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► **To cite this version:**

Mohamed Diallo, Anaël Mayeur, Anne-Charlotte Vaissière, Bruno Colas. The relevance of plant translocation as a conservation tool in France. *Plant Ecology*, 2023, 10.1007/s11258-023-01295-4 . hal-04185682

HAL Id: hal-04185682

<https://hal.science/hal-04185682>

Submitted on 23 Aug 2023

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1 **Title page**

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3 **The relevance of plant translocation as a conservation tool in France**

4

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18

19 **Abstract**

20 The practice of plant translocations to mitigate the deleterious human effects on biodiversity
21 has been increasing over the last decades. In France, although translocations are planned as
22 conservation actions, there is no study that reviews conservation and protection status of
23 translocated species, or that examines the identified threats to the populations for either
24 mitigation-driven (as part of a regulatory mitigation process) or conservation-driven (outside
25 the mitigation context) translocations. Using the TransLoc database, we compiled data on 436
26 translocated plant populations in France to determine the level of endangerment of the 193
27 translocated species using the French National Red List of vascular plant species, and their
28 national and regional protection status. We also examined the identified threats to the
29 populations following the IUCN threats classification scheme, and compared mitigation and
30 conservation-driven translocations according to the reported threats and the regions of
31 translocation.

32 There were less mitigation than conservation-driven translocations overall (142 vs 229
33 respectively), with large differences between regions. We detected large and significant
34 differences between mitigation and conservation-driven translocations in the local threats
35 affecting populations. For mitigation-driven translocations, the most frequent threats were (i)
36 transportation and service corridors and (ii) residential and commercial developments, while
37 for conservation-driven translocations it was (i) human intrusions and disturbance, and (ii)
38 natural system modifications. Approximately one third of the translocated species were
39 nationally protected and two thirds were regionally protected (34% and 72%, respectively). In
40 the IUCN red list, only 14% of the translocated species were considered threatened (CR, EN,
41 VU) at the national level and 33% at the regional level. This result reflects the fact that
42 conservationists are reluctant to use translocations as a means of conservation for the most
43 threatened species, because they require a lot of work, a lot of information on the biology and

44 ecology of the species, and their results are very uncertain, in contrast to habitat protection,
45 which is generally considered the best way to protect species.

46 **Keywords:** Biodiversity, Conservation status, Mitigation translocations, Conservation
47 translocations, Plant translocations, Threats.

48

49 **Introduction**

50 Biodiversity loss is considered a major environmental problem that threatens ecosystem
51 functioning and human well-being (Ceballos et al. 2015; Ehrlich and Ehrlich 2013). Human
52 activities, which have led to a high degree of habitat fragmentation, notably in Europe, continue
53 to pressurize natural habitats (European Environment Agency, 2011). As a result, many species
54 have small and isolated populations whose viability is altered by the increasing impact of
55 environmental and demographic stochasticities, Allee effects, inbreeding, and loss of genetic
56 diversity (Frankham 2005; Lacy 2000). In addition, it is more difficult for many species to reach
57 new favourable patches by natural dispersal (Oyama et al. 2017; Magrath et al. 2013; Wratten
58 et al. 2003; Bonnin et al. 2002). This is particularly true for plant species whose dispersal is
59 limited (Clark et al. 2007; Riba et al. 2005) and make them good candidates for conservation
60 translocation.

61 In this context, conservation translocations, i.e. intentionally human-induced
62 movements of living organisms into more or less anthropized ecosystem for conservation
63 purposes (Menges 2008, IUCN/SSC 2013), can contribute to improving the conservation status
64 of plant species and restoring communities or ecosystems (Silcock et al. 2019; Soorae 2018;
65 Fenu et al. 2019; Diallo et al. 2021). They are expected to result in new viable populations (in
66 the case of reintroduction or assisted migration, see IUCN/SSC 2013), or to improve the
67 viability of existing populations (in the case of reinforcement) by increasing population sizes
68 or genetic diversity (see Kirchner et al. 2006 for an example of demo-genetic integration in the
69 study of the dynamics of introduced populations).

70 A plant translocation project may be initiated by conservationists (researchers or
71 practitioners), with an explicit conservation goal. But it can also be initiated in response to legal
72 obligations aimed at mitigating the impacts of development projects on biodiversity, as part of

73 the mitigation hierarchy (Bradley et al. 2020; Germano et al. 2015). Hereafter in this article we
74 will refer to the former as *conservation-driven translocations*, and the latter as *mitigation-*
75 *driven translocations*. Whether conservation-driven or mitigation-driven, these translocations
76 are conservation translocations in the sense of IUCN/SSC (2013) as long as they have an
77 objective to maintain or improve the viability of populations as mentioned above. But many
78 mitigation-driven translocation cannot be considered as conservation translocations because
79 they simply aim to prolong the life of individuals without benefit at the population level. This
80 is the case when individuals are moved to a different area within the same population, or to
81 another population whose viability will not be improved by the translocation because the
82 translocated individuals do not add new alleles and the host population is large and already at
83 the carrying capacity of the environment (see, e.g. Julien et al. 2022b and Doyle et al. this issue).

84 Worldwide, plant translocations have received more attention in recent decades, and
85 conservation programmes involving plant translocations are regularly reported (e.g., Noël et al.
86 2011; Bottin et al. 2007; Fenu et al. 2019; Colas et al. 1997; Kiehl and Pfadenhauer 2007;
87 Dalrymple et al. 2008; Cogoni et al. 2013; Rita and Cursach 2013; Maschinski and Haskins
88 2012). Review articles have shown that plant translocation is a practice with a very uncertain
89 outcome, influenced by many factors to which practitioners must pay attention, including the
90 suitability of the host site for the ecological niche of the species, the composition and genetic
91 diversity of the translocated material, life history traits, the stages of the life cycle chosen for
92 translocation, the sowing or planting method, the time of year it is done, habitat management
93 and post-translocation monitoring (Dalrymple et al. 2012; Godefroid et al. 2011; Menges 2008;
94 Silcock et al. 2019). Conservation translocations are generally time-consuming and may be
95 costly (Fenu et al. 2016, 2019) even if, in the case of mitigation-driven translocations, this cost
96 is only a small portion of the budget dedicated to implement the whole mitigation hierarchy

97 (4.3%), and almost negligible compared to the total costs of development projects (0.08%, see
98 Julien et al. 2022a).

99 In France, conservation-driven translocations are sometimes included in national action
100 plans (*Plans Nationaux d'Action*) that aim at defining a range of actions necessary for the
101 conservation and restoration of the most threatened species. Mitigation-driven translocations
102 are generally a small part of a mitigation hierarchy (avoiding, reducing, and, as a last resort,
103 compensating for damage to biodiversity), included in the French environmental code (Article
104 L110-1, II 2°), to mitigate the impacts on biodiversity of construction or development works.
105 Whatever the type of translocation (mitigation or conservation-driven), legal authorisation is
106 required in France, following the opinion of a scientific council, to carry out any programme to
107 move a nationally or regionally protected species (Alligand et al. 2018; Julien et al. 2022a).

108 Following the IUCN red list criteria, France, like other countries (e.g. Italy, Orsenigo et
109 al. 2021, Spain, Moreno 2008, and England, Stroh 2014), has conducted an assessment of the
110 extinction risk of all its vascular plants, which led to the creation of the national red list of
111 vascular plants (UICN France et al. 2018). This list identified 742 threatened or near threatened
112 plant species among the 4982 known native species (excluding oversea territories). Although
113 translocations are planned as conservation actions, there is no study in France that documents
114 the conservation status of translocated species at the national and regional levels, nor is there a
115 study that reviews the identified threats to the populations and the motivations that led to
116 translocations. Such information is needed to discuss the relevance of plant translocation as a
117 conservation tool and to prioritise candidate species for translocation.

118 Here, we propose to ask the following questions: (i) What are the conservation and
119 protection status of translocated species at national and regional levels in France? (ii) What
120 threats to populations have been identified in the literature on plant translocations in France?

121 (iii) Is there a difference in identified threats to populations between mitigation-driven and
122 conservation-driven translocations? (iv) Is the proportion of mitigation vs conservation-driven
123 translocations different between French regions?

124

125 **Materials and Methods**

126

127 *Data collection*

128 The main source of information for this study is the TransLoc database, which compiles data
129 on plant and animal translocations in Europe and around the Mediterranean from peer-reviewed
130 scientific articles, books, reports, newspaper articles, interviews, and personal communications
131 (see details in Diallo et al. 2021 and at <http://translocations.in2p3.fr/>). All translocated
132 populations recorded in the TransLoc database result from a translocation with a population
133 viability objective (sometimes accompanied by other objectives such as experimental or
134 community conservation objectives), whether it was mitigation or conservation-driven
135 translocations.

136 To date, the TransLoc database contains 436 plant populations translocated in France
137 from 193 different species. For every translocated plant population in France, we first classified
138 it as *mitigation-driven* when it resulted from a translocation included in a mitigation procedure,
139 or *conservation-driven* when it was not, according to the available documentation. Then, we
140 searched for local threats identified by practitioners and researchers in the written projects,
141 activity reports or scientific articles that describe the translocations. The different threats were
142 then categorised using the IUCN classification scheme (Salafsky et al. 2008), which
143 standardises the threat nomenclature and facilitates data comparisons across ecosystems and
144 across studies (Wong 2011). We limited our classification to the first level of threat entry in the

145 standard IUCN threat classification scheme, version 3.2, as there were too few translocations
146 to allow us to consider the second and third levels of this categorisation.

147 For all 193 translocated species, we recorded their IUCN conservation status in the
148 global (IUCN 2023), European (Bilz et al. 2011), French national, and regional Red Lists.
149 Translocated species could theoretically be found in all IUCN Red List categories except
150 (obviously) in the globally extinct (EX) category. Regionally extinct (RE) referred to species
151 extirpated from the territory concerned (Europe, France or French region) but still occurring
152 elsewhere in the wild. We recorded their regulatory protection status at national and regional
153 scales, available at the Inventaire National du Patrimoine Naturel
154 (<https://inpn.mnhn.fr/accueil/index?lg=en>).

155

156 *Data analyses*

157 We used Excel pivot table to determine the sum and the proportion of threats and type of
158 translocation at national and regional level. We conducted Chi-squared tests to test for the
159 significance of the differences between the proportion of mitigation and conservation-driven
160 translocations (i) by type of threat and (ii) by French region at the translocated population scale,
161 using R statistical software (v.4.2.0; R Core Team 2022). Map was processed using the
162 cartography R package (v.3.0.1; Giraud and Lambert 2017).

163

164 **Results**

165 Among the 436 translocated populations, 5 (1.1%) were assisted colonisations, 244 (56.0%)
166 were reintroductions *sensu* IUCN/SSC (2013), 132 (30.3%) were reinforcements, and 55
167 (12.6%) were undetermined.

168

169 ***Conservation status and protection of translocated species***

170 Among the 193 translocated species, 188 were registered with a *conservation status* in the
171 French national red list of species based on the IUCN categories, and 123 in the French regional
172 red lists. On the national list, 13% of the translocated species were threatened (CR, EN, VU),
173 and 33% of them were threatened in their translocation region (Fig. 1 c and d). Most species
174 were not evaluated at the global and European scales (68 and 58%, respectively), and only a
175 few were threatened (3 and 4%, respectively, Fig. 1 a and b).

176 Nationally protected species represented one third (34%) while regionally protected
177 ones represented almost three quarters of translocated species (72%) (Fig. 2). In some regions
178 such as Ile-de-France (IDF), Pays-de-la-Loire (PdL), Bourgogne-Franche-Comté (BFC) and
179 Bretagne, all translocations concerned species that had national or regional protection (Fig. 2).
180 Among nationally protected species, 29% were threatened in the national Red List. Among
181 regionally protected species, 44% were threatened in at least one of the regions.

182

183 ***[Fig. 1 and Fig. 2 near here]***

184

185 ***Main local threats to translocated populations***

186 We were able to obtain information regarding local threats for 358 out of 436 translocated
187 populations in France. Among all populations, the most frequently identified threats were (i)
188 human intrusion and disturbance (28%), (ii) natural system modification (20%), (iii)
189 transportation and service corridors (17%), (iv) residential and commercial development (10%,
190 (v) energy production and mining (10%), invasive and other problematic species (10%, table
191 1). There were large disparities between regions. For instance, human intrusion and disturbance

192 was by far the most frequently identified threat to translocated species in Provence-Alpes-Côte
193 d’Azur (PACA) and Corse, while it was transportation and service corridors in Occitanie, and
194 energy production and mining in Grand Est (Gr. Est) (table 1).

195

196 *[Table 1 near here]*

197

198 *Motivations for translocations*

199 From the 436 translocated populations in our database, we were able to clearly identify the
200 motivation for translocation in 371 translocated populations (175 species), of which 62% (229
201 populations of 93 species) were conservation-driven and 38% (142 populations of 86 species)
202 mitigation-driven (Table 1). PACA, Occitanie, Gr. Est, Auvergne-Rhône-Alpes (AURA) and
203 Corse were the regions with the highest number of translocations (110, 64, 56, 48 and 47
204 respectively, see Fig. 3 and table 1). There were more conservation-driven translocations than
205 mitigation-driven ones in all 13 regions, except in AURA, PdL and IDF, and in Occitanie where
206 there was the same number of mitigation and conservation-driven translocations (Fig. 3). In
207 Corse, all translocations were conservation-driven. The differences among regions in the
208 proportion of mitigation vs conservation-driven translocations was significant (chi-squared test,
209 p -value <0.001).

210 Populations that were voluntarily translocated were so mainly because of “human
211 intrusions and disturbance”, “natural system modifications”, and “invasive & problematic
212 species and genes” (Table 1). Populations that were translocated for mitigation reasons were so
213 mainly because of “transportations and services corridors”, “residential and commercial
214 development” and “human intrusions and disturbance” (Table 1). Here again, the proportions
215 of mitigation and conservation-driven translocations were significantly different (Chi-squared

216 tests, p -value <0.001) for each of the threats for which comparison was possible (it was not
217 possible to compare the proportion of mitigation and conservation-driven translocations for
218 threats like agriculture & aquaculture, biological resource use and climate change because of
219 insufficient data).

220

221 *[Fig. 3 near here]*

222

223 **Discussion**

224 With the increasing rate of biodiversity loss, conservation programs such as conservation
225 translocations could become essential for the conservation of threatened plants and necessary
226 safeguards to prevent regional or global species extinctions (Orsenigo et al. 2021; Fenu et al.
227 2019). In this paper, we discuss the use of plant translocations as a conservation tool in France
228 by determining the conservation and protection status of translocated species and reported
229 threats that have triggered translocation operations, and the motivations (mitigation *versus*
230 conservation-driven) to conduct these translocations.

231

232 *On the conservation and protection status of translocated species*

233 The conservation and protection status of translocated plant species in France are contrasted
234 according to the geographic level of interest. At the broadest scales, very few species are
235 threatened (CR, EN or VU) in the global and European Red Lists, but this should be treated
236 with caution as most translocated species of our data set are not evaluated at these scales. If we
237 consider the national status, few translocated species are protected nationally (34%) and even
238 fewer are considered threatened (13%). Surprisingly, of the translocated species that were

239 nationally protected, nearly half had a conservation status of "least concern" (LC). Similar
240 observations were reported in a study of the Italian Red List of vascular plants (Orsenigo et al.
241 2021). Contrasting with the Italian and French cases, Liu et al. (2015) found that out of 154
242 species that have been subject to conservation translocation in China, the great majority (121)
243 were listed as threatened. The high rate of translocated protected species that are of least
244 concern in France could potentially be explained by the fact that the national list of protected
245 plant species in metropolitan France may not be up to date. First published in 1982 in a decree¹,
246 this list was last updated in 2013 for strictly protected plant species (Annex I), and in 1995 for
247 those for which collection or harvesting is subject to ministerial authorization (Annex II). These
248 updates consisted of adding species to the lists without removing those whose conservation
249 status had improved (see IUCN updates²). Another explanation of the low rate of threatened
250 species among translocated species could be that, in practice, the selection of target species for
251 conservation is influenced by the information available on the candidate species: local
252 knowledge, already established priorities and other pragmatic considerations such as the
253 biological characteristics of the species (e.g. breeding system), the likelihood of conservation
254 success and the monetary costs of conservation actions (Heywood et al. 2018; Fenu et al. 2016
255 and 2019, Julien et al. 2022a, b). It is possible that the lack of information on the biology of
256 threatened species, the technical difficulty of translocating them, the time and efforts necessary
257 to collect biological material, to conserve and propagate it in cold storage and gardens, to find
258 suitable host sites, and the final cost of translocations may increase the risks associated with
259 such translocations and limit their number.

¹ Arrêté du 20 janvier 1982 fixant la liste des espèces végétales protégées sur l'ensemble du territoire, <https://www.legifrance.gouv.fr/loda/id/JORFTEXT000000865328/>

² The number of species listed in each IUCN Red list Category changes over time and reasons and statistics are available at: <https://www.iucnredlist.org/assessment/updates> and <https://www.iucnredlist.org/resources/summary-statistics>.

260 If we consider the regional status, the proportion of threatened species is more than twice
261 as high as at national level. The same applies to the proportion of protected species. This
262 suggests that there is a prioritization of species with high local stakes. Although regional lists
263 provide essential information concerning conservation decisions (Rodrigues et al. 2006), the
264 fact that they are produced independently raises questions (Schatz et al. 2014). Indeed, these
265 lists do not necessarily take sufficient account of the realities of the range of species that go
266 beyond the territorial limits of the regions. Consequently, the number of translocated species
267 present in the regional lists could be overrepresented, because of repetition of species on
268 multiple lists for regional protection, compared to those that are protected at the national level
269 (Schatz et al. 2014). However, it cannot be ruled out that focusing on species with high stakes
270 in the region of translocation rather than those with national challenges could have an advantage
271 for conservation. Directing conservation efforts toward species that are regionally at risk but
272 nationally secure could serve as a measure of prevention. Early instigation of conservation
273 actions before common and/or still secure species undergo serious decline may be more
274 effective than actions undertaken when a species (considering its entire range) is uncommon or
275 rare (Lindenmayer et al. 2011).

276 The low proportion of threatened species at the regional (33%) and (especially) national
277 (14%) scales among translocated plant species could be explained by the fact that a number of
278 translocations have plant community or ecosystem restoration objectives, more than an
279 objective of improving the conservation status of translocated species. The viability objective
280 of the translocations included in the TransLoc database is sometimes embedded in a broader
281 community restoration objective, as often recommended by conservationists (IUCN-SSC 2013;
282 Swan et al. 2018). For example, *Anthyllis barba-jovis*, a nationally protected species although
283 with a ‘Least Concern’ conservation status, was translocated in the 1990s on the island of Port-
284 Cros with a population viability objective as part of operations to restore areas degraded by

285 trampling and to replace exotic vegetation with representatives of the native flora. Another
286 explanation could be that the “Conseil National de la Protection de la Nature” (CNPN, the
287 French National Council for Nature Protection, which evaluates, among other things,
288 environmental mitigation projects and requests for exemptions from prohibitions on moving
289 species) issues fewer favourable opinions for projects impacting species of national concern,
290 even if translocations or other measures of the mitigation hierarchy are planned, than do the
291 regional authorities (CSRPN for Regional Scientific Council for Natural Heritage) for species
292 of regional concern (see also Julien et al. 2022b).

293

294 ***On threats to translocated plant populations in France***

295 The analysis of identified threats behind translocated plant species in France reveals that the
296 anthropogenic pressure that contributes to habitat loss and degradation is an important driver
297 for these translocations. In the AURA region, most of the translocations result from the
298 construction of roads, railways, or residential and commercial areas. For example, a new
299 population of *Dianthus superbis* (NT at the national level, EN in the AURA region) was created
300 in a suitable site in Clarafond-Arcine (Haute-Savoie) in 2015 from several tens of individuals
301 translocated from an area where they were threatened by a project to secure a crossroads and a
302 toll barrier on the A40 motorway. Similarly, a new population of *Cytisus lotoides* (LC at the
303 national level, NT in the AURA region) was created in Crest (Drôme) in 2004 as part of the
304 compensatory measures for the construction of a high-speed railway line (unpublished activity
305 reports). Some translocated species suffer from less severe habitat loss or degradation but which
306 still have significant impacts when it comes to changes in agricultural practices (natural system
307 modification). For example, the cliff-dwelling endemic *Centaurea corymbosa* occurs in only
308 six populations near Narbonne in Occitanie Region (Colas et al. 1996). The cessation of grazing

309 by itinerant herds since the 1970s has led to the colonisation of the area by rosemary and Aleppo
310 pines, which is detrimental to this pioneer species. The creation of two new populations in the
311 1990s (Colas et al. 1997) was not enough to counter this trend.

312 Our findings are consistent with the report on the red list of threatened species in France
313 which identifies the loss of natural habitats and the various degradations suffered by these
314 habitats in connection with urbanization as the main threats to French metropolitan flora (UICN
315 France et al. 2018). It is also consistent with the study on the red list of threatened vascular
316 plants in Italy, which found that “60 % of the assessed taxa are affected by direct and/ or indirect
317 human disturbances, like natural system modifications, residential and commercial
318 development, recreational activities or transportation service corridors” (Orsenigo et al. 2021).
319 Elsewhere in their review on plant translocations in China, Liu et al. (2015) also found that 67%
320 of translocation projects were developed in response to habitat loss caused by development
321 project, mainly hydropower ones. Land use change has been identified as the primary cause of
322 biodiversity loss on a global scale (IPBES 2019).

323 Human intrusions and disturbance is another important driver of translocations. Indeed,
324 four out of the five regions where we observed the greatest number of translocations (PACA,
325 Occitanie, AURA and Corse) are highly touristic with overcrowding during the peak of touristic
326 seasons. In regions like PACA and Corse, the concentration of populations on the coast and the
327 hinterland accentuates the adverse effect of change in land use on ecosystems. Overcrowding,
328 particularly linked to tourism, leisure activities and outdoor sports involve a direct disturbance
329 of species, alterations linked to passages (trampling or wild harvesting). In Corsica for example,
330 the endemic *Centranthus trinervis* (EN at both national and Corsica levels) suffered from rock
331 climbing and the population near Bonifacio was reinforced in 2017 by planting seedlings in
332 rock crevices after removal of climbing equipment from cliffs (<http://www.care->

333 [mediflora.eu/en/news/one?event=strengthening-the-unique-population-of-a-strict-endemic-of-](https://mediflora.eu/en/news/one?event=strengthening-the-unique-population-of-a-strict-endemic-of-corsica-em-centranthus-trinervis-em&id=61)
334 [corsica-em-centranthus-trinervis-em&id=61](https://mediflora.eu/en/news/one?event=strengthening-the-unique-population-of-a-strict-endemic-of-corsica-em-centranthus-trinervis-em&id=61).

335 Two types of pressure need to be put in perspective: the demographic pressure and the
336 pressure of urbanization (Zaninetti 2006). The specialization of these regions and other non-
337 coastal touristic regions (e.g., AURA) in recreational and tourism activities makes the pressure
338 of urbanization (because of permanent tourism infrastructures) much stronger than the
339 demographic pressure, although during the peak of the seasons the number of visitors is high
340 due to mass tourism. In PACA for example, the human population has increased by 73% since
341 1962 with high density of population near the coast, impacting local species and ecosystems
342 (<https://inpn.mnhn.fr/espece/programme/listes-rouges/RG/?region=INSEER93>, PACA
343 region).

344 Climate change was identified as a threat to only 2% of our set of translocated
345 populations. Even though climate change is considered one of the most alarming threats to
346 species on a global scale (Gómez et al. 2015, IPBES 2019) it was found to have negligible
347 impact on the native flora of France to date (UICN France et al. 2018) and Italy (Fenu et al.
348 2017 ; Orsenigo et al. 2018). Diallo et al. (2021) showed that, in European plant translocations,
349 the host sites were not preferentially located in any geographical direction or at any altitude
350 relative to the natural source sites of the biological material (although in slightly colder host
351 sites). This lesser interest in climate change within the context of plant translocation may stem
352 from the difficulties in quantifying the impact of this factor because of the questionable
353 assessment methods (mainly relying on expert-based observations and literature sources)
354 (Attorre et al. 2018). More attention should be paid to this threat, however, because land use
355 change, which was identified as the main threat leading to plant species translocation in our
356 dataset, is considered an additional driver of climate change (Pörtner et al. 2021). With alarming
357 signs of climate change becoming the most pervasive threat to biodiversity in the coming

358 decades (Maxwell et al. 2016; Hoegh-Guldberg et al. 2008), translocations could serve both as
359 a preventive and/or precautionary measure against the effects of climate change on
360 biodiversity (Brooker et al. 2011; Hällfors et al. 2014; IUCN-SSC 2013).

361 In complex threatening processes, the majority of threats interact with other threats
362 (Heywood et al. 2018; Brook et al. 2008), making species responses difficult to predict, and
363 possibly hard to recover from. For instance Brook et al. (2008) revealed the synergetic effect
364 of habitat fragmentation and climate change on the viability of metapopulations. In an
365 experimental context, Mora et al. (2007) showed that habitat fragmentation and overharvesting
366 combined with environmental warming in rotifer zooplankton resulted in populations declining
367 up to 50 times more rapidly when combined than when acting singularly. Controlled
368 experiments show that climate change is altering plant communities, particularly in boreal
369 regions (Reich et al. 2015; Panetta et al. 2018) and modelling studies suggest the increasing
370 importance of climate change as a driver of plant extinction, with impacts on extinction
371 equalling or exceeding those of land use change in some regions (Gomes et al. 2019). In our
372 study, 22% of translocations have been conducted because of at least two out of the 10 major
373 threats identified.

374

375 *On the motivations behind the translocations*

376 Mitigation-driven translocations were conducted mainly in response to either transportation and
377 service corridors, residential and commercial development or human intrusion and disturbance
378 while conservation-driven translocations were conducted in response to human intrusion and
379 disturbance, natural system modifications, and invasive and problematic species. These
380 observations were somehow expected given that mitigation-driven translocations are
381 implemented within the context of a new project directly impacting species in the short term

382 (habitat destruction) whereas conservation-driven translocations tend to respond to situations
383 where degradation has already taken place or to deal with threats ignored by the regulatory
384 framework. In this study, conservation-driven translocations are undertaken either within the
385 framework of national or international programs. The French national action plans (*Plans*
386 *Nationaux d'Actions (PNA)*) for example, rely on the regulatory protection of threatened species
387 and aim to coordinate the implementation of conservation actions, when necessary, to ensure
388 or restore a favourable conservation status of the species concerned³. This is the case for
389 example for *Saxifraga hirculus* (CR at both national and Bourgogne-Franche-Comté levels),
390 which lives in nutrient-poor bogs with a permanent circulation of moderately mineralised water.
391 The species has suffered from habitat loss and pollution due to agriculture, and residential and
392 commercial development. It benefits from a PNA that coordinates the reinforcement and
393 reintroduction of a number of populations with habitat restoration actions in Bourgogne-
394 Franche-Comté (Guyonneau and Amiotte-Sucher 2019). Another example are the
395 translocations conducted in Corsica where most of them are either part of the European
396 Directive CE 92/43 within the framework of the European LIFE program « Conservation des
397 habitats naturels et des espèces végétales d'intérêt communautaire prioritaire de la Corse »
398 managed by the «Office de l'Environnement de la Corse » (Piazza et al. 2011) or of the
399 international CARE MEDIFLORA project, which aims to improve the conservation status of
400 threatened Mediterranean plant species and being implemented by institutions of six
401 Mediterranean islands (Balearic Islands, Corsica, Sardinia, Sicily, Crete and Cyprus) as well as
402 the IUCN/SSC Mediterranean Plant Specialist Group (<http://www.care-mediflora.eu/>).

403 The analysis of motivations behind translocations revealed that there were more
404 conservation than mitigation-driven translocations. Having less mitigation-driven

³ Plans Nationaux d'actions en faveur des espèces menacées, objectifs et exemples d'actions, Brochure du Ministère de l'Ecologie, du Développement durable et de l'Energie : Réf. DICOM-DGALN/BRO/11003-2 - juin 2012

405 translocations could reflect the success of conservation measures, because protected species
406 and/or their habitats should not in principle be threatened by development projects of any kind.
407 This could, on the contrary, reveal the current weak implementation of the regulatory
408 framework. Just as conservation-driven translocations are expected to increase in the coming
409 years (Swan et al. 2018), it could be expected that mitigation-driven translocations could also
410 increase through better care for the continued degradation of the conservation of certain species.
411 Fewer mitigation than conservation-driven translocations might otherwise stem from the fact
412 that the recognition of translocations as a conservation tool by the regulatory framework still
413 raises questions because of the uncertainty surrounding their effectiveness. In the context of
414 development projects, mitigation-driven translocations in France have been proposed in the past
415 as “reduction” measure in the mitigation hierarchy, in particular when the origin and host sites
416 are all located within the project area or when the feedback from similar operations concerning
417 the same species indicates a high success rate (see Julien et al. 2022b). However, since 2018,
418 mitigation-driven translocations are rather considered “accompanying” measures of the
419 mitigation hierarchy by the ministry in charge of ecology in its “guidelines to the definition of
420 mitigation measures” (Alligand et al. 2018). Indeed, translocations, whose outcomes are highly
421 uncertain, can only complement and reinforce other mitigation measures. Julien et al. (2022b)
422 showed that the protocols were of poor quality with essential information (e.g. biology and
423 ecology of the species, ecological characteristics of host sites etc.) insufficient or missing.

424 To conclude, although conservation translocations could be an option in some
425 circumstances, moving organisms to new sites, even after assessing carefully their suitability,
426 is not a guarantee for the future occurrence of a viable population. The prospect of having more
427 translocation projects undertaken in various countries (Dalrymple et al. 2012; Swan et al. 2016)
428 calls for a better alignment between conservation measures and national/regional policy
429 implementation and a better reporting of translocation outcomes to facilitate analyses of

430 translocation effectiveness. Whether mitigation or conservation-driven translocations, it is
431 essential that these operations be conducted with the same rigor, according to the same
432 frameworks, namely to promote and evaluate the long-term results thanks to experimental
433 setups allowing the collection of data in order to better understand the ecology and the biology
434 of species, their habitats and to improve translocation technics. As recommended in previous
435 studies (Swan et al. 2018), we suggest that decision-makers must consider and emphasize the
436 importance of habitat protection and other preservation efforts that prevent the need for
437 translocations in the first place.

438 **Acknowledgments**

439 We thank Thomas Abeli and one anonymous reviewer for their valuable comments and
440 suggestions to improve the manuscript. This study was financially supported by the initiative
441 of Recherche Stratégique ACE-ICSEN from Université Paris-Saclay, by the ‘Partenariats’
442 projects from LabEx BASC, and by a PEPS project from CNRS-INEE.

443

444 **Authors’ contributions**

445 M.D., B.C., and A.-C.V. conceived the ideas; M.D. and B.C. designed the methodology; M.D.,
446 B.C, and A.M. collected the data; M.D. analysed the data; M.D. and B.C. led the writing of the
447 manuscript. All authors contributed critically to the drafts and gave final approval for
448 publication.

449

450 **Data availability statement**

451 The data used in this paper concern taxa translocated in France. Many source documents related
452 to the region of translocation, information on the threats and motivations for these translocations
453 were given to us by providing confidential reports or during interviews. We have no right to
454 make them public, but they can be accessible upon request from the managers of the database
455 TransLoc (<http://translocations.in2p3.fr/index.php>). Other source documents are publicly
456 available in scientific articles or non-confidential reports. French National and regional red list
457 of vascular plants are public and accessible at: <https://inpn.mnhn.fr/accueil/index?lg=en>.

458

459

460 **Tables & Figures**

461

462 **Table 1.** Number of translocations in France according to their type, the region, and the local threats to the populations of translocated species.
463 Because species may be subject to different threats, the total number of identified threats (485) exceeds the total number of translocated populations.
464 AURA = Auvergne-Rhône-Alpes, BFC = Bourgogne –Franche-Comté, Bret. = Bretagne, CVL = Centre-Val de Loire, Gr. Est = Grand Est, HDF
465 = Hauts-de-France, IDF = Île-de France, Norma. = Normandie, N. Aquit. = Nouvelle Aquitaine, Occit. = Occitanie, PdL = Pays-de la Loire,
466 PACA= Provence-Alpes-Côte d’Azur, Undeter. = Undetermined region or type of translocation.

Types of threats	Type of translocation (at national level)			Region														Total	%
	Mitigation-driven	Conservation-driven	Undeter.	AURA	BFC	Bret.	CVDL	Corse	Gr. Est	HDF	IDF	Norma.	N. Aquit.	Occit.	PDL	PACA	Undeter.		
All threats	142	229	65	48	8	1	5	47	56	27	17	21	4	64	19	110	9	436	
Human intrusion and disturbance	12	88	21	0	0	0	0	22	4	8	0	0	0	12	0	75	0	121	28
Natural system modification	5	76	5	2	1	0	0	2	15	8	7	19	0	13	3	15	1	86	20
Transportation & Service corridors	71	4	0	11	0	1	0	1	7	1	3	1	0	19	11	18	2	75	17
Residential & Commercial development	30	20	2	4	5	0	0	0	1	7	6	2	2	12	1	12	0	52	12
Invasive & Other problematic species	2	39	4	2	0	0	0	17	6	0	0	0	0	1	4	15	0	45	10

Energy production & mining	11	1	32	3	2	0	5	0	31	0	1	0	0	1	0	1	0	44	10
Pollution	1	23	0	2	5	1	0	0	3	0	0	0	0	6	3	4	0	24	5
Agriculture & aquaculture	0	20	2	0	5	0	1	0	2	7	1	0	1	0	3	2	0	22	5
Biological resource use	0	8	1	2	0	0	0	0	1	0	4	0	0	0	0	2	0	9	2
Climate change	0	7	0	2	0	0	0	0	0	3	0	0	0	2	0	0	0	7	2

468

469

470 **List of figures:**

471 **Fig. 1** Distribution of the 193 species translocated in France according to the different
472 categories of the Red List (number of species in brackets) at different levels: (a) World, (b)
473 Europe, (c) National and (d) Regional. At the regional level, numbers in brackets correspond to
474 species*regions combination. So the total exceeds the number of species at the national level
475 because same species were translocated in several regions (with the same or a different
476 conservation status)

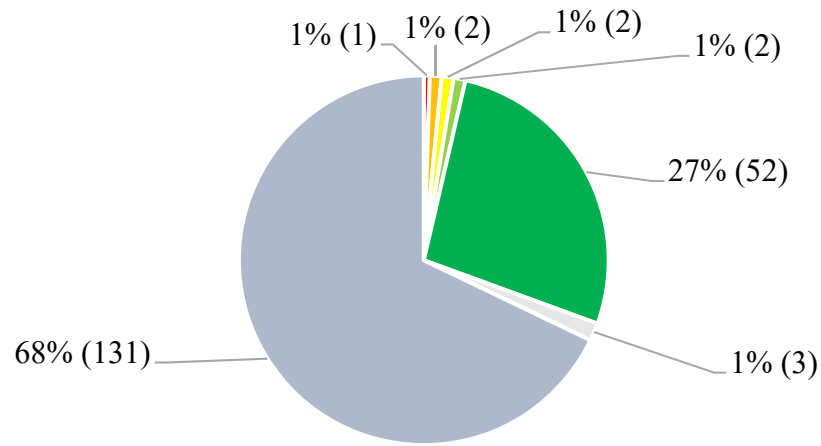
477

478 **Fig. 2** Distribution of translocated species between national, regional or unprotected status at
479 the regional scale. The total of translocated species with a regional protection status exceeds
480 the total number of translocated species (193 at national level) because a species can have a
481 different protection status (protected or unprotected) depending on the regions. The regions'
482 acronyms are as in Table 1

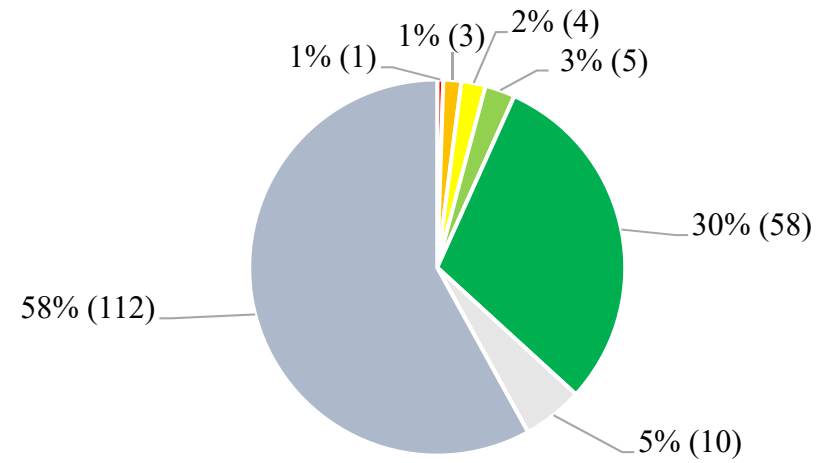
483

484 **Fig. 3** Share of Mitig.driven (mitigation-driven) and Cons.driven (conservation-driven)
485 translocations in each region of metropolitan France. The size of the pie chart is proportional
486 to the number of translocation in each region (in brackets). The regions' acronyms are as in
487 Table 1

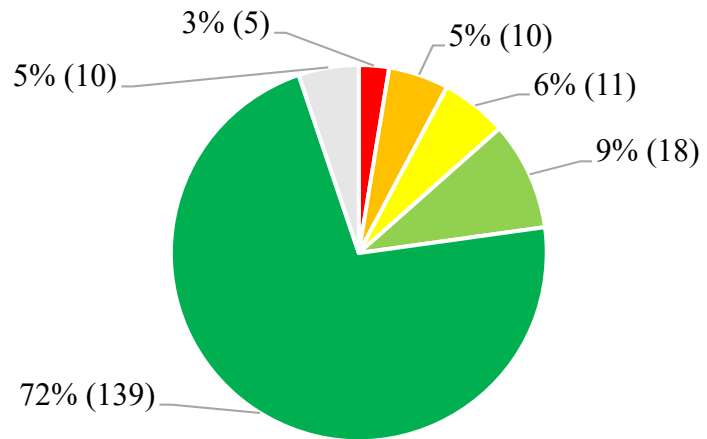
a World



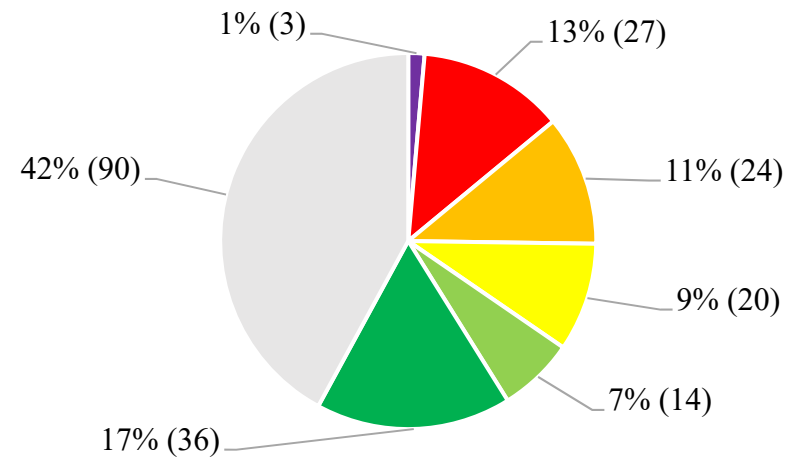
b Europe



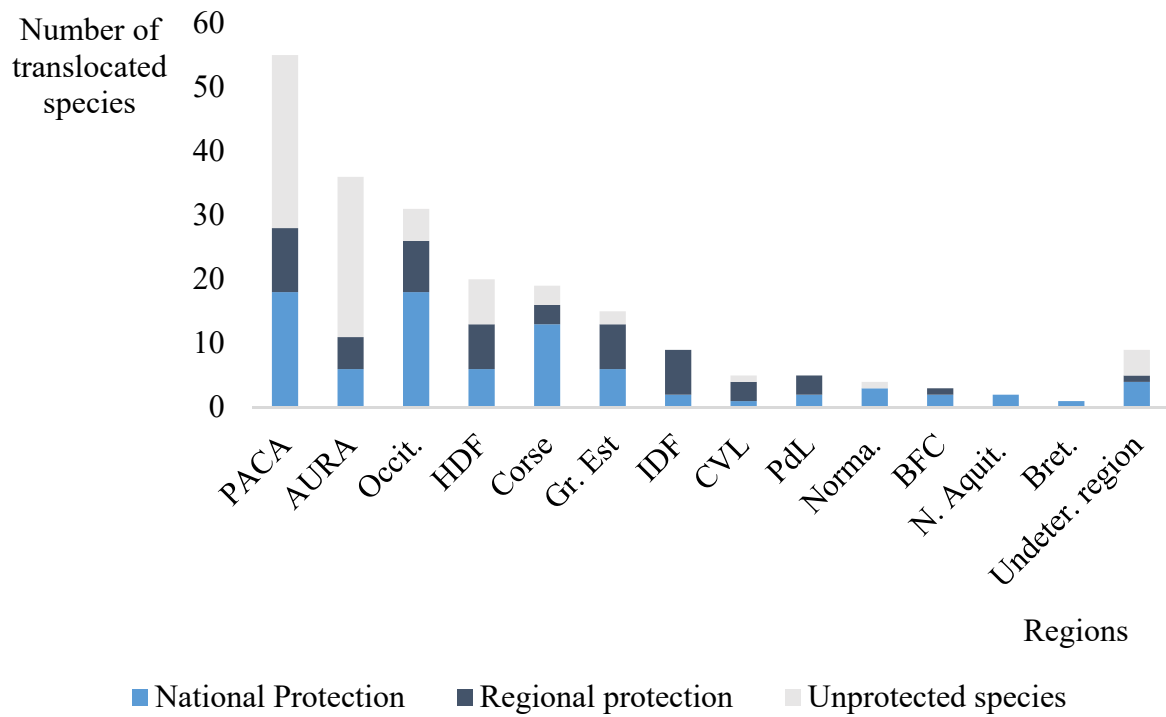
c National



d Regional



■ RE ■ CR ■ EN ■ VU ■ NT ■ LC ■ DD ■ NE



489

490 **Fig. 2**

491

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493

494

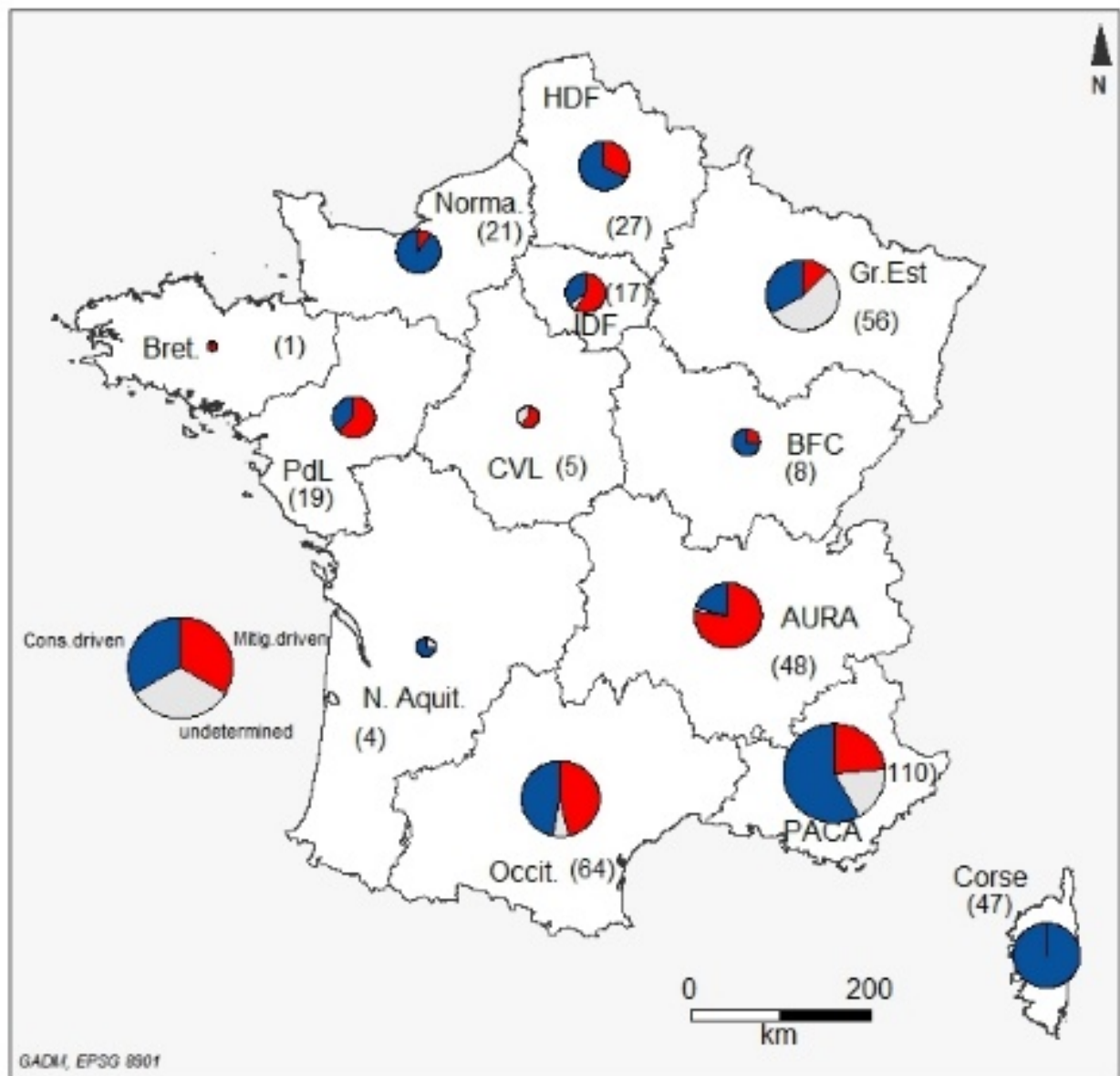
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503 **Conflicts of interest statements**

504 The authors certify that they have NO affiliations with or involvement in any organization or
505 entity with any financial interest (such as honoraria; educational grants; participation in
506 speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity
507 interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such
508 as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter
509 or materials discussed in this manuscript.

510

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515 [%20Guide%20d%E2%80%99aide%20%C3%A0%20la%20d%C3%A9finition%20de](https://www.ecologie.gouv.fr/sites/default/files/Th%C3%A9ma%20-%20Guide%20d%E2%80%99aide%20%C3%A0%20la%20d%C3%A9finition%20des%20mesures%20ERC.pdf)
516 [s%20mesures%20ERC.pdf](https://www.ecologie.gouv.fr/sites/default/files/Th%C3%A9ma%20-%20Guide%20d%E2%80%99aide%20%C3%A0%20la%20d%C3%A9finition%20des%20mesures%20ERC.pdf).
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