Translocations of endangered plant species: facts, problems and needs

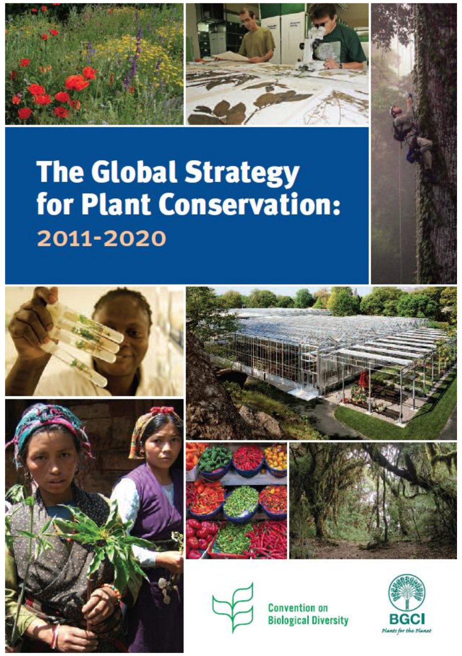
Sandrine Godefroid
Meise Botanic Garden, Belgium

Introduction

- The reintroduction of individual plants in the wild may be an essential measure to conserve threatened species

- Species translocation has been more and more acknowledged in international treaties and legislations

- Consequently, it has become an increasingly used conservation approach worldwide



# translocations	# plant taxa	geographic scope	Source
249	172	worldwide	Godefroid et al. (2011)
949	849	worldwide	Godefroid & Vanderborght (2011)
304	128	worldwide	Dalrymple et al. (2012)
222	154	China	Liu et al. (2015)
1001	376	Australia	Silcock et al. (2019)

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Definition of success ?

Success is defined as the ability of the population to survive and reproduce, and to adapt to changing environmental conditions

Primack and Drayton (1997) *Plant Talk*:
"A reintroduction can be considered truly successful only when a population is expanding in numbers and area, when individuals are ***flowering*** *and* ***fruiting****, when a second and third generation of plants are appearing on their own, and the population gives every indication that it will persist into future decades. Further success would involve the population* ***dispersing seeds*** *into the surrounding countryside and* ***producing satellite populations****"*

How successful are plant translocations ?

Biological Conservation 144 (2011) 672–682

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Review

How successful are plant species reintroductions?

Sandrine Godefroid [a,b,c,*], Carole Piazza [d], Graziano Rossi [e], Stéphane Buord [f], Albert-Dieter Stevens [g], Ruth Aguraiuja [h], Carly Cowell [i], Carl W. Weekley [j], Gerd Vogg [k], José M. Iriondo [l], Isabel Johnson [i], Bob Dixon [m], Doria Gordon [n], Sylvie Magnanon [f], Bertille Valentin [o], Kristina Bjureke [p], Rupert Koopman [q], Magdalena Vicens [r], Myriam Virevaire [s], Thierry Vanderborght [a]

Biological Conservation 236 (2019) 211–222

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Review

Threatened plant translocation in Australia: A review

J.L. Silcock [a,*], C.L. Simmons [a], L. Monks [a,b], R. Dillon [a,b], N. Reiter [c,d], M. Jusaitis [e,f], P.A. Vesk [g], M. Byrne [b], D.J. Coates [a,b]

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Chapter 3

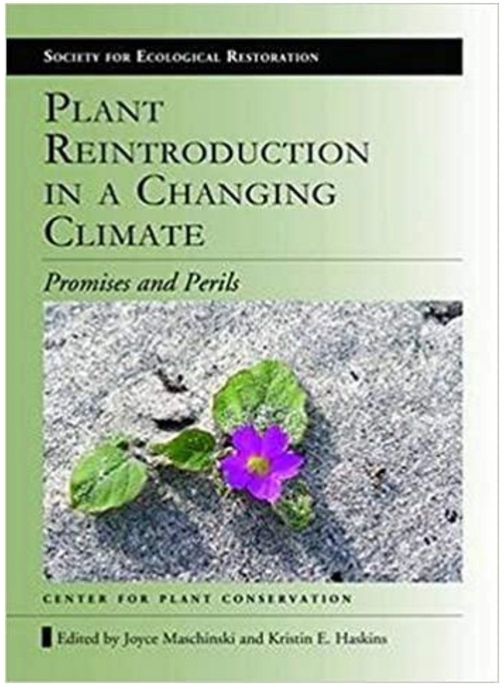
A Meta-Analysis of Threatened Plant Reintroductions from across the Globe

Sarah E. Dalrymple, Esther Banks, Gavin B. Stewart, and Andrew S. Pullin

Chapter 10

Influence of Founder Population Size, Propagule Stages, and Life History on the Survival of Reintroduced Plant Populations

Matthew A. Albrecht and Joyce Maschinski



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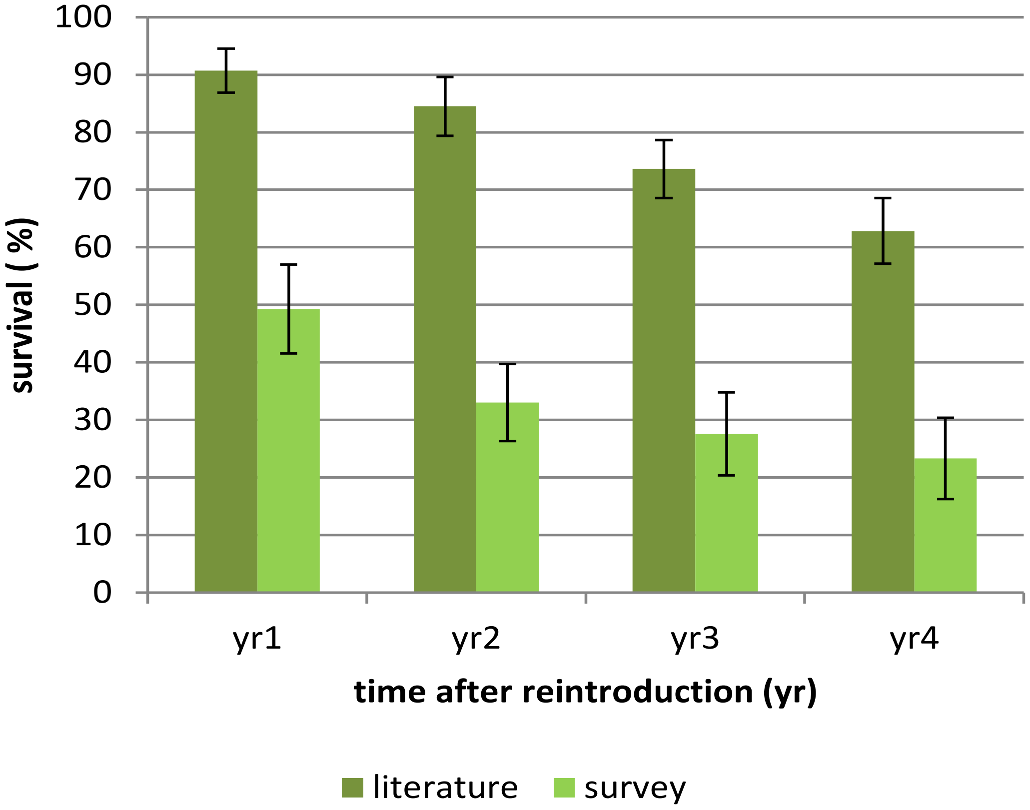
Survival (first generation establishment)

By far the most commonly reported assessment of translocation success



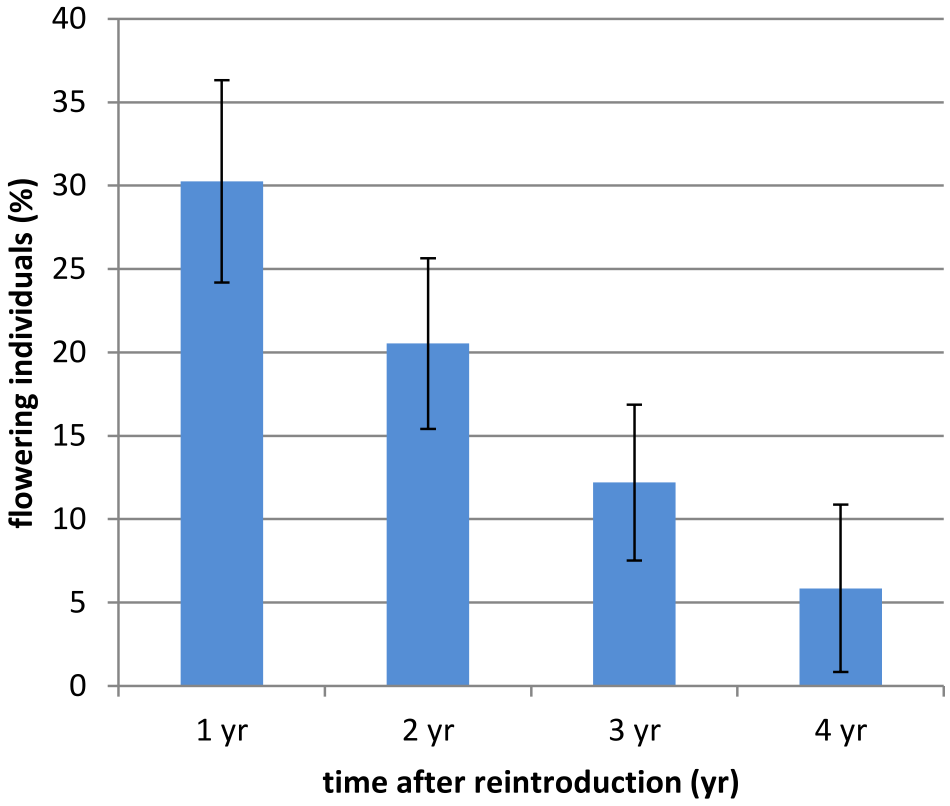
Godefroid et al. (2011)

Time since reintroduction	population still extant	extinct	n
5 years	64%	36%	72
10 years	40%	60%	50

Dalrymple et al. (2012)

Survival rates are usually quite low and decrease with time

Flowering and recruitment



Godefroid et al. (2011)

	seeds n = 47	juveniles n = 134	adults n = 115
Percentage achieved reproductive maturity	48.9	18.7	34.8
Percentage of attempts where offspring recruted	46.8	5.2	20.9

Dalrymple et al. (2012)

Flowering and recruitment are weak and can decline over time

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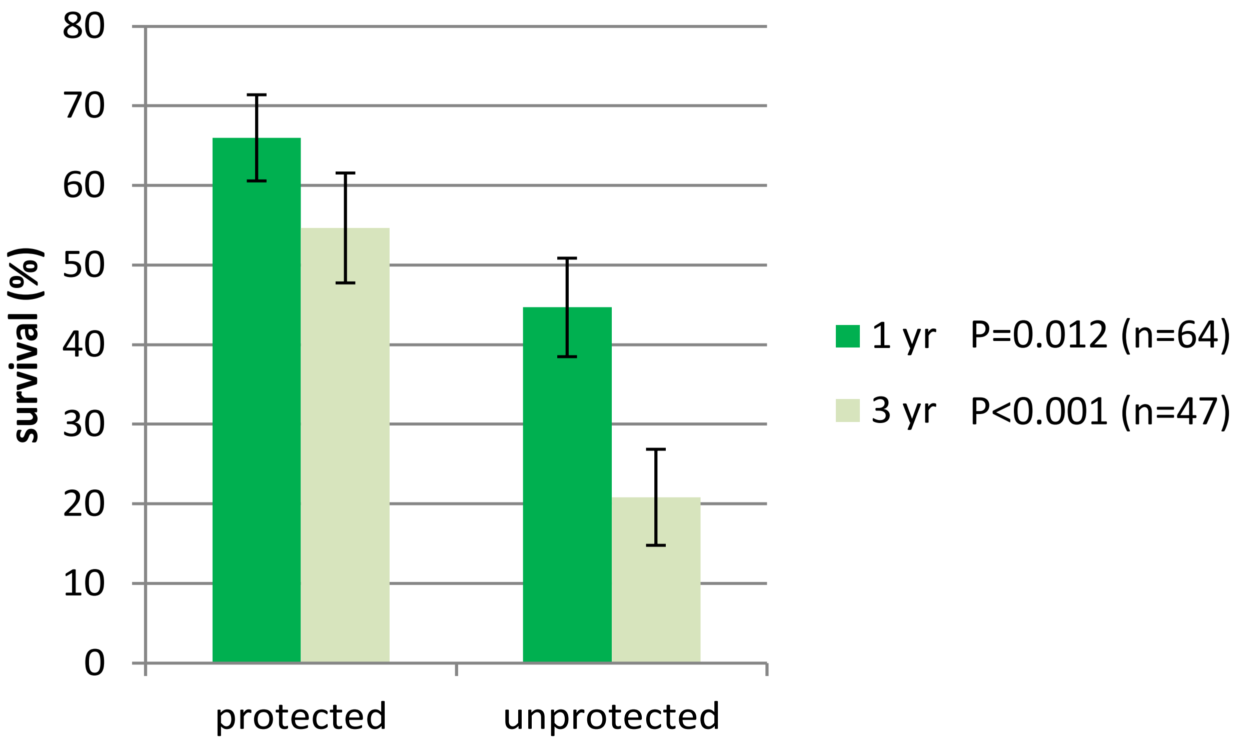
Why are many translocations not successful?

Some attempts are carried out in unprotected areas



Godefroid et al. (2011)

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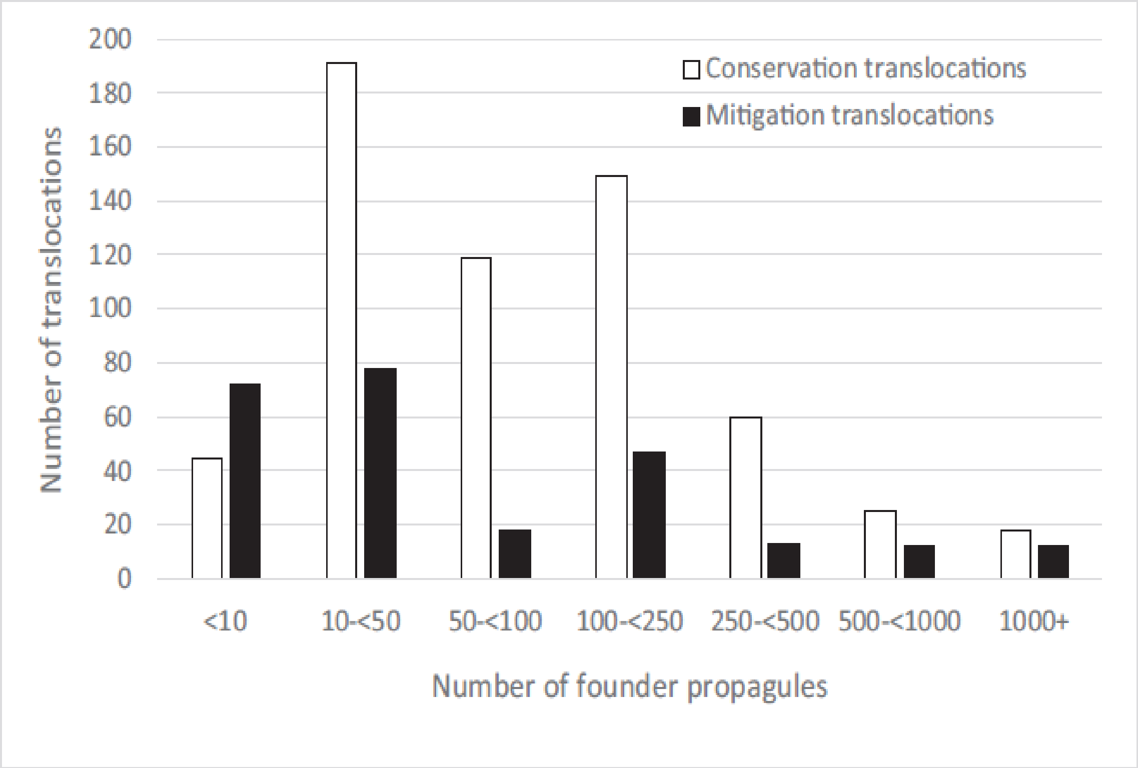
Why are many translocations not successful?

The number of outplanted individuals is usually too small

	juveniles n=134	adults n=115
mean number of propagules	157 ± 31	111 ± 22

Dalrymple et al. (2012)



Silcock et al. (2019)

→ lower than the MVP size !

Why are many translocations not successful?

Minimum Viable Population size?

The smallest possible size at which a biological population can exist without facing extinction from natural disasters or demographic, environmental, or genetic stochasticity

- no 'magic number' or universal threshold around which we can plan translocations
- fitness problems in plant species generally occur in small populations, often less than 500 individuals (Frankham et al. 2014)
- the reproduction of *Primula veris* and *Gentiana lutea* is depressed most strongly in populations consisting of less than 200 and 500 plants, respectively (Kéry et al. 2000)
- also for *Silene regia*, populations <100 plants <50% germination; populations >150 plants >85% germination (Menges 1991)

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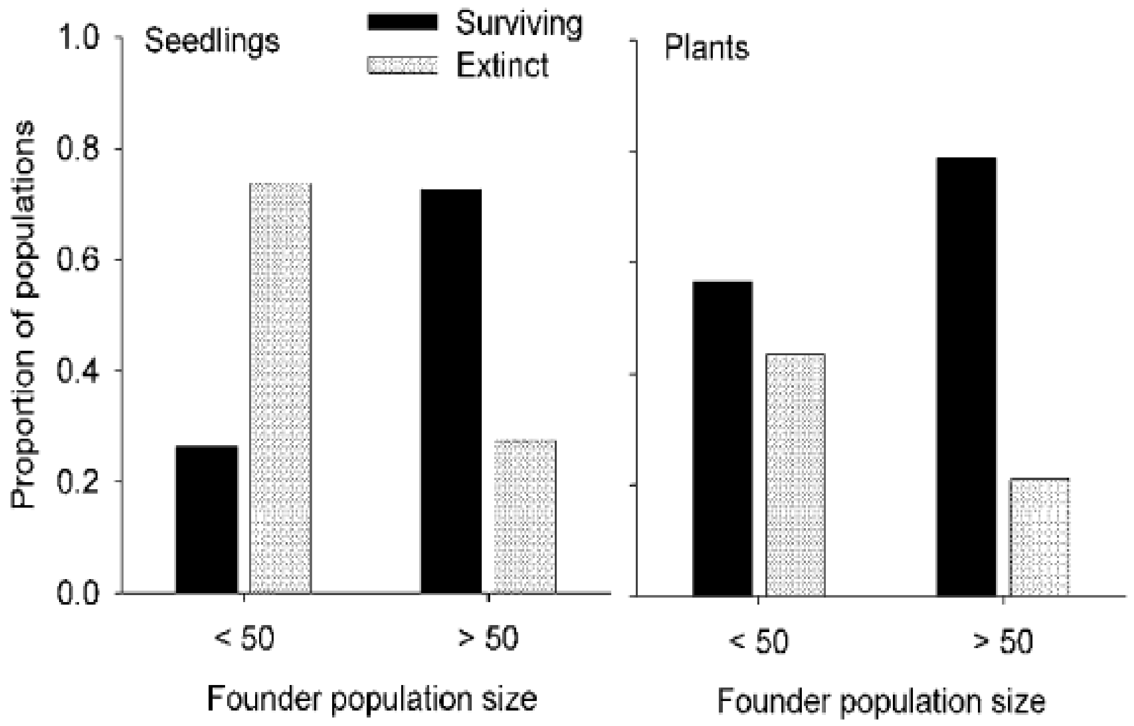
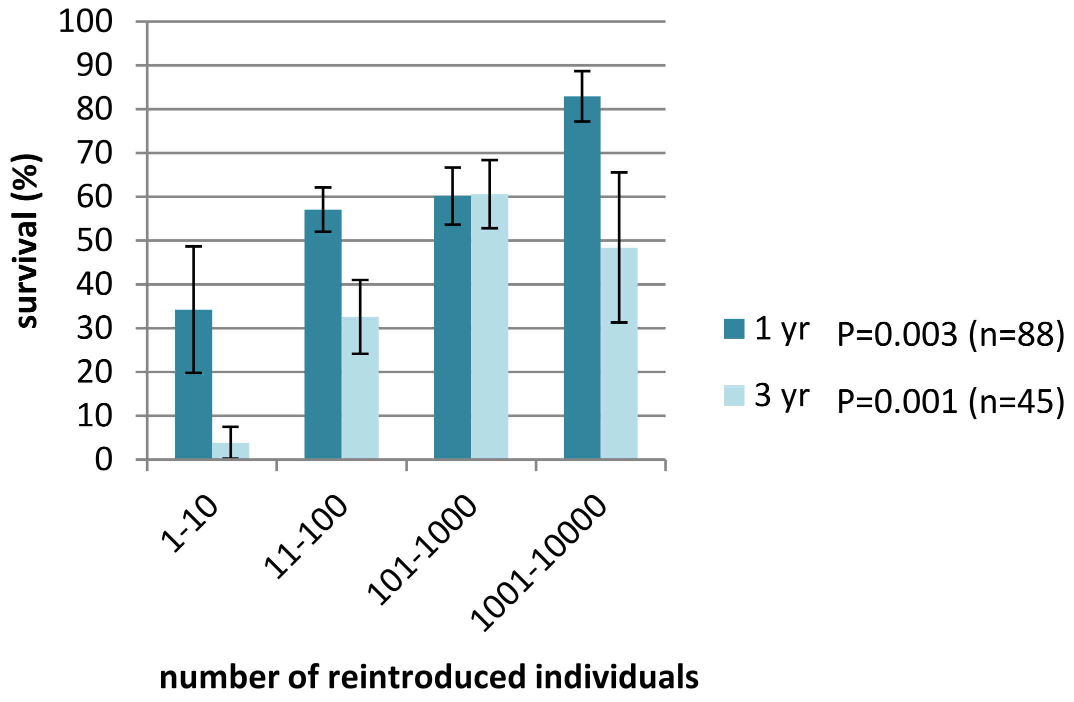
Why are many translocations not successful?

The number of outplanted individuals is usually too small (lower than the MVP size)



Albrecht & Maschinski (2012)



Godefroid et al. (2011)

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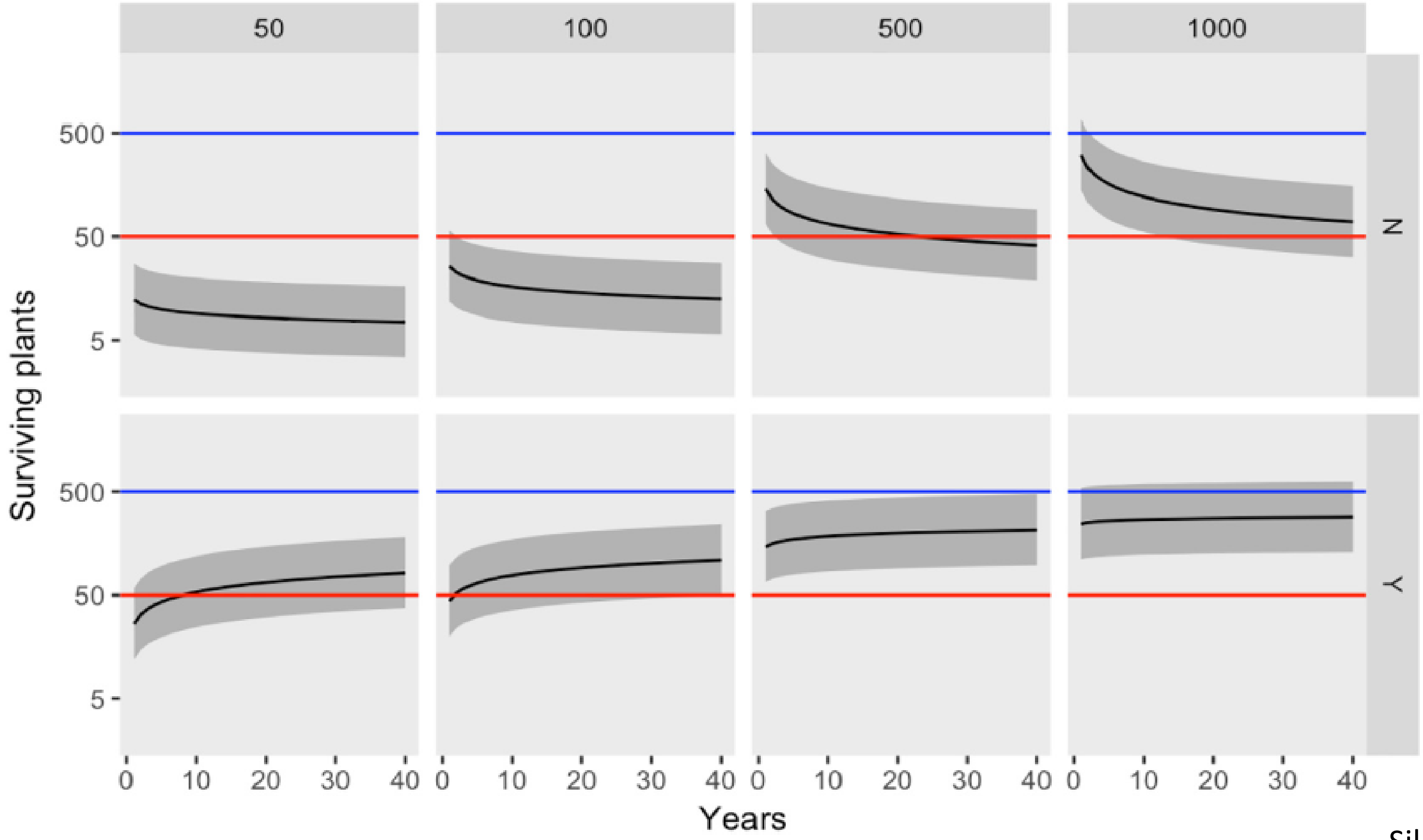

Silcock et al. (2019)

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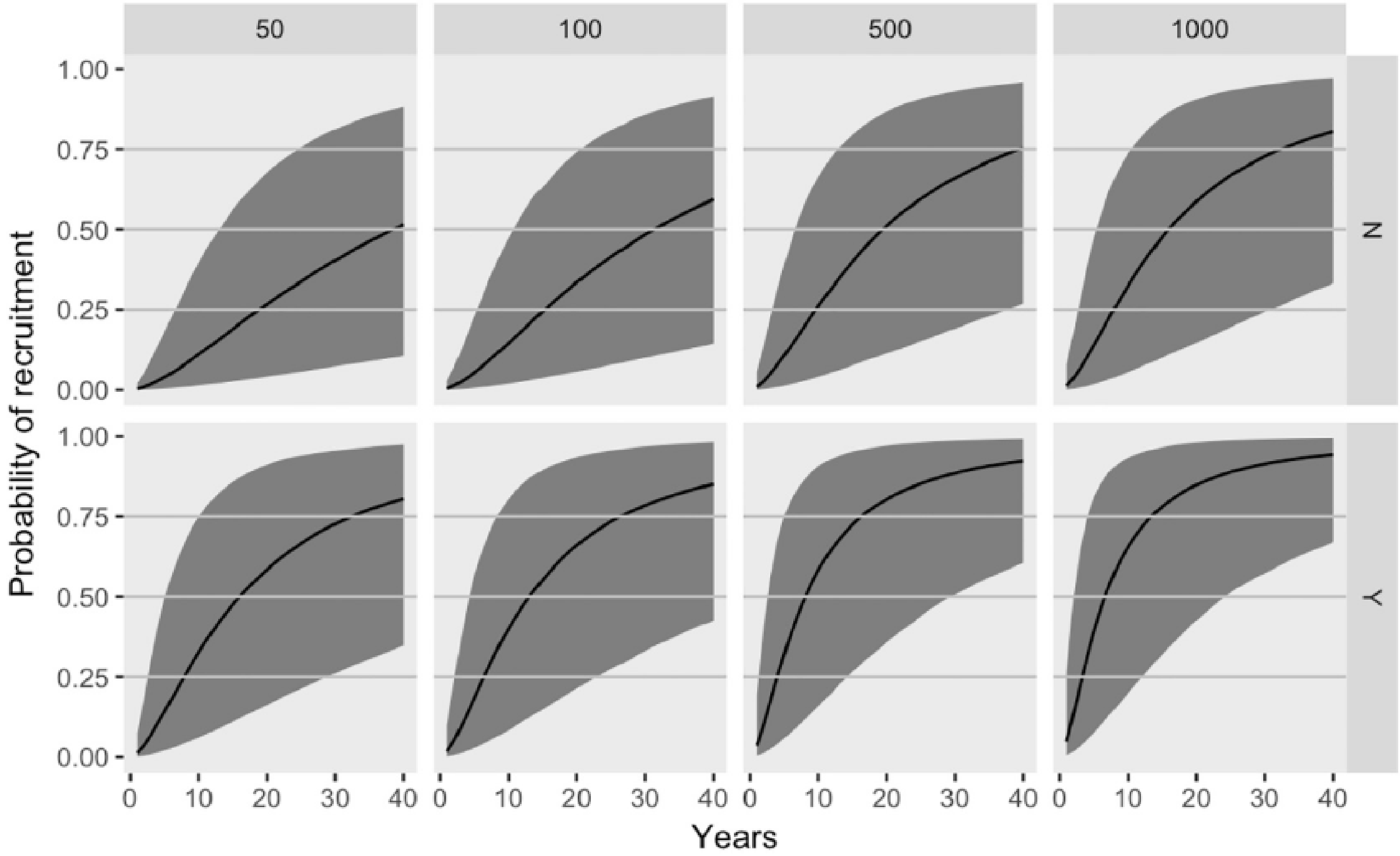
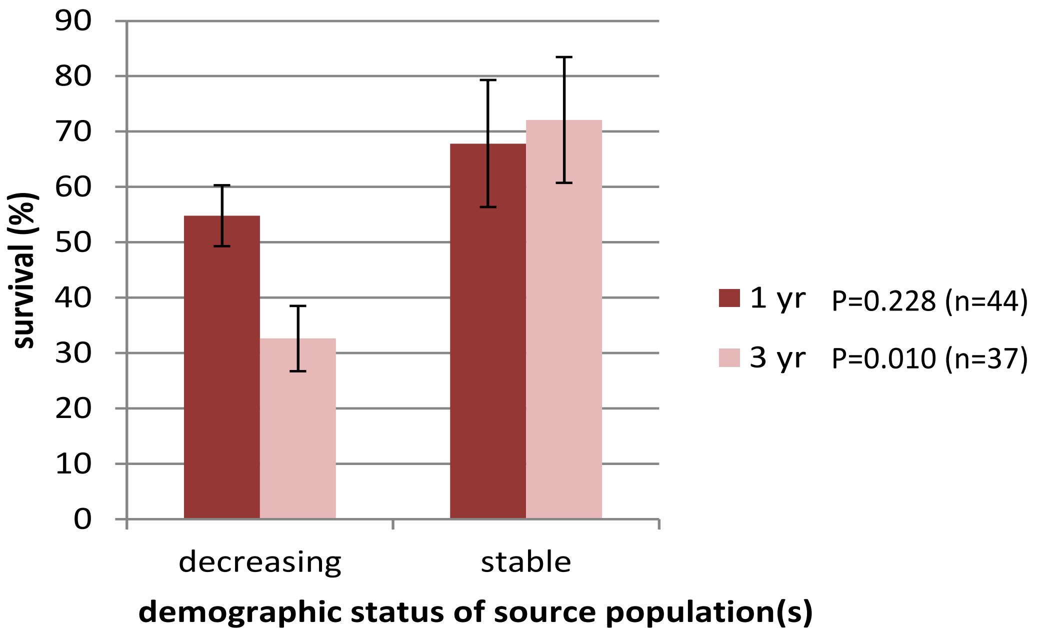


Silcock et al. (2019)

Why are many translocations not successful?

Seed source material is sometimes collected in depleted populations



Godefroid et al. (2011)

- loss of genetic variation
- accumulation of detrimental mutations
- increased inbreeding and inbreeding depression

Why are many translocations not successful?

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Seed source material is sometimes not suited to the (a)biotic conditions existing at the translocation site

Argyroxiphium sandwicense subsp. macrocephalum

Argyroxiphium sandwicense subsp. sandwicense

Populations develop adaptations in response to different local environments

→ Illustrates the role of isolation and distinctive ecological conditions in promoting evolution

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Why are many translocations not successful?

Seed source material is sometimes not suited to the (a)biotic conditions existing at the translocation site

→ Crossing individuals from these populations may produce progeny that is less fit than either parental form → Outbreeding depression

When choosing seed sources

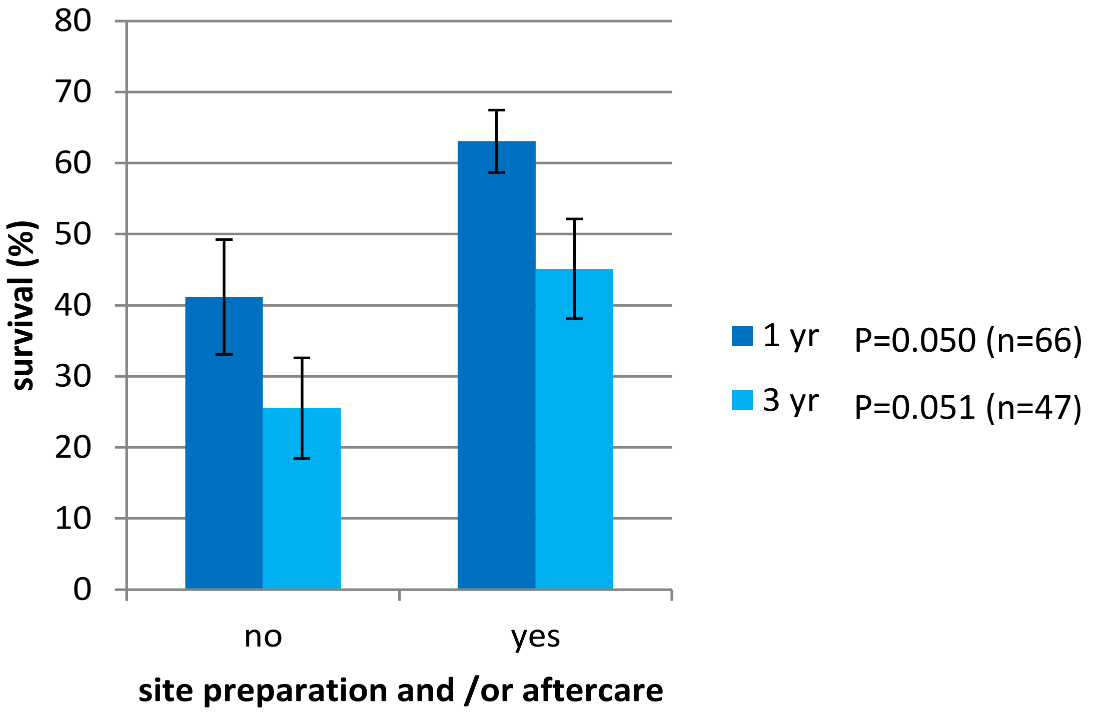
Geographical distance
=
linear distance between source and target sites

Environmental distance
=
difference in environmental variables (soil, climate, elevation) between source and target sites

→ Most important for translocations in islands

Why are many translocations not successful?

Site preparation (e.g. fencing, top-soil removal) and post-planting aftercare (e.g. watering, weeding) are sometimes overlooked



Godefroid et al. (2011)

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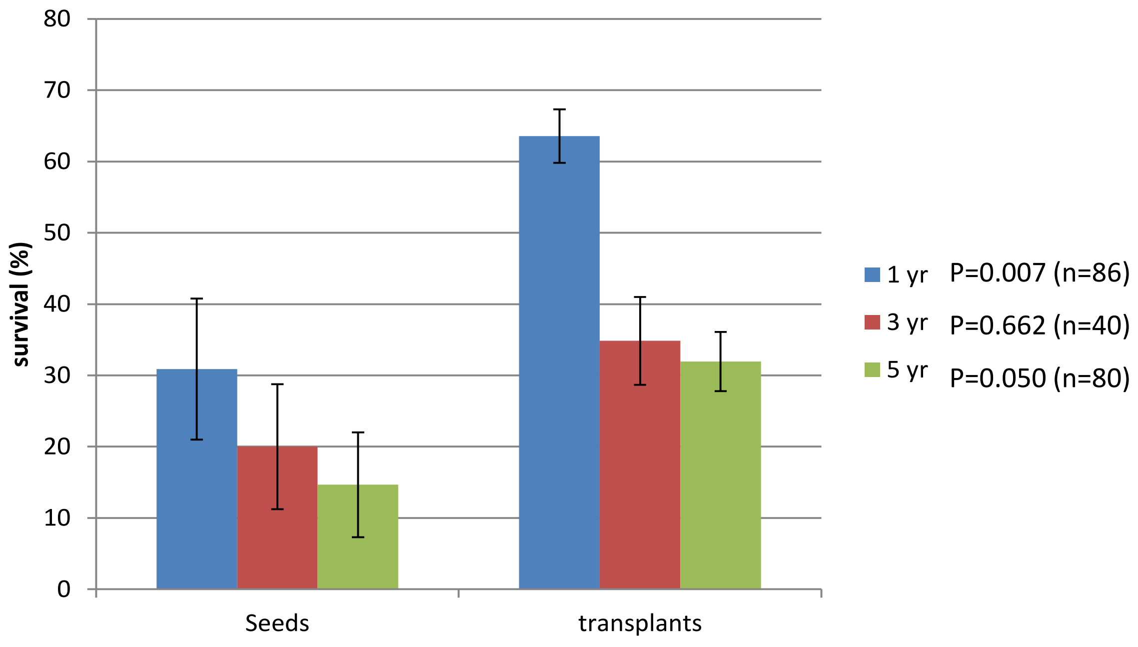
Why are many translocations not successful?

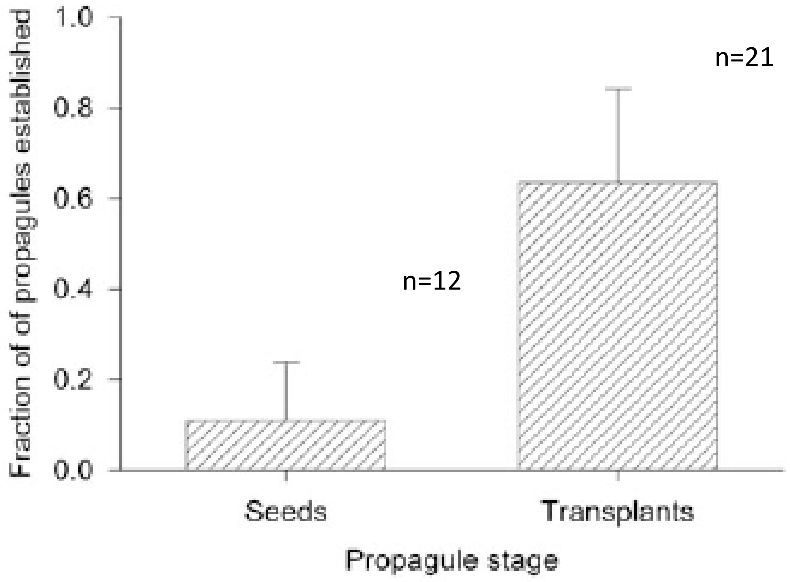
Many attempts use seeds rather than transplants

	seeds n = 47	juveniles n = 134	adults n = 115
Percentage of unsuccessful attempts (extinct at last survey)	36.1	9.0	15.7

Dalrymple et al. (2012)



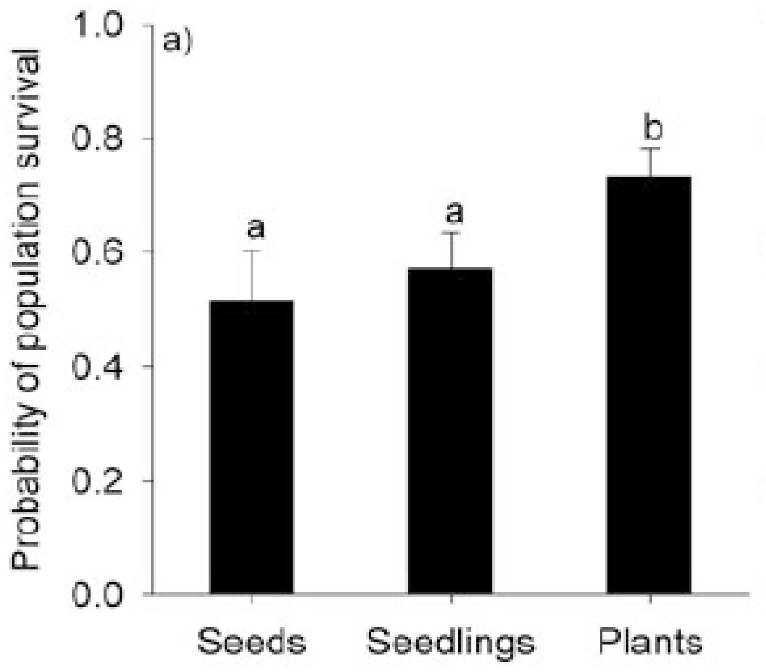
Godefroid et al. (2011)



Albrecht & Maschinski (2012)

Why are many reintroductions not successful?

Some attempts use seedlings instead of adults



Albrecht & Maschinski (2012)

Why are many reintroductions not successful?

October 2015

June 2016

June 2019

Life Herbages

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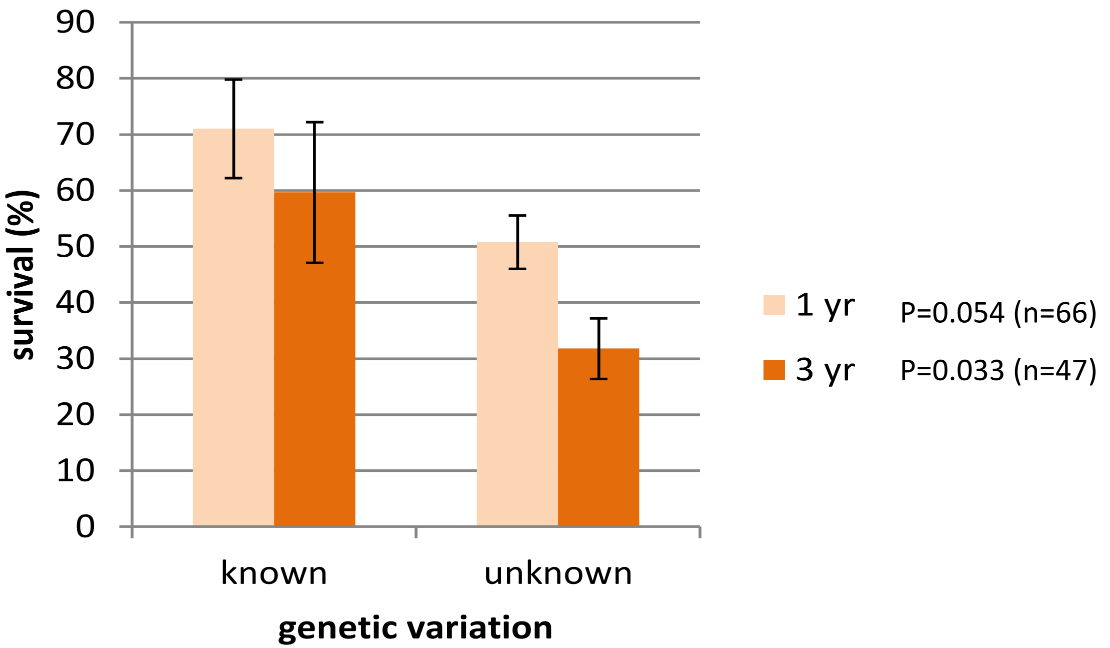
Why are many reintroductions not successful?

Species' biological traits are frequently little known

	known	unknown
	n=135	
breeding system	57%	43%
past and present distribution	56%	44%
genetic diversity	13%	87%

Dalrymple et al. (2012)

Genetic data are rarely available ahead of translocation activity

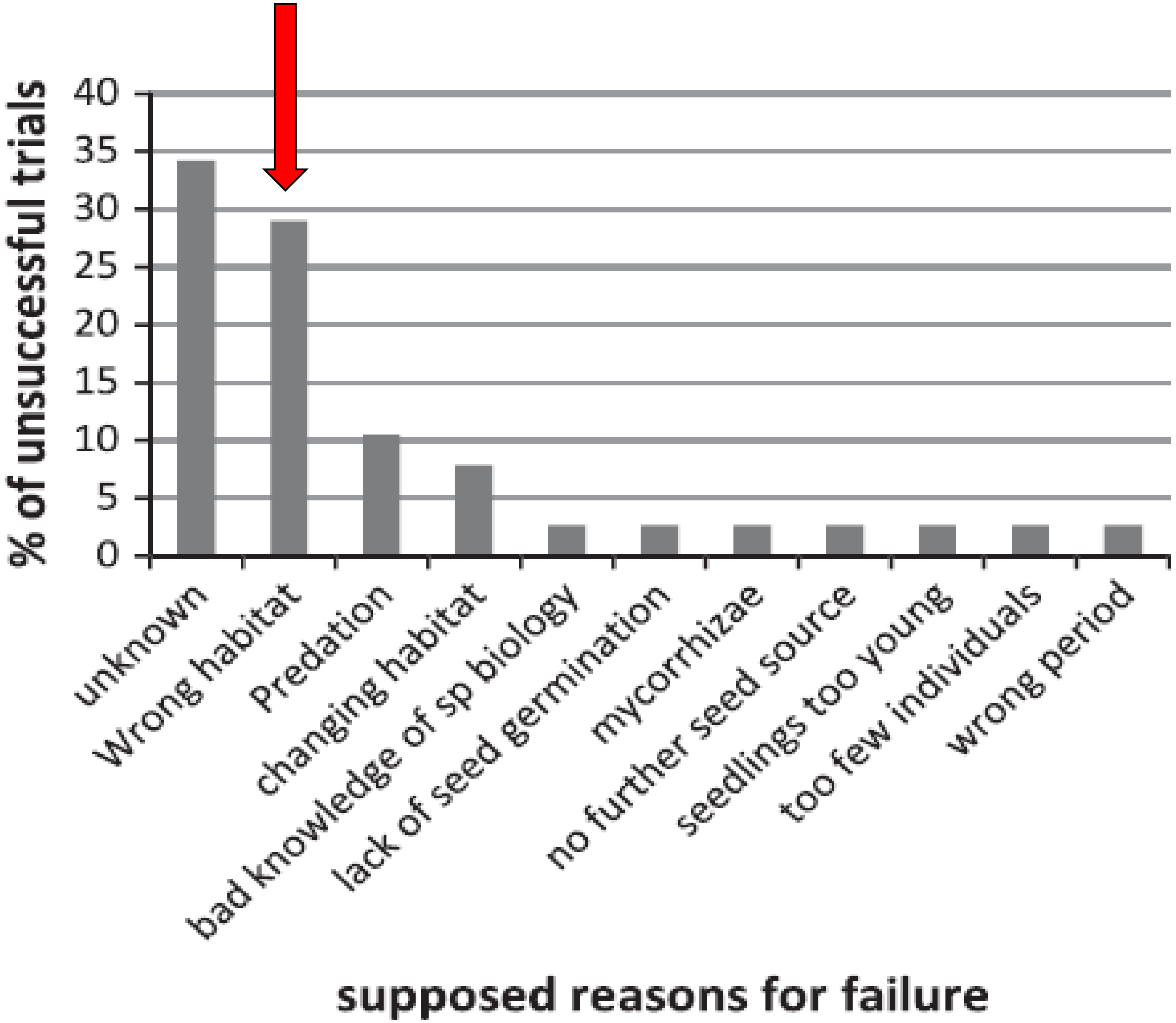


Godefroid et al. (2011)

Why are many reintroductions not successful?

Species' ecological requirements are frequently little known

Poor selection of translocation sites



Godefroid et al. (2011)

How to improve translocation successfulness ?

1. Document the species' biology and ecological requirements

- Reproductive system: allogamous, autogamous, self-incompatible
- Reproductive morphology: dioecious, monoecious
- Need for mycorrhizae: EcM, AM, orchid mycorrhizae
- Need for host-plant: hemiparasites, holoparasites
- Soil seed bank type: transient, short-term persistent, long-term persistent
- Seed dispersal capacity: long vs short distance
- Propagation mode: by seed or vegetatively
- Pollinators: e.g. butterflies, bumblebees, syrphids
- Environmental conditions: soil pH, moisture, nutrients, light levels
- Adverse management methods: e.g. abandonment, mowing, eutrophication
- …

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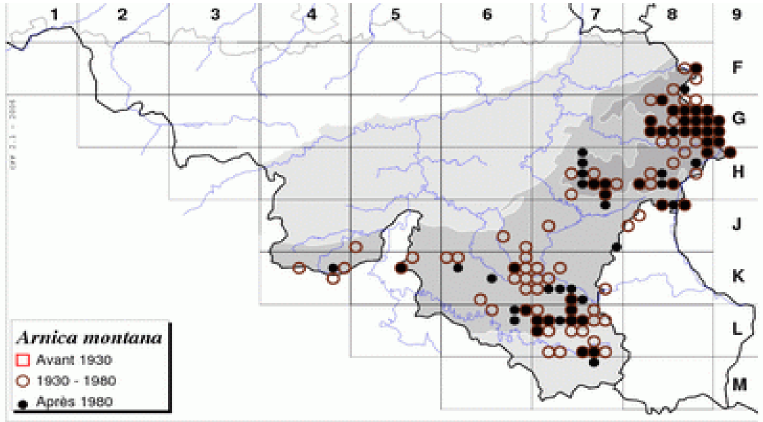
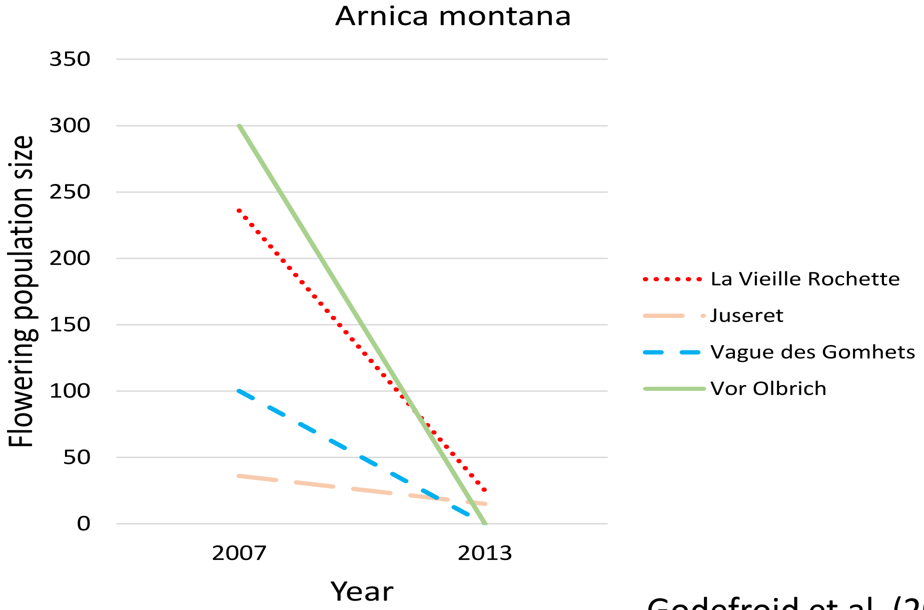
How to improve translocation successfulness ?

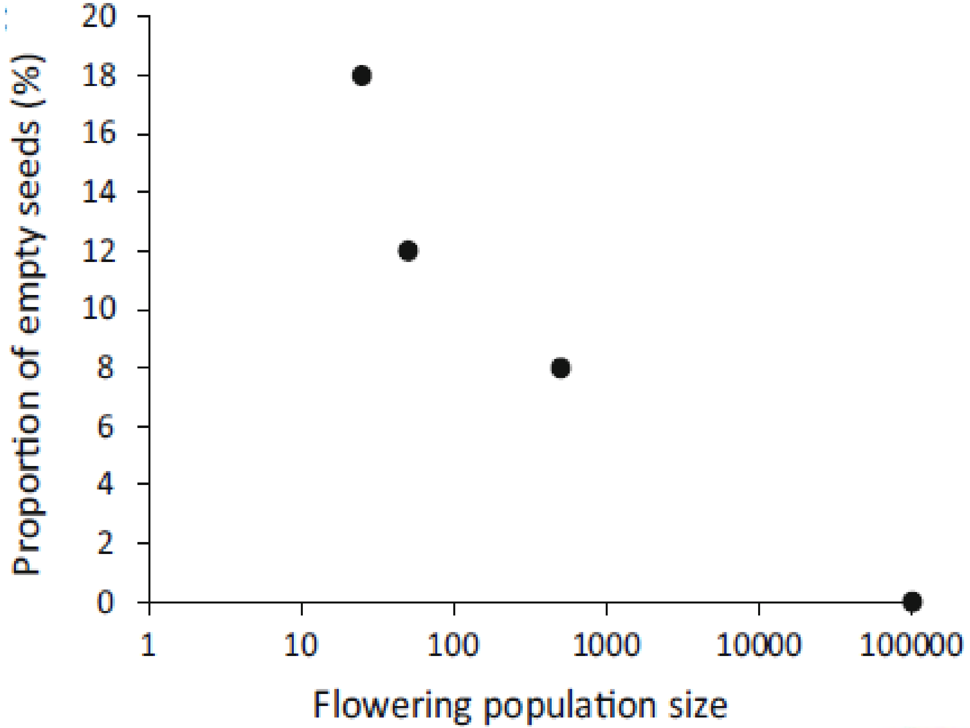
2. Document the species’ status and distribution



helps to select appropriate source material



Godefroid et al. (2016)



Godefroid et al. (2016)

How to improve translocation successfulness ?

3. Collect seeds from preferably large source populations with positive growth rate

Helichrysum arenarium

Arnica montana

How to improve translocation successfulness ?

4. Choose your recipient site carefully

- With sufficient long-term protection
- With a known history
- Ecologically and climatically similar to the donor site
- Having the habitat conditions necessary for the target species
- Without known threats (e.g. invasive species, eutrophication)
- For which the causes of extinction of the target species are identified and can be counteracted
- With current and future land use compatible with population sustainability
- Consider landscape-level phenomena (e.g. topography, ecosystem dynamics)

How to improve translocation successfulness ?

5. Prepare your site before transplantation

In the framework of habitat restoration

- topsoil removal
- fencing

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How to improve translocation successfulness ?

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6. Use transplants rather than seeds

… after having developed a protocol allowing the propagation of the target species

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7. Place plants in a spatial pattern that will promote effective pollination, seed production and recruitment

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	V104		W229		M123		C281		V42		F176		M275	
2		M61		L63		V155		W20		M19		V230		V150
3	C176		V215		E16		M214		V212		V275		W172	
4		F99		M42		L16		V207		C92		M200		L51
5	V131		L221		M172		W216		V210		E126		M120	
6		M92		W28		V54		F52		M209		W199		
7	L200		V251		F130		M15		C279		V106			
8		W82		M31		V7		V128		F143		M104		
9	V114		C204		M241		W51		V80		C241			
10		M16		E105		V26		L76		M220		W224		
11	W102		V142		F160		M278		V252		V148			
12		C64		M288		W17		V187		F44		M215		

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How to improve translocation successfulness ?

8. Maximize the number of outplanted individuals

10 individuals

700 individuals

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How to improve translocation successfulness ?

9. Do not overlook post-planting aftercare

Population reinforcement of *Campanula glomerata*

Without weeding

With weeding

How to improve translocation successfulness ?

9. Do not overlook post-planting aftercare

Population reinforcement of *Helichrysum arenarium*

Without weeding

With weeding

How to improve translocation successfulness ?

10. Consider sowing accompanying species in addition to transplants

→ Priority effects: early-arriving species influence the establishment and growth of later-arriving species

Transplants: *Campanula glomerata*
Sowing mixture: *Rhinanthus minor, R. alectorolophus, Anthyllis vulneraria, Leucanthemum vulgare, Lotus corniculatus, Onobrychis viciifolia*

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How to improve translocation successfulness ?

11. Monitor population demography for 10 years

How to improve translocation successfulness ?

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12. Keep detailed documentation and register your data in a centralized database (preferably online)

Institution name: Archbold Biological Station			
Address: PO Box 2057, Lake Placid, FL 33862			
Name of the contact person: Carl Weekley			
email: cweekley@archbold-station.org			
	pop. 1	pop. 2	pop. 3
Taxon name: *Ziziphus celata*	Carter Creek South	Tiger Creek05	Tiger Creek07
Species conservation status (IUCN code: EX, EW, CR, EN, VU, NT, LC, DD, NE)	VU-D1	VU-D1	VU-D1
Type of project (according to IUCN definitions):			
- reintroduction	x	x	x
- translocation			
- reinforcement/supplementation/augmentation			
Starting date of the project (yyyy/mm/dd)			
Reintroduction date (yyyy/mm/dd)	2002/06/15	2005/06/28	2007/10/23
Reintroduction site information:			
- national park	US Fish & Wildlife Service		
- Natura 2000 area			
- nature reserve		The Nature Conservancy	The Nature Conservancy
- unprotected			
- private land			
Material source:			
- in situ material			
- direct translocation			
- ex situ conservation collection	x	x	x
- horticultural	x	x	x
Material type (plant life stage):			
- Seeds	x	x	x
- Seedlings (please mention the age)	2-3 yrs	1-2 yrs	1-2 yrs
- Adult plants (please mention the age)			

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How to improve translocation successfulness ?

12. Keep detailed documentation and register your data in a centralized database (preferably online)

	pop. 1	pop. 2	pop. 3
Number of seeds/seedlings/adults (please specify) per reintroduced population	144 xplants, 1728 seeds	286 xplants, 3000 seeds	110 xplants, 1200 seeds
Provenance of material introduced:			
- plants from only one population			
- mixing plants from diverse populations	x	x	x
Demographic status of source population:			
- decreasing			
- stable	x	x	x
- increasing			
Survival rate (in %) after 1 year	89.7	80.1	
Survival rate (in %) after 2 years	84.6	79	
Survival rate (in %) after 3 years	83.6	71	
Survival rate (in %) in subsequent years (please specify which year)	70.8 (6.5 yrs post-intro)	66.1 (3.5 yrs post-intro)	94.5 (1.5 yrs post-intro)
Percentage of flowering individuals after 1 year	0	0	0
Percentage of flowering individuals after 2 years	0	0	0
Percentage of flowering individuals after 3 years	0	0	0
Percentage of flowering individuals in subsequent years (please specify which year)	0	0	0
Percentage of fruiting individuals after 1 year	0	0	0
Percentage of fruiting individuals after 2 years	0	0	0
Percentage of fruiting individuals after 3 years	0	0	0
Percentage of fruiting individuals in subsequent years (please specify which year)	0	0	0
Number of naturally recruited individuals after 1 year	0	0	0
Number of naturally recruited individuals after 2 years	0	0	0
Number of naturally recruited individuals after 3 years	0	0	0
Number of naturally recruited individuals in subsequent years (please specify which year)	0	0	0
Seed production (please specify the year if time measurements):	0	0	0
- mean per individual	0	0	0
- total number for the population	0	0	0

Conclusions

- The translocation of plant species is a widely used technique, but it suffers from a generally low success rate
- Variables that play a major role in the successfulness of translocations are: material type, number of founder individuals, protection status of target area, demographic status of source population and management of out-planting sites
- The effectiveness of this technique can however be improved by following strict rules and striving to build the necessary knowledge of target species, donor sites and recipient sites
- Given the high cost of operations and the ever more rapid species extinction, it is also important to share our respective experience in methods and outcomes across the practitioner community

Any questions ?

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