor dispersal capacity compared to the velocity of climate change, being a keystone species or a species that is relevant for ecosystem service provision should be taken into account in decisions as to whether a species is suitable for assisted colonization (Hällfors et al., 2017). The importance of species values and the importance of ecological functional properties

indicate that different and sometimes competing motivational goals exist to select a species for assisted colonization (Hagerman et al., 2014; Aubin et al., 2011). Thus, fundamental perspectives on nature and causes of its endangerment seem to influence the opinions of experts on assisted conservation (Aubin et al., 2011; Burbidge et al., 2011 Ste-Marie et al., 2011).

4.1.2 Risks of assisted colonization

Experts were most concerned about failure of the long-term establishment of the translocated species caused by biotic constraints in the target region (e.g. competition, predation, parasitism). This view reflects the difficulty of assessing certain crucial pieces of information that are essential for planning and implementing assisted colonization projects Such information include species-specific data (e.g. species sensitivity to climate change, dispersal abilities, habitat requirements, habitat availability), information pertaining to the target region (e.g. biotic interactions among species, land ownership), and uncertainty about future environmental and climate change trajectories (Hällfors et al., 2017). Nevertheless, each candidate species should be evaluated carefully to judge the balance between the potential benefits of helping to save a species from extinction and any changes to native biota within the recipient area (Thomas, 2011). For identifying potentially suitable sites for translocation several systematic processes are suggested such as multiple criteria analysis (MCA) that allows to check whether assisted colonization is well planned and monitored, whether it could be a possible solution to conservation goals and whether it will ultimately result in the establishment of long-term sustainable populations (Carroll et al., 2009; Miller et al., 2012; Dade et al., 2014).

The survey showed that a relatively high percentage (71%) of experts were concerned about the transmission of diseases and, more generally, the emergence of invasive behaviour in the recipient region potentially threating native biota. For instance, the potential invasive spread of the target species and unforeseen pathogen transmission to native species in the recipient region are plausible and potentially highly impactful scenarios (Aubin et al., 2011; Pedlar et al., 2012; Ferrarini et al., 2016). From invasion science it is well-known that the transport of animals and plants by humans spreads disease-causing pathogens (Collins et al. 2009) and promotes the spillover to new host species (Slippers et al., 2005). Assisted colonization may entail similar risks. An example is the introduction of the American red squirrel *Tamiasciurus hudsonicusto* into Newfoundland. Assisted colonization was done to improve the diet of the pine marten (*Martes americana*), a declining species. However, a previously unexpected competition with birds for black spruce cones as a food resource developed, which in combination with assisted colonization might have resulted in an extinction of the Newfoundland red crossbill (*Loxiacurvirostra percna*) (Schwartz, 2005).

There are further examples where negative environmental impacts have been caused by targeted species introductions, e.g. the introduction of biological control agents (Louda et al., 1997; Pearson et al., 2003; Sheppard et al., 2018) or facilitated by cultivation and unintentional actions (Mack et al., 2000). Many traditional biological control programmes are proving successful and contributing positively to ecosystem services by reducing the need for insecticides and herbicides, increasing agricultural production and increasing native biodiversity (Myers et al., 2017). Nonetheless, assessing potentially invasive assisted

behaviour prior to implementing assisted colonization projects is essential (Mueller et al., 2008; IUCN, 2013; Roy et al., 2017). Clearly, the protection of native biota should have priority over possible benefits that an endangered species might obtain via assisted colonization (Genovesi et al., 2020).

Several experts expressed concerns on the potential impacts of translocated species on cultural and aesthetic values of the recipient region (Palmer, 2014). Translocated species may affect the physical appearance of the recipient region, particularly if they are conspicuous or abundant species, and this in turn may change the cultural value of the recipient region. On the other side, the loss of a species in its original range also may affect cultural values (Sandler, 2013; Palmer, 2014). Assisted colonization cannot fully restore such context-specific values, but preserving a species allows potentially to preserve the values attached to the species in question (Palmer, 2014).

4.1.3 Reducing risks of assisted colonization projects

The results of my study showed that the following measures are considered most relevant to enable successful assisted colonization: (i) selecting a target area with a carrying capacity large enough to sustain a minimum viable population, (ii) identification and protection of climate change refugia, and (iii) implementation of adaptive management to minimize the risk that the migrant population fails to establish in the target area.

As a necessity to justify assisted colonization as an effective conservation tool, careful study, risk management, and supported implementation are essential (Mueller et al., 2008). Of particular importance for the success of assisted colonization projects is assessing habitat suitability and availability to the needs of the candidate species (IUCN, 2013). The determination of carrying capacity and estimates on climate change refugia are additional important criteria for identifying suitable habitats for the translocated species and to ensure successful establishment (Hällfors et al., 2017). For instance, climate models that show future climate changes in relation to the tolerance limits of species could be a useful tool to obtain appropriate information (IUCN, 2013). Further, in the case of translocation by assisted colonisation, the implementation of management measures is essential and depends on monitoring results, which create the basis for progressive or adaptive management measures (IUCN, 2013).

In this regard and in order to minimize negative effects on native biota, a majority of the respondents considered that one of the most relevant activities should be monitoring of the target region and areas adjacent to the target region to identify negative impacts. The IUCN guidelines highlight that monitoring in the course of a translocation is an essential activity. It should be considered as an integral part of translocation design, not to be merely added on at a later stage (IUCN, 2013). In this respect it is important before the implementation of an assisted colonization project, to reflect the effect of future climate scenarios on ecological and hydrological processes of the recipient ecosystem (Carroll et al., 2009), monitoring target species and its social environment (Schwartz et al., 2013) as well as to evaluate the predictions through niche models and species distribution models (Hällfors et al., 2017).

Furthermore, this also includes the monitoring to identify new threats to the translocated population which were not part of translocation design to minimize the risk that the

translocated population fails to establish in the target area (IUCN, 2013). Further, assessing and monitoring the demography, behaviour, ecological functions, genetics, health conditions and mortality, social, cultural, and economic interest of the translocated species are important (IUCN, 2013).

4.1.4 Acceptance and implementation of assisted colonization

A large majority of experts considered secured financial and political commitment and appropriate regulatory frameworks as necessary preconditions for implementing assisted colonization. The costs of translocating species are highly context-specific (Pedlar et al., 2012). Costs for implementing assisted colonization can result from a wide array of measures such as captive breeding of the target species, monitoring, land purchase (Pedlar et al., 2012). The IUCN (2013) guidelines highlight that there should be awareness of possible needs for funding from any damage caused by the translocated species. Furthermore, flexible budget plans should be available to allow for adaptive changes to an assisted colonization project during implementation (IUCN, 2013).

The translocation of species requires specific laws and regulations on international, national, or sub-national levels. Consideration of the compatibility of permitted and non-permitted land-uses in areas either proposed for translocation or where translocated organisms might subsequently expand should be taken into account (IUCN, 2013). Any translocation event has to comply with international requirements, e.g. with the World Organisation for Animal Health standards for animal movement and those of the International Plant Protection Convention (IUCN, 2013).

In terms of responsibility for the implementation and related decisions of assisted colonization projects, most of the respondents held the opinion that this should be the task of government agencies and inter-governmental and multi-national agencies (e.g. IUCN). Government agencies and multinational agencies should not only assume responsibility but should also involve conservation experts. Their ability to identify potential benefits and risks could lead to important contributions to the development of principles, laws and legal guidelines (Javeline at al., 2015). Further, cooperation between the various stakeholders is needed to minimize the risk of poor implementation of assisted colonization projects (Javeline at al., 2015).

4.1.5 Recommendations for improving assisted colonization

It is particularly important to assess in advance whether a species is a suitable candidate for assisted colonization by creating species distribution models under contrasting climate change scenarios to assess the likely climatic suitability of the intended target region under different plausible future climatic conditions. In addition, precise monitoring of the target area must be carried out in advance. Each candidate species should be considered individually to tailor a potential project to its particular requirements. Further, assisted translocation projects should be multi-disciplinary, incorporating social sciences and biological and technical expertise.

5. Conclusions

The present study shows support of conservation experts to improve survival prospects of threatened species by assisted colonization and recognizes it as a useful conservation strategy under rapid environmental change, in particular when other conservation strategies are not an available option. Experts most strongly support assisted colonization for pressures related to climate change, but also are in favor of assisted colonization as management option for other anthropogenic threats. However, experts clearly expressed concerns on possible risks and negative consequences that are inherent to assisted colonization. Therefore, the approval of this conservation method is bound by several requirements such as (i) a collection of precise species-specific data of needs and conditions, (ii) a completed exhaustive risk assessment, (iii) implementation of previously defined management measures, and (iv) further monitoring of target areas to successfully establish the translocated species while protecting native biota. Accordingly, reducing the risks caused by possible disease and pathogen transmissions, potential invasiveness of the translocated species and failure of long establishment are required.

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8. Annex

8.1 Expert survey

Expert survey

„Assisted colonization – usefulness, risks, acceptance and implementation"

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Owing to climate change and other human-induced environmental changes, the habitats of many animal and plant species are changing. In order to survive, species have to adapt in situ or move to other areas.

Assisted migration (AM), also known as assisted colonization, managed relocation or benign introduction, is commonly understood as relocating threatened species to new locations outside their native range before their historical native range becomes inhospitable. This novel conservation strategy has been suggested as potentially useful when animals and plants cannot adapt quickly enough to local, changing environmental conditions and when dispersing to higher latitudes and altitudes on their own is assumed to be unlikely (Minteer and Collins, 2010; Ste-Marie et al., 2011; Hällfors et al., 2014).

The aim of this research is to evaluate the usefulness, risks, benefits, acceptance and implementation of AM. This includes the evaluation of conditions and criteria, under which AM could and should be used in conservation biology. Furthermore, relating to ethical aspects, I aim at evaluating at which point AM will be justified and who should be responsible for implementing AM and for monitoring translocated species.

The target group for this survey are conservation experts experienced in research or practice. Please answer the following questions.

All answers will be treated anonymously and confidentially.

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USEFULNESS

For which kinds of threats to species assisted migration (AM) should be applied?

1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree, 6 = I do not know

● The prevention of <u>global</u> species extinction caused by climate change

O 1 O 2 O 3 O 4 O 5 O 6

● The prevention of <u>global</u> species extinction caused by anthropogenic influence other than climate change (e.g. fragmentation, habitat loss, competition, predation, pathogens)

O 1 O 2 O 3 O 4 O 5 O 6

● The prevention of <u>global</u> species extinction not caused by anthropogenic influence (e.g. rarity, endemism)

O 1 O 2 O 3 O 4 O 5 O 6

● The prevention of <u>regional (e.g. national)</u> species extinction caused by climate change

O 1 O 2 O 3 O 4 O 5 O 6

● The prevention of regional (e.g. national) species extinction caused by anthropogenic influence other than climate change (e.g. fragmentation, habitat loss, competition, predation, pathogens)

O 1 O 2 O 3 O 4 O 5 O 6

● The prevention of regional (e.g. national) species extinction not caused by anthropogenic influence (e.g. rarity, endemism)

O 1 O 2 O 3 O 4 O 5 O 6

Which should be the criteria to identify species for AM?

1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree, 6 = I do not know

● Extinction risk (i.e. Red List status) of species

O 1 O 2 O 3 O 4 O 5 O 6

● Species whose extinction risk could not be reduced despite the implementation of conservation strategies other than AM

O 1 O 2 O 3 O 4 O 5 O 6

● Species with small ecological amplitudes related to climatic conditions

O 1 O 2 O 3 O 4 O 5 O 6

● Species with a long generation time when compared to the velocity of climate change

O 1 O 2 O 3 O 4 O 5 O 6

● Species with low genetic variability

O 1 O 2 O 3 O 4 O 5 O 6

● Species of high phylogenetic uniqueness

O 1 O 2 O 3 O 4 O 5 O 6

● Keystone species or other species that are relevant for ecosystem functions

O 1 O 2 O 3 O 4 O 5 O 6

● Species that are relevant for ecosystem service provision

O 1 O 2 O 3 O 4 O 5 O 6

● Other criteria: _____

RISKS

How would you consider the importance of the following potential risks of failure for implementing AM?

1 = no importance, 2 = little importance, 3 = some importance, 4 = much importance, 5 = very much importance, 6 = I do not know

● Risk of failure of the long-term establishment of the migrated species due to abiotic constraints

O 1 O 2 O 3 O 4 O 5 O 6

● Risk of failure of the long-term establishment of the migrated species due to biotic constraints (competition, predation, parasitism)

O 1 O 2 O 3 O 4 O 5 O 6

● Risk of failure of the long-term establishment of the migrated species due to human impacts

O 1 O 2 O 3 O 4 O 5 O 6

How would you consider the importance of the following potential risks of AM for native biota and ecosystems of the target area?

1 = no importance, 2 = little importance, 3 = some importance, 4 = much importance, 5 = very much importance, 6 = I do not know

● Displacement of native species

O 1 O 2 O 3 O 4 O 5 O 6

● Increased competition with native species

O 1 O 2 O 3 O 4 O 5 O 6

● Increased herbivory (when AM implemented for herbivorous animals)

O 1 O 2 O 3 O 4 O 5 O 6

● Increased predation (when AM implemented for carnivorous animals)

O 1 O 2 O 3 O 4 O 5 O 6

● Transmission of diseases

O 1 O 2 O 3 O 4 O 5 O 6

● Hybridization risk for native species

O 1 O 2 O 3 O 4 O 5 O 6

● Changes in species interactions and food webs

O 1 O 2 O 3 O 4 O 5 O 6

● Changes in ecosystem functioning

O 1 O 2 O 3 O 4 O 5 O 6

● Changes in ecosystem service provision

O 1 O 2 O 3 O 4 O 5 O 6

● Other potential risks:

RISK AVOIDANCE

How would you consider the importance of the following measures to reduce the risk of failure?

1 = no importance, 2 = little importance, 3 = some importance, 4 = much importance, 5 = very much importance, 6 = I do not know

● Application and further development of internationally agreed guidelines for AM

O 1 O 2 O 3 O 4 O 5 O 6

● Careful adaptation and enforcement of relevant laws and regulations

O 1 O 2 O 3 O 4 O 5 O 6

● Identification and protection of climate change refugia for the target species following ecological niche models or other methods based on biological data

O 1 O 2 O 3 O 4 O 5 O 6

● Selection of target areas with a carrying capacity to sustain a minimum viable population

O 1 O 2 O 3 O 4 O 5 O 6

● Selection of target areas for AM that at least partly are covered by protected areas

O 1 O 2 O 3 O 4 O 5 O 6

● Selection of target areas for AM with low anthropogenic pressures in foreseeable future

O 1 O 2 O 3 O 4 O 5 O 6

● Consideration of maximizing genetic diversity whilst minimizing risk of outbreeding depression to safeguard the evolutionary potential of the translocated species

O 1 O 2 O 3 O 4 O 5 O 6

● Implementation of adaptive management to minimize the risk that the migrated population fails to establish in the target area

O 1 O 2 O 3 O 4 O 5 O 6

● Other risk avoidance measures:

How would you consider the importance of the following measures to avoid risks for native biota and ecosystems?

1 = no importance, 2 = little importance, 3 = some importance, 4 = much importance, 5 = very much importance, 6 = I do not know

● Comprehensive and standardized assessment of the potential risks to the biological community of the target area before implementation of AM

O 1 O 2 O 3 O 4 O 5 O 6

● Implementation of adaptive management to minimize the risk for the biological community of the target area

O 1 O 2 O 3 O 4 O 5 O 6

● Monitoring of the target region and areas adjacent to the target region to identify negative impacts if they occur

O 1 O 2 O 3 O 4 O 5 O 6

Other risks avoidance measures:

ACCEPTANCE

Please specify the level of agreement with the following statements regarding acceptance of AM and socio-economic, societal and legal requirements:

1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree, 6 = I do not know

● Socio-economic studies should be carried out for the proposed AM to assess its impacts, costs and benefits for the local human population

O 1 O 2 O 3 O 4 O 5 O 6

● Careful assessment of the local citizen attitudes to the proposed AM project are necessary to ensure the continued protection of the migrated population

O 1 O 2 O 3 O 4 O 5 O 6

● Long-term financial and political commitment in the target area is required for AM projects

O 1 O 2 O 3 O 4 O 5 O 6

● An AM project should only be started if there is full authorization and involvement of all relevant government agencies of the beneficiary or host country (particularly in border areas when several states are involved or when a migrated population can expand into other states)

O 1 O 2 O 3 O 4 O 5 O 6

● The political stance of an AM recipient country towards AM projects should be assessed. This includes reviewing relevant laws and regulations

O 1 O 2 O 3 O 4 O 5 O 6

IMPLEMENTATION

Who should be responsible for the implementation of AM projects and AM-related decisions?

1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree, 6 = I do not know

● Government agencies (national to sub-national)

O 1 O 2 O 3 O 4 O 5 O 6

● Inter-governmental and multi-national agencies (e.g. IUCN)

O 1 O 2 O 3 O 4 O 5 O 6

● Conservation NGOs

O 1 O 2 O 3 O 4 O 5 O 6

● Local citizens

O 1 O 2 O 3 O 4 O 5 O 6

● Other stakeholders:

SUMMARY STATEMENTS

Please specify the level of agreement with the following statements:

1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree, 6 = I do not know

● AM should be recognized as an effective tool for species conservation but with potential risks that need to be carefully addressed

O 1 O 2 O 3 O 4 O 5 O 6

● AM should only be implemented if exhaustive assessments are made that conclude that it will not cause a decline in the conservation status of any species native to the target area

O 1 O 2 O 3 O 4 O 5 O 6

● Negative impacts on the environment caused by migrated species in the target region can intensify the expected negative ecological consequences of climate change (or other human-induced environmental changes)

O 1 O 2 O 3 O 4 O 5 O 6

● Efficiency (best results at lowest costs) should be a very important criterion for providing AM

O 1 O 2 O 3 O 4 O 5 O 6

● AM is ethically questionable (since it is a human intervention into historical evolutionary and ecological processes) and should be avoided

O 1 O 2 O 3 O 4 O 5 O 6

● In case of probable failure despite conservation management measures an AM project should be abandoned in favour of repatriation or continuation in alternative areas

O 1 O 2 O 3 O 4 O 5 O 6

Personal information:

Gender:

Male O Female O Other/n.a. O

Please provide the proportion (%) of your working time did that you dedicated in the last 5 years to:

● Research or implementation of assisted migration

☐ %

● Research on climate change impacts on biodiversity (excluding AM)

☐ %

● Research on biodiversity and nature conservation (excluding all above)

☐ %

● Applied conservation management (excluding all research)

☐ %

● Conservation policy

☐ %

Other: _____

☐ %

Which country do you mainly work on (related to AM, if applicable)?

Which broad ecosystems do you mainly work on, particularly when working on AM?

[choose only one]

O Marine

O Coastal

O Freshwater

O Wetlands

O Forests

O Grasslands

O Agricultural

O Mountains

O Polar

O Tundra

O Urban

Thank you for participating in this survey. If you would like to leave a comment or feedback, please answer below:

If you are interested in the result of this survey, please leave your email address:

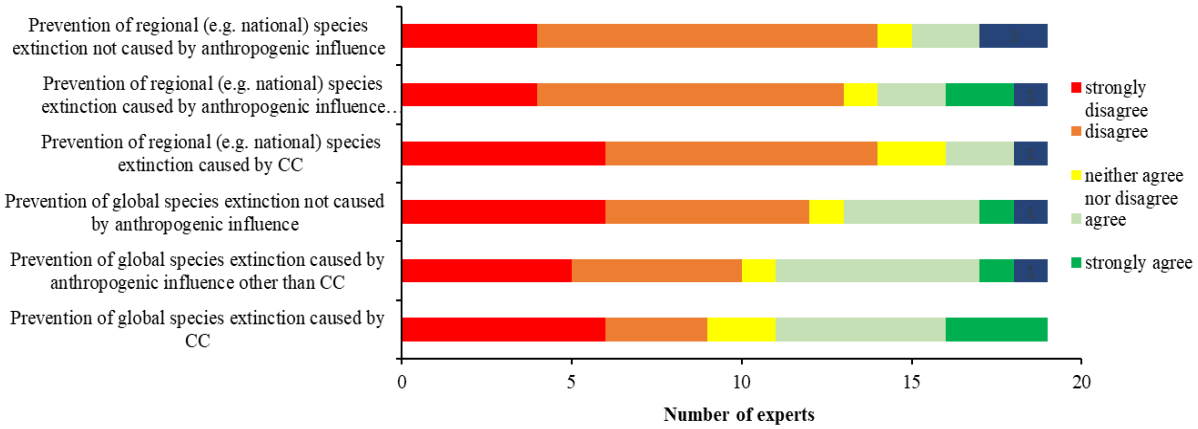
8.2 Results – Expert survey Austria

In addition to the globally representative sample just described, the same survey among Austrian experts were conducted.

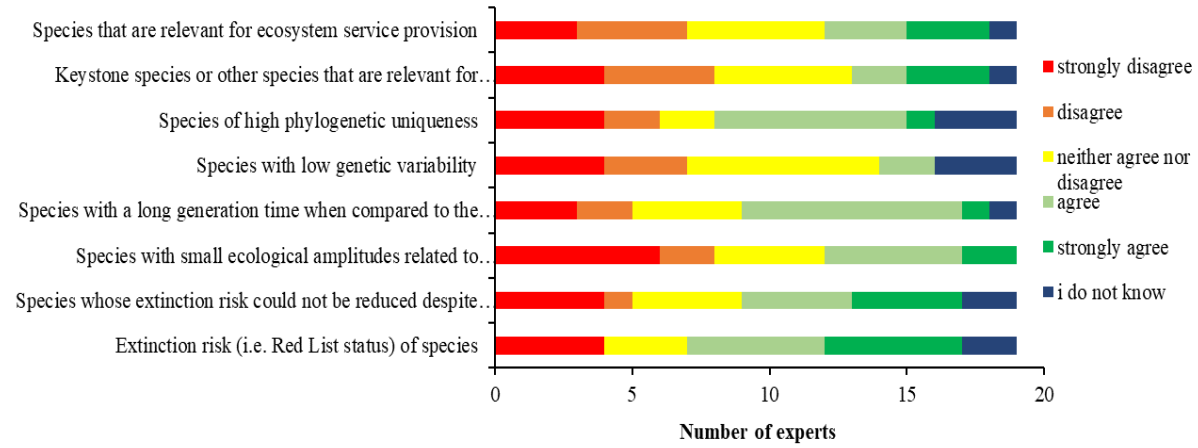
The sample included 19 Austrian experts who participated in the CCCCCS (Conservation under Climate Change: Challenges, Constraints and Solutions) Stakeholder-Workshop in Vienna (Umweltbundesamt/07.03.2019).

After a short introduction to the topic of assisted colonization, the survey was handed out and answered.

8.2.1 Results usefulness



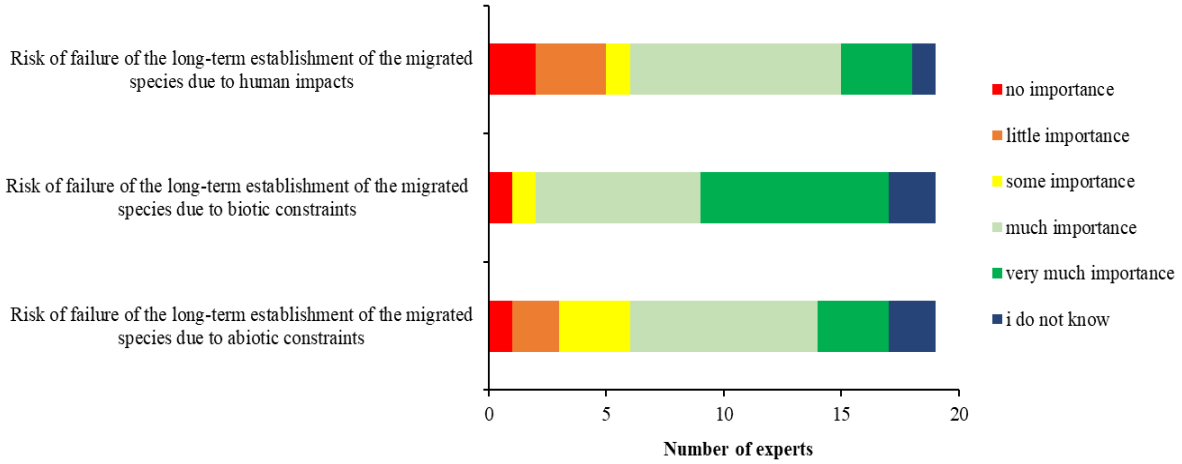
(a)



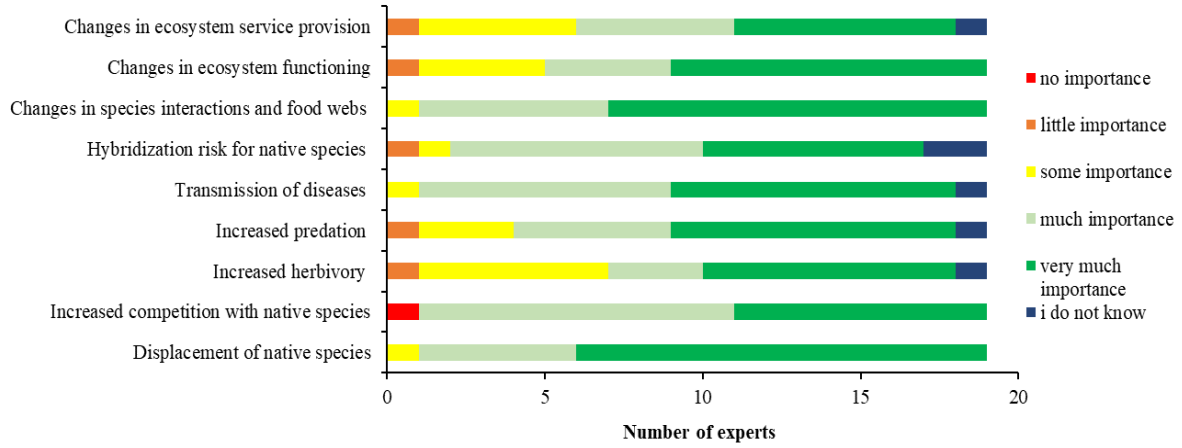
(b)

Fig 1.: Answers to the question (a) "For which kinds of threats to species, assisted colonization should be applied?“, and (b) Answers to the question " Which should be the criteria to identify species for assisted colonization?"

8.2.2 Results risk and risk avoidance

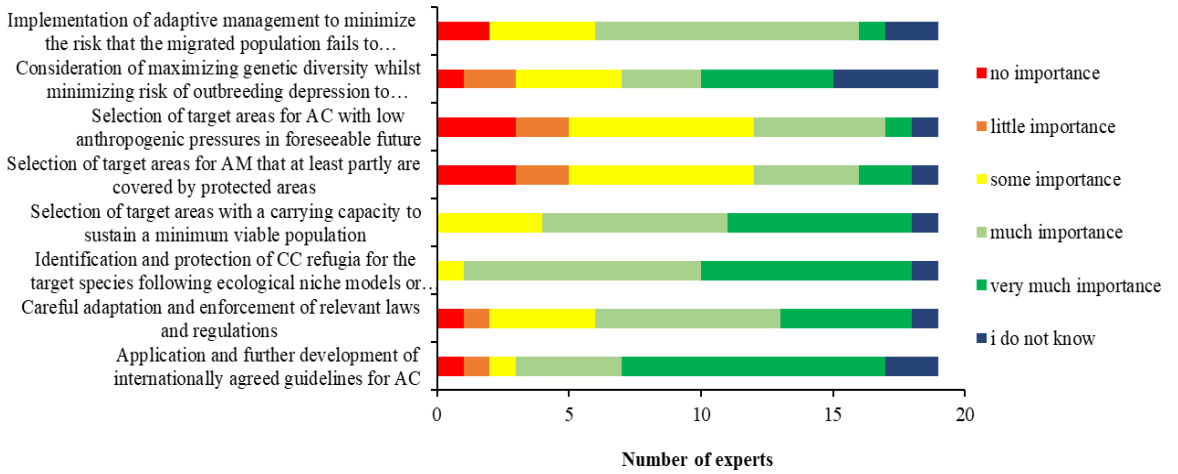


(a)

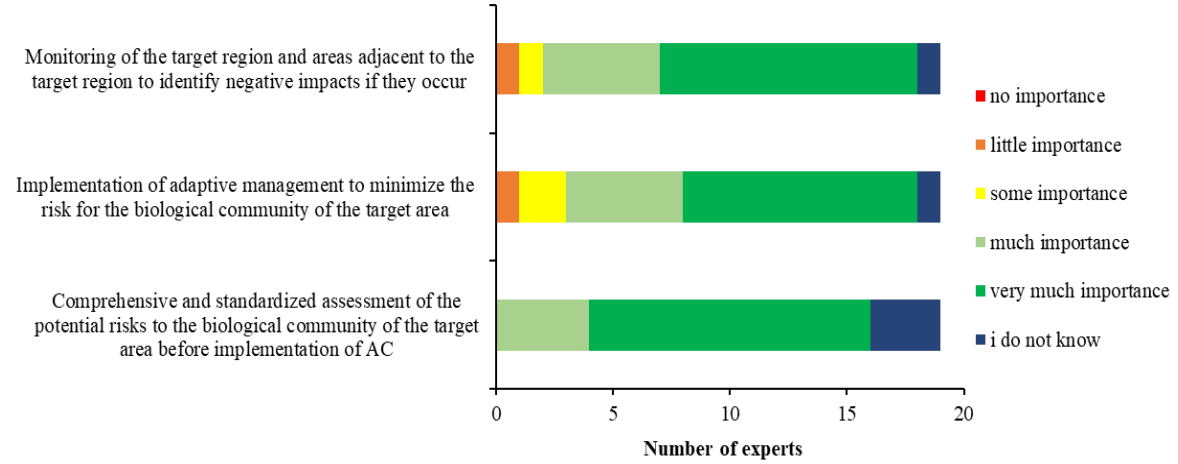


(b)

Fig. 2: Answers to the question (a) "How would you consider the importance of the following potential risks of failure for implementing assisted colonization?", and (b) " How would you consider the importance of the following potential risks of assisted colonization for native biota of the target area?"



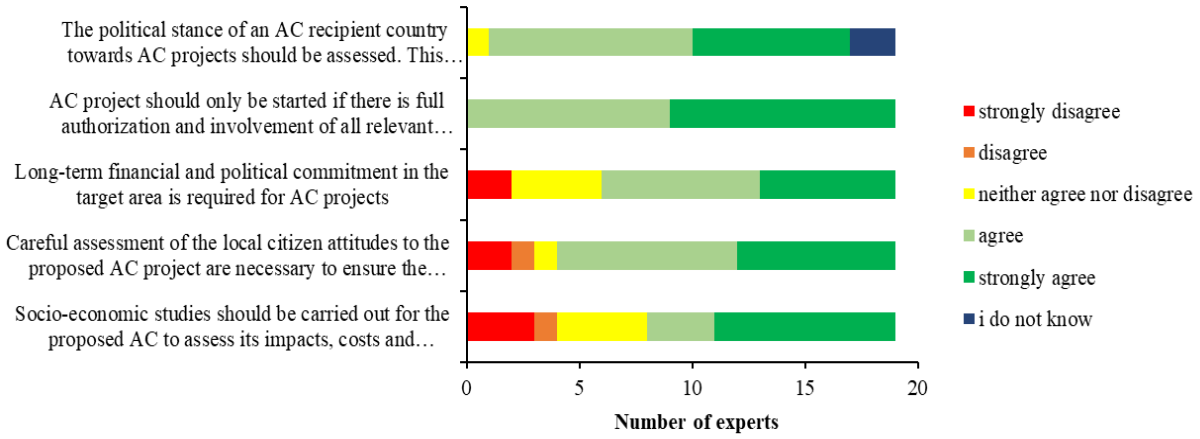
(a)



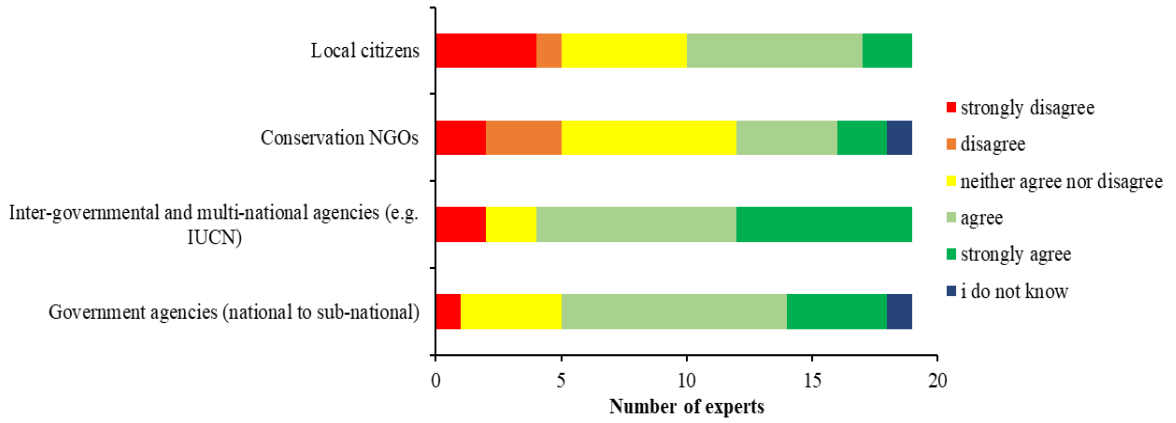
(b)

Fig. 3: Answers to the question (a) "How would you consider the importance of the following measures to reduce the risk of failure", and (b) "How would you consider the importance of the following measures to avoid risks for native biota and ecosystems?"

8.2.3 Results acceptance and implementation



(a)



(b)

Fig.4: Answers to the question (a) "How would you consider the importance of the following measures to reduce the risk of failure", and (b) "Who should be responsible for the implementation of assisted colonization projects and AM-related decisions?"

8.2.4 Results summary statements

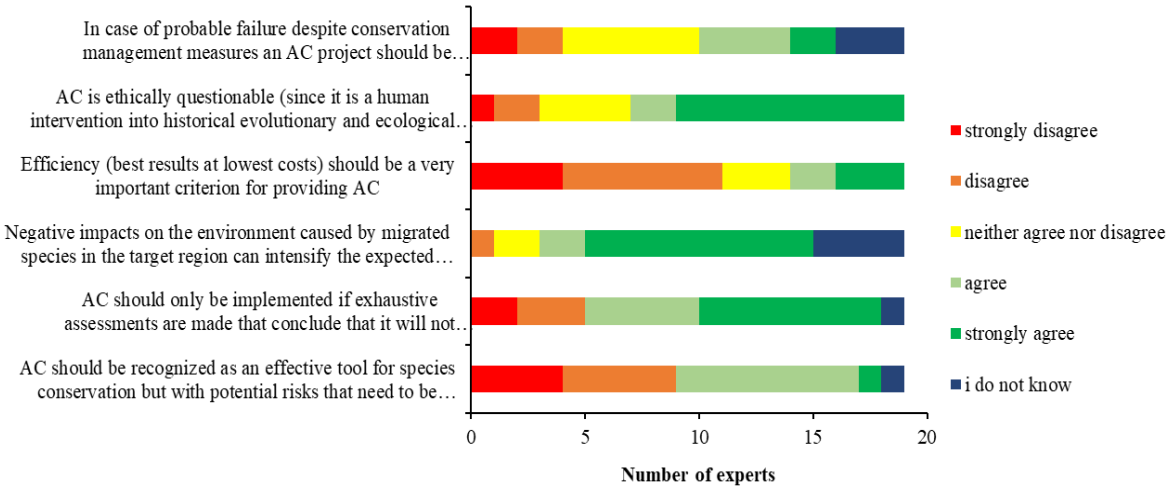


Fig.5: Answers to the question "Please specify the level of agreement with the following statements"

8.3 Results open questions

Other criteria:

- Another important consideration might include the species potential to become invasive in a novel ecosystem

- Species with very limited or (effectively) no dispersal capacity to reach suitable habitat

- Practicality, likelihood of success, technical feasibility

- Species with dispersal limitations that make natural colonization of suitable habitat highly unlikely over management time frames

- Whether or not establishment is possible; whether benefits outweigh the costs of assisted colonization; will the species survive on its own

- Species facing major dispersal limitation (intrinsic or through habitat and climatic barriers, such as would be faced by local montane endemics unable to disperse to other habitats

- Evidence for non-invasive "behaviour"

Other risks:

- I don't like Q4 because it lacks context. Assisted colonization can occur at a variety of spatial scales, and even within a particular species' range!

- Cultural value loss

- Changed aesthetics of the focal environment, societal opinion about the translocation process and outcome.

- Taking funding from more effective conservation actions

- Animals are expected to move on their own; if they move via assisted colonization, they are likely to cause immediate disruption to the environment

- Islands and insular environments are the places most at risk; we probably shouldn't do managed relocation in insular environments or if we do then only with much caution

- Economic loss

- The above items cannot really be answered ‘in general' because they are situation-specific. For example, the risk of total displacement of a 'native' species in the UK

- Risk to source populations and opportunity costs (viable alternatives and cost of time and money for ineffective assisted colonization) are two very important factors

Other risks avoidance measures:

- Root fungal associations also need to be considered in translocations

- Just want to point out that the IUCN Reintroduction Guidelines already provide guidance on assisted colonisation

- Pilot scale studies to provide insights for effective implementation of assisted colonization

- Establishment of semi-wild populations as 'half-way house' between zoo/botanical garden and truly wild population [e.g., Pere David deer story, or use of private or public parks to establish naturalised plant populations, instead of using standard hort

Other stakeholders:

- Scientists, sub-national government land managers, indigenous cultures

- farmers, other landholders, miners (in the case of restoration sites)

- It's likely important for no one to work in isolation

- Wildlife conservation-related research centres

- Universities

- Industries dependent (positively or negatively) by assisted colonization, species may have some role in financially and logistically supporting assisted colonization programs

- First Nations; comment: it really depends on the situation.

- Private as well as public landowners

- Scientific community (besides NGOs)

- Land owners

- Traditional owners

- Not just responsibility but who bears the risk of taking action, e.g., lawsuits. This is a major impediment to implementation

Survey comments:

- With regards to assisted colonization, I would never rule it out as an option, but also take feasibility studies and risk assessment very seriously.

- Context is important in this debate, and the questions in this survey seemed to be targeting long-distance events. But assisted colonization can occur across a variety of scales, and even within a species' current range. I'm not sure the questions will reflect that nuance.

- I see assisted colonization as an additional conservation tool for species on the brink, not replacing conservation of existing wild populations. I, therefore, avoid the term "assisted migration", which only focuses on helping species to move away from changing environmental conditions.

- I have not worked on assisted colonization directly, so am no expert in that sense, nor can I indicate a country. I have contributed towards an assessment of marine conservation translocations, including assisted colonization, which is presumably how I got on your list.

- It was not possible to answer your questions because you did not define assisted migration in the beginning, or you cited several differing definitions. Assisted migartion as defined in Hällfors et al. 2014 - which in my view is the correct definition.

- I have not doubts that assisted colonization have risks of failure and of affectation to local plant communities, but inaction I believe is even worst, because contemporary plant communities will be seriously affected by climate change.

- Although the questions related to plants and animals, they seemed very animal-oriented. Answers are different for plants vs animals in my mind.

- I am working on orchid reintroduction by seed sowing-directly with fungi, which benefits species and diversity conservation but no risk to local environment in my opinion

- My expertise is in conservation and climate change law and policy, including for assisted colonization so my work has not been restricted to a single ecosystem type. However, my work does focus primarily on terrestrial laws and policies rather than marine.

- Single most important thing is to put in place guidelines for both 'donating' and 'receiving' responsibility across administrative boundaries. It is also important to recognise that assisted colonization is an 'as well' strategy, not an abandonment of any other measures.

- The questions above reflect general approaches, but in my experience each organism has special needs and generalization is very difficult. I also feel that extinction rates will become so high with global change that if we greatly restrict implementation.

- I trust you have seen the results of previous surveys about assisted colonization. See Javeline et al. in Elementa (2015) and BioScience (2013). It would be nice to compare your findings with those results, though may not be possible without (some) directly comparable.

Abstract

Owing to climate change and other anthropogenic environmental changes, the suitability of locations is changing for many animal and plant species. In order to survive, species have to adapt in situ or move to other areas. Assisted colonization, also known as assisted migration, managed relocation or benign introduction, is commonly understood as intentional anthropogenic movement and release of an organism outside its native range to facilitate tracking changing environmental conditions and thus to reduce the threat of extinction. This conservation method has been proposed when animals or plants presumably cannot adapt in situ nor follow environmental changes by dispersal or migration. However, there have been contentious debates about the shortcomings and risks of implementing assisted colonization.

Here, I evaluate usefulness, risk, acceptance and implementation of assisted colonization. This includes the evaluation of conditions and criteria under which assisted colonization could be used in conservation biology. Furthermore, it should be determined who is responsible for the implementation and monitoring of translocation events. To this end, an online survey was designed and implemented, targeting conservation experts experienced in research or practice related to assisted colonization.

The majority of the 48 experts (82%) participating in this survey were in favour of the conservation method assisted colonization. However, a clear result was also that certain preconditions must be met, which were highlighted in this survey. Some of them are part of the IUCN guidelines for assisted colonization and include a completed risk assessment, clearly defined management plans and secured political as well as financial support. Other issues such as who takes responsibility for the implementation and further decision-making processes as well as other possible risks (e.g. cultural value loss, changing aesthetics of the local environment) were mentioned by the respondents. The advocacy of assisted colonization, regarding global / regional threats such as climate change and anthropogenic pressures, was not dependent on the geographic origin of the experts but Oceanians agreed significantly more than European that assisted colonization should also be considered for prevention of regional extinctions. On the other hand, the working background of the experts (e.g. research on assisted colonization, climate change research, biodiversity research, applied conservation management, conservation policy) showed a significant effect on some responses, as experts who were primarily active in biodiversity research were more likely opposing supporting assisted colonization.

Regarding possible risks, most of the participating experts were concerned about consequences like failure of the long-term establishment of the translocated species related to biotic constraints (competition, predation, parasitism), and the transmission of diseases and invasiveness potentially endangering native species. To keep these risks as low as possible and to achieve successful assisted colonization, most of the experts agreed that a target area must have a reasonable carrying capacity to sustain a minimum viable population and that identification and protection of climate change refugia is of essential importance. Adaptive management should be implemented, including monitoring of the prospective target area, to minimize the risk that the translocated population fails to establish. In terms of ethical justification, a large number of the participating experts agreed that this issue was less of a concern. In summary, the survey showed that the participating experts mostly considered

assisted colonization as a viable approach in species conservation. However, respondents also stressed that there are clear limits to implementing this approach. Future application of this conservation approach will generate further evidence that needs to be considered for matching the conservation needs of the Anthropocene.

Zusammenfassung

Aufgrund des Klimawandels und anderer anthropogener Umweltveränderungen verändern sich die Lebensräume vieler Tier- und Pflanzenarten. Um zu überleben, müssen sich die Arten vor Ort anpassen oder in andere Gebiete ziehen. Unter assistierter Kolonisation, auch als assistierte Migration, kontrollierte Umsiedlung oder gutartige Einführung bekannt, versteht man im Allgemeinen die absichtliche Bewegung und Freisetzung eines Organismus außerhalb seines einheimischen Verbreitungsgebiets, um das Aussterben von Populationen dieser Art zu verhindern. Diese Artenschutzstrategie wird in Betracht gezogen, wenn sich Tiere und Pflanzen weder in situ anpassen noch verändernden Umweltbedingungen durch Ausbreitung oder Migration folgen können. Jedoch gab es diverse Debatten darüber, welche Risiken die Umsetzung der assistierten Migration mit sich bringt.

In der vorliegenden Studie bewerte ich den Nutzen, die Risiken, die Akzeptanz und die Umsetzung der assistierten Kolonisation. Dies beinhaltet die Bewertung von Bedingungen und Kriterien, unter denen die assistierte Kolonisierung in der Naturschutzbiologie eingesetzt werden könnte. Darüber hinaus wird ermittelt, wer für die Umsetzung und Überwachung von translozierenden Arten verantwortlich sein soll. Um die dazu notwendigen relevanten Informationen zu erhalten, führte ich eine Umfrage unter Naturschutzexperten/innen durch, die Erfahrung in Forschung oder Praxis im Zusammenhang mit assistierter Kolonialisierung vorweisen konnten.

Die Ergebnisse dieser Befragung zeigten, dass die Mehrheit der teilnehmenden Experten/innen (n = 82%) für die assistierte Kolonisierung stimmten. Ein weiteres klares Ergebnis lag auch in dem Punkt vor, dass bestimmte Voraussetzungen für eine assistierte Kolonisierung erfüllt sein müssen, die zumeist auch Teil der IUCN-Richtlinien für die assistierte Kolonisierung sind. Sie umfassen zum einen eine vollständige Risikobewertung, klar definierte Managementpläne sowie politische und finanzielle Unterstützung. Weitere Aspekte, wie z. B. wer die Verantwortung für die Umsetzung und weitere Entscheidungsprozesse übernimmt, sowie andere mögliche Risiken (z. B. kultureller Wertverlust, sich verändernde Ästhetik des lokalen Umfelds) wurden ebenfalls von den Experten/innen als wichtig angesehen. Darüber hinaus zeigten statistische Analysen, dass die Befürwortung einer assistierten Kolonisierung in Bezug auf globale / regionale Bedrohungen wie Klimawandel und anthropogene Einflüsse nicht oder nur marginal von der geografischen Herkunft der Experten/innen abhängig war aber die Ozeaner waren sich signifikant mehr als die Europäer einig, dass die assistierte Kolonisation auch zur Verhinderung regionaler Auslöschungen von Arten in Betracht gezogen werden sollte. Andererseits zeigte der Arbeitshintergrund der Experten/innen (z. B. Forschung zur assistierten Kolonisation, Klimaforschung, Biodiversitätsforschung, angewandtes Naturschutzmanagement und

Naturschutzpolitik) einen signifikanten Einfluss auf einige ihrer Antworten. Experten/innen, die hauptsächlich in der Biodiversitätsforschung tätig waren unterstützten die assistierte Kolonisierung etwas geringer als andere Teilnehmer/innen.

Hinsichtlich möglicher Risiken äußerten sich die meisten der befragten Experten/innen besorgt über Folgen wie das Scheitern der langfristigen Etablierung der umgesiedelten Arten im Zusammenhang mit biotischen Faktoren wie zum Beispiel Wettbewerb, Prädation und Parasitismus) sowie über die Übertragung von Krankheiten und über Invasivität, die möglicherweise einheimische Arten gefährden könnten. Um diese Risiken so gering wie möglich zu halten und eine erfolgreiche assistierte Besiedlung zu erreichen, waren sich die meisten Experten/innen einig, dass ein Zielgebiet über eine angemessene Tragfähigkeit verfügen muss, um eine lebensfähige Mindestpopulation zu erhalten, und dass die Identifizierung und der Schutz von Klimarefugien von wesentlicher Bedeutung ist. Um das Risiko zu minimieren, dass sich die umgesiedelte Bevölkerung nicht etabliert, sollte ein adaptives Management, einschließlich der Überwachung des potenziellen Zielgebiets, durchgeführt werden. Was die ethische Rechtfertigung anbelangt, so waren sich viele der beteiligten Experten/innen darin einig, dass diese Frage weniger Anlass zur Sorge gebe. Die Befragten betonten jedoch, dass es klare Grenzen für die Umsetzung dieser Naturschutzstrategie gibt. Es bleibt demnach abzuwarten wie sich die künftige Anwendung von assistierter Kolonisation weiterentwickeln wird, um den Naturschutzbedürfnissen des Anthropozäns gerecht zu werden.