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Advances in plant conservation translocation

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Abstract
With thousands of performed cases, conservation translocation is now widely used to restore rare and threatened plant populations worldwide. While we begin to understand from previous mistakes and best practices what makes translocations successful, we realize also how complex the process of performing a translocation is, from the very initial planning phases to the final monitoring phase. Conservation biologists and practitioners met in Rome at the Roma Tre University in June 2022 for the 1st International Plant Translocation Conference, a conference fully dedicated to the most recent advances in plant translocations. This special issue, containing eight articles on different aspects of plant translocation, is a tangible output of the efforts by all attendees to sharing knowledge and establishing plant translocation best practices. Besides reviews and species-specific apsects of translocation, the special issue highlights the importance of the community of scientists and practictioners and the multidisciplinarity of conservation translocations to achieve succesful outcome.

Keywords Mediterranean biodiversity hot-spot · Mitigation translocation · Plant conservation · Plant reintroduction · Translocation aftercare

Main text

With thousands of performed cases, conservation translocation is now widely used to restore rare and threatened plant populations worldwide (e.g., Soorae 2021, 2022). The large amount of data accompanying past and present plant translocations is a massive source of information for improving techniques of future translocations and their outcomes. While the need for a large worldwide database of plant translocation has not been met yet (Godefroid and Vanderbought 2011), several databases developed at the country level has made these data available or partially available to the scientific community and practitioners involved in plant translocation (Silcock et al. 2021; Abeli et al. 2021; TRANSLOC, http://translocations.in2p3.fr/; CPC Reintroduction Registry https://saveplants.org/reintroduction-registry/). Thanks to these databases, we have entered a new era of translocation science, an era where the analysis of large data sources is shedding light on a key question: What are the drivers of plant translocation outcome (i.e., success or failure)? Several recently published reviews have started to highlight some corner-stones of translocation performance in terms of plant survival, flowering and fruiting rates and recruitment (Godefroid et al. 2011; Dalrymple et al. 2012; Albrecht and Maschinski 2012; Liu et al. 2015; Silcock et al. 2019; Fenu et al. 2019). Key drivers of performance so far include; the number of released plant individuals, their age, the demographic trends of their source, their genetic diversity, and how they were propagated (Godefroid et al. 2011; Dalrymple et al. 2012; Liu et al. 2015), as well as some intrinsic species characteristics like the plant life form (Liu et al. 2015) and preferred habitat (Silcock et al. 2019).

While we begin to understand from previous mistakes and best practices what makes translocations successful, we realize also how complex the process of performing a translocation is, from the very initial planning phases to the final monitoring phase (CPC 2018; Commander et al. 2018).

The process leading to a conservation translocation includes at least three phases that can be summarized as follows: (1) *planning phase* including feasibility studies, social and financial considerations, authorization process,

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understanding of the target species characteristics, source material and release site selection; (2) *implementation phase* including material propagation, site preparation, plant release; (3) *post-release phase* including monitoring, aftercare, outcome assessment. Considering the different expertise involved in the abovementioned phases, we may assert that conservation translocation is the most comprehensive and multifaceted conservation tool we have today, encompassing not less than four macro-disciplines, i.e., biological sciences (taxonomic, genetic, ecological, biological considerations), environmental sciences (geographic, geological, topographic and pedological considerations), social sciences (risk and conflict management, authorization process), and economic sciences (financial risks and sustainability; Fig. 1).

Despite recent advances, there are still several aspects of plant translocation that need to be clarified, as in most cases the drivers of outcome identified in the abovementioned reviews were species-specific and/or site-specific, which prevents identification of a single recipe (or even a few) recipes for all target taxa. For instance, how intrinsic plant traits and preferred habitat affect translocation outcome is still poorly investigated, as is the trade-off between cost of aftercare and its contribution to translocation performance. For this reason, conservation biologists and practitioners met in Rome at the Department of Science of the Roma Tre University from 20 to 23 June, 2022 for the 1st International Plant Translocation Conference (IPTC2022; https://host.uniroma3.it/eventi/IPTC2022/), a conference fully dedicated to the most recent advances in plant translocations. This special issue, containing eight articles on different aspects of plant translocation, is a tangible output of the efforts by all attendees to sharing knowledge and establishing best practices. One the most important achievements of the IPTC that is reflected in this special issue is the recognition that mitigation translocations are in fact translocation with a different perspective, but with important commonalities in terms of methods.

The special issue opens with Doyle et al. (2023), the first and most comprehensive review and perspective article on mitigation translocation aimed at reframing mitigation translocations as conservation driven. Doyle et al. (2023) sets a new state-of-the-art for mitigation translocation and bridges the science-based standards of conservation translocations to achieve global standards for mitigation translocations.

In the new era of large dataset analysis, Fenu et al. (2023) reviews translocations in the Mediterranean area, with the aim to mark the current situation of plant translocations in this Biodiversity Hotspot and identify future directions. The great discrepancy between translocations performed (836 cases related to 572 plant species) and published (133 published papers related to 56 plant species) further reflects the need for database implementation and analysis.

According to Fenu et al. (2023), France is among the most active countries for the number of conservation and mitigation translocations performed. Diallo et al. (2023) analyses the threats affecting 193 plant species subjects to mitigation and conservation translocation in France, with clear differences in terms of threats between the two types of action. While mitigation translocation is usually applied to populations threatened by infrastructure development, conservation translocations are often applied to other types of human-induced disturbances and natural system modifications.

How long post-translocation monitoring should last is one of the most debated topics in plant translocation, with globally agreed standards not yet achieved. Julien et al. (2023) provides an overview of monitoring duration in 575 conservation and mitigation translocations in France. In

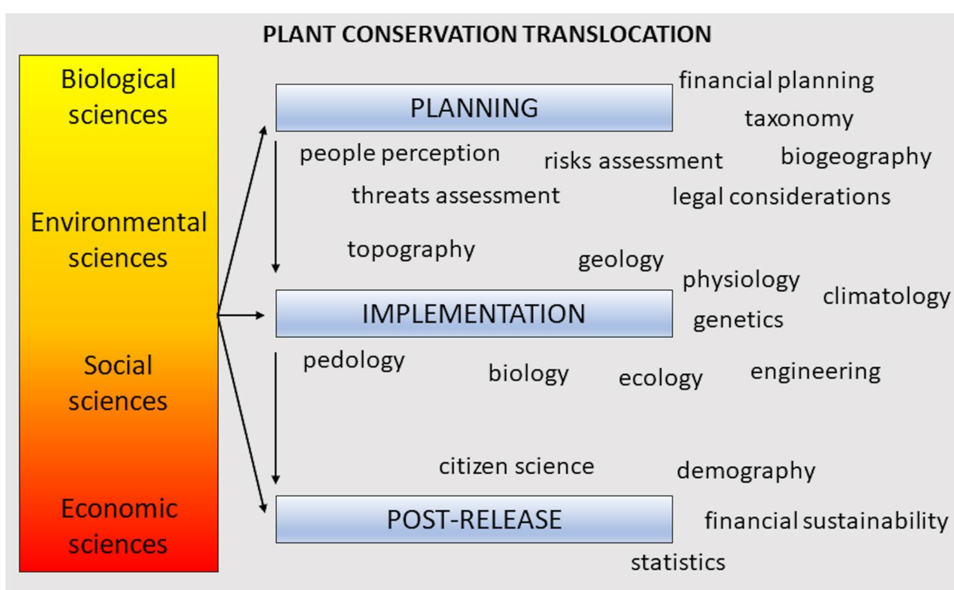

Fig. 1 Overall complexity of a plant translocation with at least four macro-disciplines involved in three phases. Disciplines are represented as a cloud near each of the translocation phase where they provide the main contribution; however, every discipline may contribute to plant translocation outcome in more than one phase

most translocations monitoring lasted less than four years, with shorter monitoring in mitigation translocations than in conservation translocations, further evidence of higher standards needed for mitigation translocation. Monitoring is important also to identify and mitigate the consequence of unexpected issues on translocated populations, through aftercare techniques.

One of the most important aspects in translocation includes genetics and genomics considerations for ensuring that translocated populations are adaptively representative, diverse, and composed of unrelated individuals. Using two Australian species as case studies (*Prostanthera densa* and *Fontainea oraria*), Rossetto et al. (2023) developed a workflow to better support the use of genetic and genomic studies in plant translocation.

Monks et al. (2023), reviewed the role of fencing and watering for the outcome of 76 translocations of 50 species in the Mediterranean province of Western Australia and found that fencing and watering significantly improved translocation outcomes in terms of survival and growth, and reproduction, respectively.

Literature reviews and database analysis are very important to inform practical activities in the field, for instance, the selection of suitable sites for translocation. Prado et al. (2023) built their study on current knowledge on limnological and ecophysiological requirements of quillworts to assess suitable sites for the translocation of the threatened endemic quillwort *Isoëtes cangae*, in Brazil.

Finally, Reiter et al. (2023) showcases the complex relationships between plant reproduction, weather and pollinator activity using the endangered orchid *Caladenia xanthochila* as a case study. The study highlights that pollinators play a key role in translocation outcome and suggests hand pollination as an aftercare technique to improve translocation outcome.

The importance of the plant translocation community

Although the contributions in this special issue, and previous literature, can attest to the long-established utilization of plant translocation, we feel that this editorial is an opportunity to commend and promote the excellent work happening in the plant conservation translocation community. The amount of activity, longevity of projects, and quality of work has reached a new level of scientific rigor and professionalism that positively reflects on an engaged and committed community of practitioners and researchers. Indeed, the boundaries between practice and research are blurred and are a product of the willingness of practitioners to adopt best practice, to learn from each translocation attempt, and of researchers to address applied questions of direct relevance to practice. This willingness to work collaboratively is evident in data sharing and calls for strengthened databases, a feature of an emerging movement in conservation to rigorously incorporate evidence in conservation actions (Downey et al. 2022). The importance of experimental trials in conservation interventions has been noted recently (Sutherland et al. 2022) but is long-established in plant conservation translocations. Finally, as was evident at the International Plant Conservation Translocation Conference, as well as in this Special Issue, the plant translocation community continually demonstrates its appetite to learn from past failures to improve—an aspect of conservation practice which is crucial to future success (Dickson et al. 2023). Our ability to share experiences and identify the root causes of failures will be improved by greater sharing between national databases (Fenu et al. 2023) and is something we should strive to do globally in order to most effectively protect plant diversity for future generations.

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Declarations

Conflict of interest Authors have no conflicts of interest to declare.

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