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CONTRIBUTED PAPER

Best practices, errors, and perspectives of half a century of plant translocation in Italy

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Article impact statement: Source population trends, propagation methods, propagule age, and aftercare significantly affect translocation outcomes in Italy.

Abstract

Conservation translocations are becoming common conservation practice, so there is an increasing need to understand the drivers of plant translocation performance through reviews of cases at global and regional levels. The establishment of the Italian Database of Plant Translocation (IDPlanT) provides the opportunity to review the techniques used in 186 plant translocation cases performed in the last 50 years in the heart of the Mediterranean Biodiversity Hotspot. We described techniques and information available in IDPlanT and used these data to identify drivers of translocation outcomes. We tested the effect of 15 variables on survival of translocated propagules as of the last monitoring date with binomial logistic mixed-effect models. Eleven variables significantly affected survival of transplants: life form, site protection, material source, number of source populations, propagation methods, propagule life stage, planting methods, habitat suitability assessment, site preparation, aftercare, and costs. The integration of vegetation studies in the selection of suitable planting sites significantly increased the success of translocation efforts. Although posttranslocation watering had a generally positive effect on translocation outcome, other aftercare techniques did not always increase transplant survival. Finally, we found that how funds were spent appeared to be more important than the actual amount spent. Plant translocations in Italy and in the Mediterranean area should account for the complexity of speciation, gene flow, and plant migrations that has led to local adaptations and has important implications for the choice and constitution of source material.

KEYWORDS
best translocation practices, conservation translocation, costs of translocation, IDPlanT, Italian Plant Translocation Database, threatened plants, translocation aftercare, translocation outcome

INTRODUCTION

Conservation translocations (translocation hereafter) are intentional movements of plant and animal individuals for conservation purposes, including population reinforcement (augmentation of an existing population), reintroduction (release of an organism in a site from which it has disappeared), and conservation introduction (release of an organisms outside its natural range) (IUCN, 2013). Although translocations remain high-risk and high-cost conservation practices (Fenu et al., 2016), their importance in conservation science is increasing worldwide, as demonstrated by successful projects (Colas et al., 2008; Draper Munt et al., 2016; Holzapfel et al., 2016; Maunder et al., 2000; Soorae, 2021).

With translocation becoming a common conservation practice (Swan et al., 2018), reviews are important to define the drivers of performance in plant translocation and inform future advances in the field. However, the results of most translocations are either confined to the gray literature or not published at all, although recent studies on animals and plants provide interesting information on drivers of translocation performance (Brichieri-Colombi & Moehrenschlager, 2016; Bubac et al., 2019; Diallo et al., 2023; Silcock et al., 2019). In plants, translocation success in terms of transplant survival and recruitment is typically related to the planting of a high number of juvenile or adult individuals from mixed source populations with stable demographic trends (Dalrymple et al., 2012; Godefroid et al., 2011). Site preparation, management, and protection also improve the chance of success (Godefroid et al., 2011; Whitehead et al., 2023).

Reviews at the regional or national level highlight additional cues of translocation success that could be useful in designing guidelines and best practices. For instance, Liu et al. (2015) found that plant translocation performance in China is related to plant life form and type of plant materials used; herbs and juvenile plants have the highest percentage of survival. Moreover, flowering and fruiting were higher among herbs propagated vegetatively and for introductions relative to reinforcements and reintroductions (Liu et al., 2015). Silcock et al. (2019) found that species' life form and habitat can affect translocation performance in Australia.

Italy is in the Mediterranean mega-hotspot and hosts a rich native flora of 8249 vascular plant species and subspecies, including 1739 endemic taxa (Bartolucci et al., 2018, 2021; Cañadas et al., 2014; Peruzzi et al., 2014), and many evolutionarily distinct taxa (Carta et al., 2019). A recent red-listing initiative for about 2400 taxa (including vascular and nonvascular plants and lichens) highlights that 24.3% of assessed taxa are listed under one of the International Union for Conservation of Nature threat categories (i.e., vulnerable, endangered, or critically endangered) (Orsenigo et al., 2021); 22.4% of the threatened taxa are endemic to Italy (Orsenigo et al., 2018); and 54 taxa are extinct or possibly extinct in the wild (Orsenigo et al., 2021). Moreover, the IV Italian report on the conservation status of the 115 Italian plants listed in the European Union Habitats Directive (92/43/EEC) shows that 54% are in an "unfavourable–inadequate" or "unfavourable–bad" status (Fenu et al., 2021). Overall, a considerable proportion of Italian flora requires conservation action, and translocations represent an effective tool to halt or reduce the risk of extinction of threatened plant species.

In Italy, the first documented plant translocation involved the iconic species *Pinus heldreichii* subsp. *leucodermis* (Antoine) E. Murray in Pollino National Park (Calabria) (Brogi, 1960). This translocation is a success story and likely the longest plant translocation activity ever performed; the reinforcement and reintroduction of this species are still ongoing after 64 years. Since the first reinforcement of this translocation, many other plant translocations have been performed in Italy, most of them (~98%) in the last 2 decades. Unfortunately, only a small number of Italian translocation cases have been published in the scientific literature (Fenu et al., 2016, 2019; Paoli et al., 2020) or in dedicated monographs (e.g., IUCN Global Reintroduction Perspectives) (Soorae, 2021, 2022). Given the increasing use of translocation by Italian conservation practitioners and scientists, it is important to devise recommendations based on translocations already performed so as to support future activities and increase the probability of positive outcomes. Therefore, we analyzed the results of plant translocations performed in Italy since the first documented case in 1958.

The data we used came from the Italian Database of Plant Translocation (IDPlanT) (Abeli et al., 2021), a recently developed database that includes unpublished translocations and, to our knowledge, is the only translocation database that provides data on economic resources invested in translocations. Ours is the first complete account of plant translocation of Italian flora. We aimed to identify best practices, errors made, and future directions in plant translocation in specific Italian contexts but that could also apply to other regions in the Mediterranean basin. We addressed following questions: How successful are plant translocations in Italy, are findings from previous global reviews transferable to translocations in Italy, and what factors shape translocation success in Italy? We analyzed translocation performance in terms of percent survival of transplants.

Specific hypotheses tested were as follows: life form and native habitat affect translocation performance and outcomes for trees and shrubs are better than for herbs; planting sites selected based on expert opinion do not perform as well as those based on models and correlational studies (in IDPlanT, most planting sites were selected based on expert opinion or vegetation studies [Biondi, 2011; Pott, 2011]); aftercare increases survival; and the more funds allocated to a translocation project, the greater the chance of plant survival.

METHODS

IDPlanT has a standardized format for entries and was created as a repository for data on plant translocations in Italy with Abeli et al. (2021). This database includes published and unpublished plant translocation cases, monitored on average for 5 years after outplanting, so our work refers to the medium term. Seven cases were excluded because they referred to translocation activities at multiple sites and did not provide separate data for each site.

Descriptive analyses

The analysis of IDPlanT was conducted on 178 out of 185 cases in the database. Because a single translocation project may imply the planting of a focal species in one or more populations, we considered every single established population separately. This allowed us to account for even minor variations between sites and translocated populations (e.g., differences in microsite, number of planted individuals, pre- or posttranslocation management, etc.). In "RESULTS," we briefly describe IDPlanT by quantifying the types of materials, techniques, and information available in the database.

Statistical analyses

Data on posttranslocation plant survival were available in about 40% of cases, whereas data on recruitment were available in 25% of cases and were in most cases null.

To understand the factors shaping translocation outcome in Italy, we fitted binomial logistic mixed-effect models with logit link function in which the proportion of planted to surviving individuals at the last monitoring date was the response variable. The full list of explanatory variables we considered is in Table 1. When a single translocation case used more than one technique within a group of operations (e.g., more than one site preparation method, more than one aftercare technique, etc.), we treated this as a different treatment in the models we called *combined techniques*. It means that levels within a variable group were mutually exclusive (Table 1). Life form, preferred habitat, and distribution refer to those specified in Pignatti et al. (2017–2019).

Due to the large number of explanatory variables and the relatively low number of cases in IDPlanT that provided survival proportion (sample size of each model in Table 2), we fitted separate models for each variable as reported in Table 1. The cost of the translocation was categorized in one of 4 groups: unknown, €0–€5,000, €5,000–€10,000, and >€10,000.

We included in each model time and operator as random factors to account for variation deriving from different lengths of monitoring and different research groups involved in each translocation, respectively. Because the length of the monitoring time was not available for all analyzed cases, time was included as a categorical variable with 3 levels: unknown monitoring length, monitoring up to 5 years after outplanting, and monitoring for >6 years after outplanting. However, given the small number of cases with which to run such complex models with random factors (i.e., time and operator), we further simplified the models by excluding the random factors that were never very important (time, in particular, was never significant), and in the interest of simplicity, we present results from models without random factors.

Sequential Bonferroni post hoc tests were performed for all significant models. We used a χ^2 test to examine associations

TABLE 1 Explanatory variables used to test the effect of plant translocation methods on percent survival and percent fruiting of translocated propagules at the time of last monitoring.

Variable[a]	Level
Life form	Geophytes, forbs, trees, herbs (hemicryptophytes), hydrophytes, helophytes, annuals, lichens
Preferred habitat	Woodlands, grasslands, cliffs, scrublands, freshwater, salt marshes, coastal dunes
Distribution	Mediterranean endemics
	European–Eurasiatic
	Circumboreal
	Southern European mountains
Type of action	Reinforcement
	Reintroduction
	Introduction
Site protection status	Protected area
	Not protected area
Material source	Same population
	Closest population
	Not closest population
Number of source populations	One population
	Two populations
	Three or more populations
Source population trends	Decreasing
	Stable
	Increasing
Propagation methods	Vegetative
	Seed/spore
	In vitro
	Combined methods
Propagule life stage	Seeds
	Seedlings
	Juveniles
	Adults
	Combined life stages
Planting methods	Sowing
	Bare root
	Potting soil
Acclimation	No acclimation
	Greenhouse
	Growth chamber
	Open field
	Combined methods
Habitat suitability assessment	Correlation studies & SDMs
	Vegetation studies
	Expert based

(Continues)

TABLE 1 (Continued)

Variable[a]	Level
	Combined methods
Site preparation	No preparation
	Fencing
	Topsoil removal
	Watering[b]
	Soil loosening[b]
	Reducing competition
	Combined methods
Aftercare	No aftercare
	Fencing
	Watering
	Reducing competition
	Combined methods
Translocation costs	

[a]All variables are categorical, with the exception of the number of translocated propagules.
[b]Not included in the model for site preparation and survival percentage is the response variable because all translocations in which watering and competition reduction were used conducted these tasks in combination with other techniques, so they are all included in combined methods.

between variables. All statistical analyses were performed using SPSS 21.0.

RESULTS

Most translocations were population reinforcements (51.9%), followed by reintroduction (36.2%) and introductions (11.9%). Overall, plant survival was on average 47.39% (SD 38.66), flowering was 30.78% (37.49), fruiting was 21.80% (34.54), and recruitment was 57.08% (196.56). The most represented life forms were perennials geophytes, trees, and shrubs (altogether accounting for about 70% of cases). Woodlands and grasslands were the most represented types of land cover (about 50% altogether), and 61% of analyzed cases targeted Italian or Mediterranean endemics (Figure 1). The high variation in recruitment occurred because some translocations were highly successful, so the population size at last monitoring date overcame the initial number of translocated propagules. Associations between the categorical variables used as predictors of transplant survival and fruiting are in Appendix S1.

Characteristics of the source material for translocation

Although most reinforcements used propagated material from the same population, the propagules used for reintroduction and introduction were mainly juvenile or adult plants from the closest population (Appendix S2). In 5 translocations, a combination of juveniles and adults (4 cases) and seeds and juveniles was used. Moreover, vegetative propagules were often com-

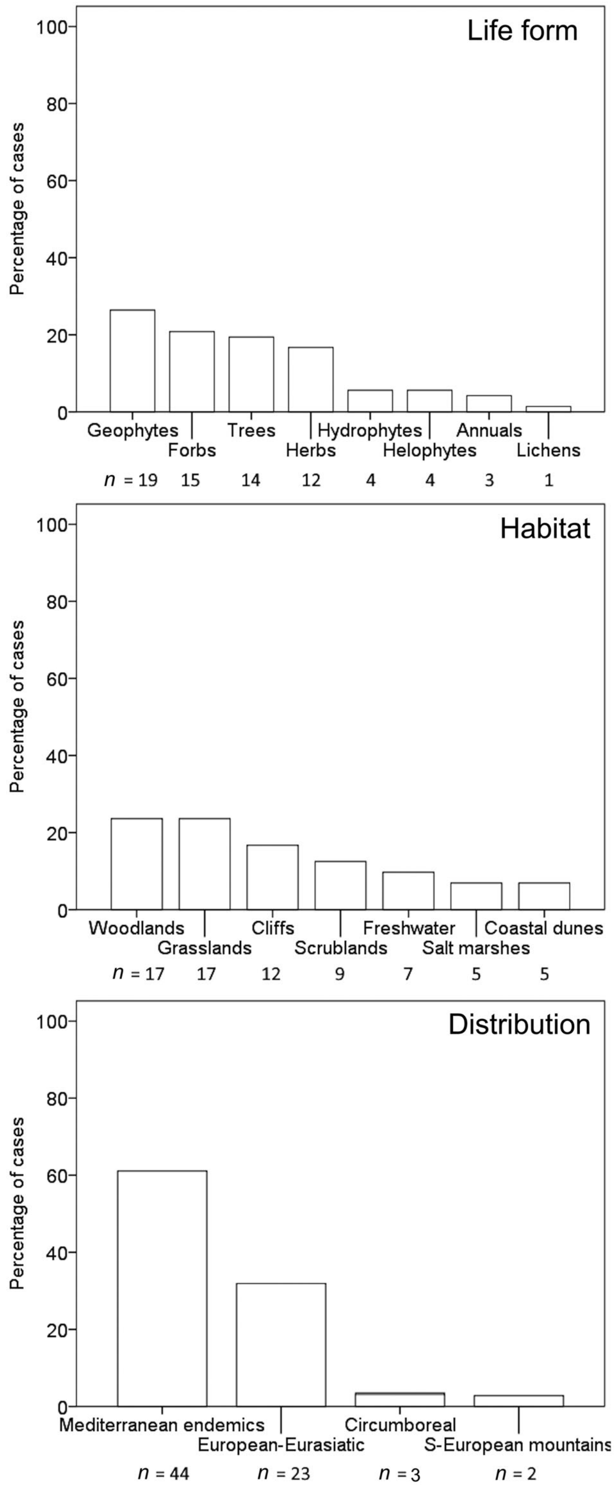

FIGURE 1 Percentage of plant translocation cases that accounted for species life form, preferred habitat, and distribution (total cases 72) (i.e., cases had to have survival percentage of translocated propagules) (*n*, number of cases for the variable; S, southern).

TABLE 2 Results of the binary logistic mixed-effect models of plant transplant survival proportion at the time of last monitoring as the dependent variable.

Variable	*n*	*F*	df	*p*
Life form*	63	0.511	6	0.767
Habitat	64	3.117	6	0.010
Distribution*	63	0.130	2	0.878
Type of action	64	1.168	2	0.318
Site protection	64	4.287	1	0.043
Material source	50	6.425	2	0.003
Number of source populations	64	6.352	2	0.003
Source population trend	59	2.773	2	0.071
Propagation methods	64	8.814	3	<0.001
Propagule life stage	60	3.911	4	0.007
Planting method	60	0.743	2	0.480
Acclimation	63	5.365	3	0.002
Habitat assessment*	63	3.677	2	0.031
Site preparation	63	4.078	3	0.011
Aftercare	64	3.208	4	0.019
Translocation cost	50	13.102	2	<0.001

*Terophytes, circumboreal, and phytosociology groups removed because they were represented by one case.

bined with seeds or spores. In 2 cases (*Hypericum elodes* L. and *Marsilea quadrifolia* L.), swards containing rhizomes were used as a source of inoculum. In an introduction of *Corynephorus canescens* (L.) P. Beauv., the soil containing the natural soil seed bank of the species was collected and relocated to the selected planting site.

The number of translocated propagules ranged from 1 to 4800, and 20% ($n = 35$) of translocations released fewer than 50 propagules, most often from a single population with a trend that was mostly unknown (Appendix S2). Source population trend was unknown in 12.5% of cases, increasing or stable in 43% of cases, and decreasing in 44.5% of cases. Unfortunately, we do not know for all cases how source population trends were measured because this information is not included in the database. However, in some cases (e.g., *Isoëtes malinverniana*, *Hieracium australe* subsp. *australe*), a regular monitoring of the population size was performed by counting or estimating the number of individual plants.

Choice of the planting site, planting techniques, and site preparation

The most used method to assess habitat was expert opinion, followed by vegetation correlational studies and species distribution models (SDMs) (Appendix S3a). When more methods were used to determine habitat presence for target species, vegetation studies and expert-based opinions were the main combination (22 cases). Additional details on planting techniques (e.g., how the material was planted) and acclimation are in Appendix S3. As for prerelease site preparations, the most frequently used was competition reduction, followed by fencing, no action, topsoil removal, watering, and soil loosening (Appendix S4). The most common combinations of techniques were fencing and competition reduction (12 cases) and competition reduction and watering (5 cases).

Aftercare

Postrelease manipulations (Appendix S4) included competition reduction by periodical mowing and non-native species control, watering, no action, fencing, and other techniques, such as shading (*H. elodes* L.) or modification of the water flow to avoid sediment accumulation (*Isoëtes malinverniana* Ces. & De Not). Nutrient enrichment was not carried out in any translocation case, and the most common combination of aftercare techniques was watering associated with competition reduction (23 cases).

Cost of translocation

Data on translocation cost were provided for 96 out of 178 cases. About 18% of cases were carried out at no cost because the work was conducted by volunteers. For 7 cases, the full budget of a larger project was provided, and there were no details on actual costs of translocations. By excluding the abovementioned cases, the cost of a translocation in Italy ranged from €100 to €30,000, and the average was €6,890 per case.

Survival percentage

Translocation performance in terms of transplant survival percentage at last monitoring date was significantly affected by all considered variables with the exception of species life form, species distribution, type of action, source population trend, and planting method (Table 2; Figures 2 & 3). Most of these variables were associated with each other (Appendix S1), which may confound the interpretation of our results. On the one hand, site protection and planting methods showed less correlation with other variables; thus, they were unequivocally important for the translocation outcome. On the other hand, preplanting site preparation, costs, acclimation, and propagule life stage were highly correlated to many other variables, which confounds their real contribution to translocation outcomes.

In detail, species habitat affected translocation outcome; grassland and salt marsh species had low survival (Figure 2). Moreover, transplant survival percentage was increased by the planting of propagules in protected areas, by the use of material from the closest population to the planting site, and by the use of mixed material from 2 or more populations (Table 2; Figure 2). Among the propagation methods, vegetative propagation or combined propagation methods (vegetative + seeds) led to increased survival. Propagule life stage affected the

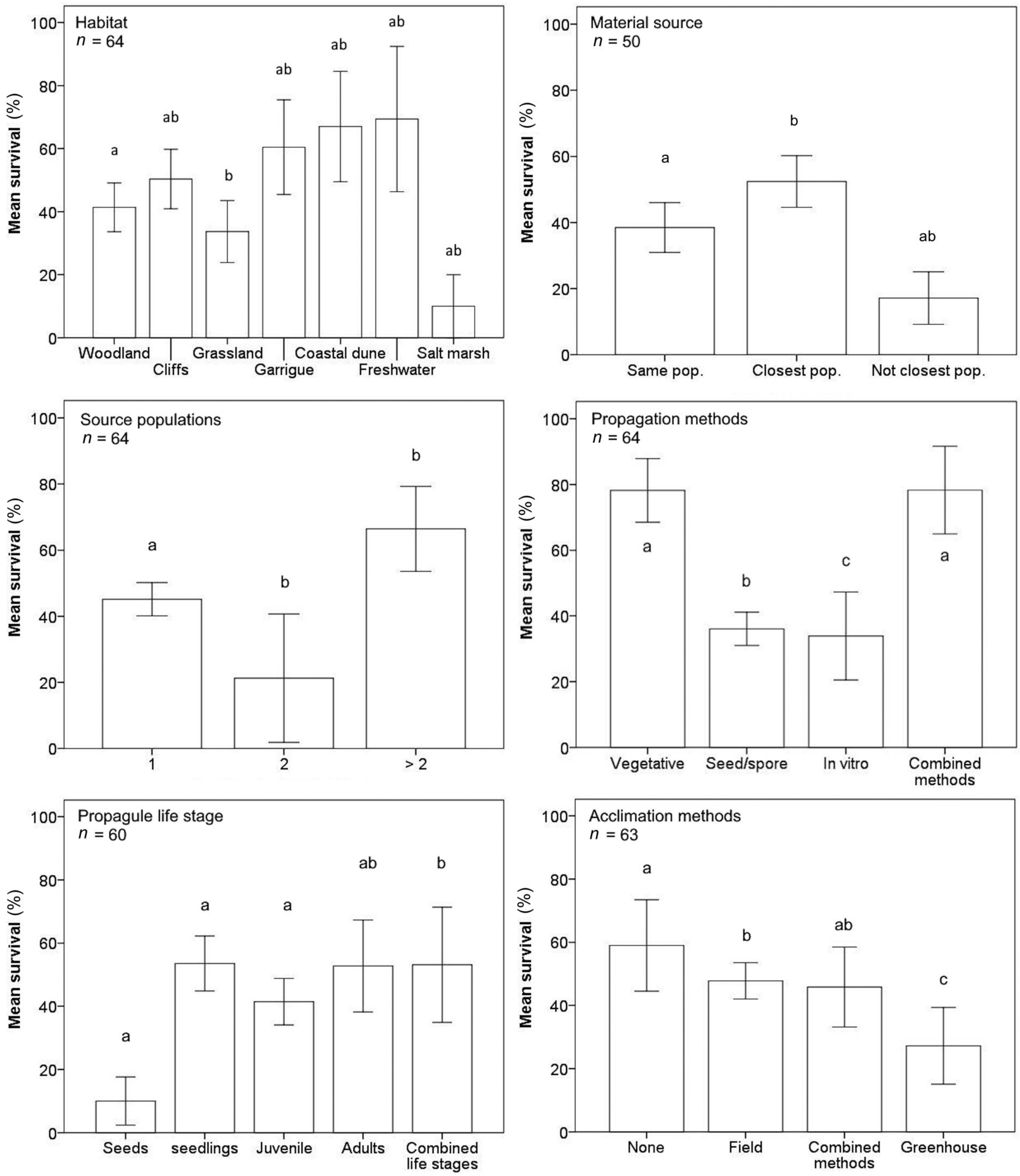

FIGURE 2 Mean survival of translocated plant propagules as a function of habitat type, material source, source populations, propagation method, propagule life stage, and acclimation methods (*n*, total number of cases available for a given variable; error bars, SE; differing letters, statistically significant differences at $p < 0.05$).

translocation outcome, but results were quite variable. Seeds were clearly associated with low survival, but no effects were detected when using seeds, seedlings, and juveniles in combination or separately. Nevertheless, survival was clearly increased by propagules of mixed life stages (Table 2; Figure 2). Acclimation of material in the field or in a greenhouse was not associated with increased survival. The most effective method to assess habitat and in turn to select a suitable planting site was the study of vegetation alone combined with expert opinion. This combination yielded high survival percentage relative to more sophisticated correlational studies or SDMs; the latter was highly variable in terms of performance (Figure 3). As for site preparation, fencing contributed to high survival. In contrast, the effect of aftercare, although significant, was highly variable, and we could not detect any clear pattern (Figure 3). Higher survival was associated with medium-level expenditure

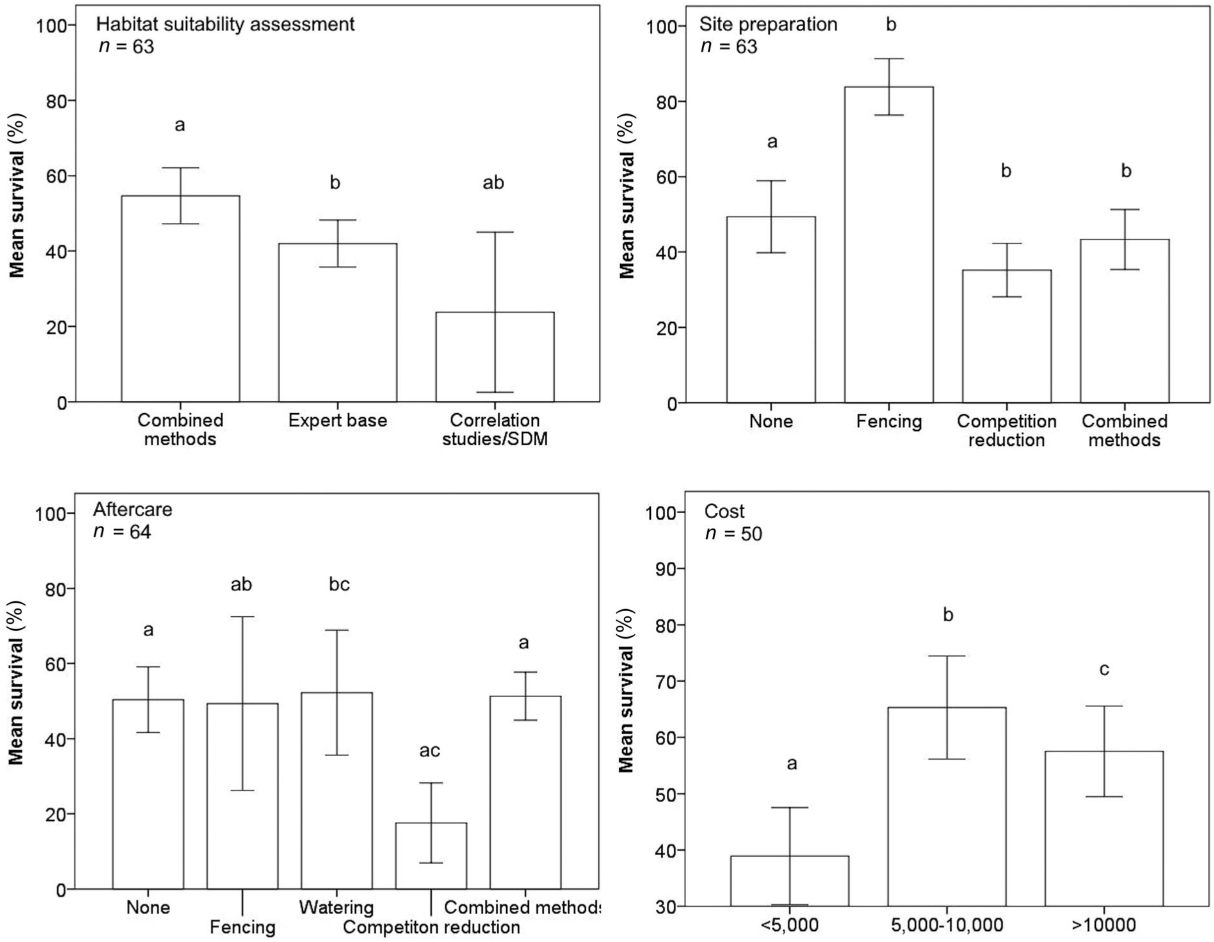

FIGURE 3 Mean survival percentage of translocated plant propagules as a function of habitat suitability assessment, prerelease site preparations, postrelease site manipulation (aftercare), and funds allocated to translocation (n, total number of cases available for a given variable; error bars, SE; differing letters, statistically significant differences at $p < 0.05$).

(between 5,000€ and 10,000€) compared with low and high levels of funding.

DISCUSSION

The establishment of IDPlanT allowed the first overview of the drivers of plant translocation outcomes in Italy (Abeli et al., 2021). Through IDPlanT, we collected data on 185 plant translocations (most of them unpublished) performed in Italy since the first recorded case in 1958 (e.g., Carra et al., 2019; Fenu et al., 2016). IDPlanT is one of the most important sources of information on recent translocations in the Mediterranean area (Fenu et al., 2023; TransLoc [http://translocations.in2p3.fr/]).

Effect of life form, preferred habitat, and distribution on translocation outcome

We found similarities and differences with other reviews of plant translocations at global and regional scales (e.g., Godefroid et al., 2011; Liu et al., 2015; Silcock et al., 2019). Survival performance was not related to some intrinsic characteristics of the target species, such as life form and distribution, indicating that the techniques adopted to perform a translocation are more crucial than the abovementioned intrinsic species characteristics. This result contrasts with those from other reviews in which life forms significantly affected the outcome of translocations (i.e., translocated herbs had greater success than translocated trees and shrubs [e.g., Bellis et al., 2023; Liu et al., 2015]). However, our results are difficult to compare with other similar analyses because we considered many more life forms (8 categories) than other researchers (3 in Liu et al. [2015] and 4 in Silcock et al. [2019]). One explanation for the lack of effect of intrinsic species characteristics on translocation performance may be the high variability of outcomes within each category and the fact that in IDPlanT most species had a strict Mediterranean distribution (i.e., were endemic to the peninsular part of Italy or of the Alps) and 36% of species were widely distributed (Eurasiatic, Eurosiberian, and Circumboreal) (Pignatti et al., 2017–2019). Grassland species had lower survival than species in other habitats, which is similar to what

Whitehead et al. (2023) reported for Australia. Our first hypothesis, that translocation performance is affected by species intrinsic characteristics, was therefore partially rejected.

Drivers of translocation performance

The highest survival was achieved when propagules were obtained from 2 or more populations close to the planting site (Figure 2), an indication that in the Mediterranean areas, complex colonization and dispersal patterns are key aspects for translocation of endemic taxa (Fenu et al., 2020). For instance, Gargano et al. (2022) found that even geographically close populations of *Dianthus guliae* Janka have very different adaptations to environmental cues and that population artificial crossing may result in maladaptation. Choosing the best performing source populations or deciding whether more source populations can be mixed is even more difficult with plants that have long-distance dispersal patterns, such as *Stratiotes aloides* L. (Orsenigo et al., 2017). In contrast with other studies (e.g., Godefroid et al., 2011), a stable or increasing demographic trend in source populations did not affect the translocation outcome (Table 2). Vegetative propagation of plant material had a positive effect on transplant survival that likely depended on higher tolerance to stress of adult-like cuttings or vegetative propagules compared with seeds and seedlings, which typically have higher mortality when moved (Albrecht & Maschinski, 2012; Godefroid et al., 2011; Silcock et al., 2019). This was obviously mirrored in the low (but not significant) survival when seeds were used as the only life stage (Figure 2). The poor performance of seeds may be due to predation or dormancy or intrinsic low seed viability (Krauss et al., 2002). In general, a much higher number of propagules are needed when young life stages are used in translocation (Liu et al., 2015; Silcock et al., 2019).

The combined methods for assessment of habitat for the selection of a planting site grouped together the vegetation study (phytosociology) and the expert-based approaches and resulted in significantly greater transplant survival than an expert-based approach alone (Figure 2). This suggests that vegetation studies, under the combined methods condition, contribute more in achieving higher transplant survival. The study of the vegetation likely captures the habitat complexity that is not identified otherwise, making the study of vegetation a very helpful way to select suitable planting sites. In many Mediterranean countries (e.g., Italy, France, Spain, Greece, Petraglia & Tomaselli, 2007; Tomaselli et al., 2000; Zanzottera et al., 2021), there is a deep understanding of species associations and their relationships with abiotic factors (Coppi et al., 2015) that makes vegetation studies very informative.

Correlational studies and SDMs were associated with lower (but not significant) survival and with a high variability of performance compared with other methods for assessing site suitability. Correlational studies and SDMs provide important data on how a species responds to selected variables and may include the most relevant ecological factors for a given species or not (Paoli et al., 2020). However, they are usually performed at a scale that does not consider microsite variations of ecological factors that are an important determinant of translocated plant survival (Jusaitis, 2005; Reiter & Menz, 2022) (see also Bianchi et al. [2020] and Di Nuzzo et al. [2022] for the effect of microclimatic factors on lichen growth). Microsites characteristics are even more important in mountain areas (e.g., Casazza et al., 2021), so both the correlational studies and SDMs used for selecting suitable sites for translocation may miss key ecological variables shaping the occurrence of a target species that are intrinsically considered when the plant community is considered. Therefore, our second hypothesis was also rejected.

Role of site preparation, aftercare, and amount of allocated funds in translocation outcome

Prerelease fencing significantly increased transplant survival because it protected plants from grazing and accidental damages, as shown in other studies (Fenu et al., 2016; Jusaitis, 2005; Monks et al., 2023; Whitehead et al., 2023). Although our models did not detect any significant effects of prerelease fencing and competition reduction, the latter treatment through soil loosening and topsoil removal is associated with low transplant survival (Tischew et al., 2017). A possible explanation could be that bare soil dries out quickly in the warmth of the Mediterranean climate.

This is confirmed by the importance of posttranslocation watering that was associated with increased survival. In the Mediterranean area, watering seems crucial in the very initial posttranslocation phase. Except for watering, there were no differences between "no aftercare" and other postplanting site manipulations, such as fencing and combined techniques, which is in contrast to a recent study that shows fencing and competition reduction are important measures to increase plant survival (Corli et al., 2023). The third hypothesis on the importance of aftercare in translocation was therefore accepted even though there was high variability between the tested techniques. Aftercare is reported as a best practice in several plant translocation guidelines as part of adaptive monitoring and implementation of translocation (Commander et al., 2018; Maschinski & Albrecht, 2017; Rossi et al., 2013). However, the contribution of aftercare to plant translocation performance is poorly understood and likely species specific. There are only a few studies that report the results of experimental long-term postplanting manipulations (e.g., Al Farsi et al., 2017; Daws & Koch, 2015). For this reason, further research is needed to understand the effect of aftercare techniques on translocation performance and to better evaluate the general costs and benefits of aftercare, including for translocated populations that require continuous management (Adamski et al., 2020; Rumsey & Stroh, 2020).

Finally, IDPlanT is likely the only plant translocation database reporting on the actual costs of translocation. Although it is difficult to precisely identify actual costs of translocation, especially when they are part of larger projects that include other management activities, in Italy they are lower than, for instance, in Australia (Zimmer et al., 2019). We found that medium-level expenditure was associated with higher survival than low- and high-level expenditure. Higher costs for fencing a reintroduced population of *Dianthus morisianus* Vals. resulted in higher plant survival compared with an unfenced reintroduced population (and cheaper) (Cogoni et al., 2013; Fenu et al., 2016). However, this does not seem to be a general rule, and how funds are spent may be more important than their amount.

Our analyses of IDPlanT, a reference for the translocation of Mediterranean plant species, highlighted the complexity and multidisciplinary nature of plant translocation (Abeli & Dalrymple, 2023). The importance of posttranslocation monitoring emerged from our study because we could analyze only 72 cases with survival and fruiting data out of 178 translocations. Ongoing and future plant translocations in Italy and in the Mediterranean area should consider the speciation and colonization history that has led in many cases to local adaptations with important implications for the provenance and genetic diversity of source material. In IDPlanT, only 24 out of 178 translocations were based on genetically informed decisions; this should become more common considering the costs for gathering genetic data are becoming more affordable (Rossetto et al., 2023). The integration of vegetation studies into the recipient site selection process is being applied in Italy and should be expanded and transferred to other areas. More research is needed on posttranslocation plant and site manipulations that, when possible, should be carried out with an experimental approach to identify and develop suitable techniques. Finally, understanding the costs of translocations is important to plan a translocation budget and to assess the credibility and appropriateness of conservation programs based on translocations. Currently, there are no standardized methods to properly account for the expenses of translocation, especially when translocations are carried out within larger restoration projects; thus, this aspect requires more investigation. The constant implementation and periodic analysis of large translocation data sets will provide additional key insights into successful plant translocation.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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