MONITORING AND PRIORITISATION OF FLORA TRANSLOCATIONS: A SURVEY OF OPINIONS FROM PRACTITIONERS AND RESEARCHERS

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Summary

This document provides the results of a survey of practitioners and researchers working within the field of flora translocations throughout Australia. Specifically, opinions were sought on optimal strategies for monitoring translocations after they have occurred and for which factors are most important for prioritising candidate species. A dichotomous key containing a series of questions that need to be addressed prior to the approval of a translocation are also provided. This key is intended to act as a set of guiding principles for choosing between potential candidates for translocations.

Acknowledgements

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SECTION 1 - A synthesis of opinions on monitoring of flora translocations – results from the *Flora translocation survey (2013)*

1. The Flora translocation survey (2013)

1.1 Introduction

Translocations intentionally move organisms from one site to another and are broadly classified as re-introductions and augmentations (reinforcements) within an organisms' known distribution, and introductions and ecological replacements beyond the known range (IUCN/SSC, 2013). Translocations are regarded as an appropriate (but not risk free) tool, in a suite of measures aimed at the conservation of biodiversity (IUCN/SSC, 2013).

The challenge for conservation managers is to minimise project costs but at the same time, retain the benefits that key processes, such as monitoring, add to the success of a translocation project. To investigate how (or if) this is being achieved, we surveyed practitioners and researchers involved in Australian flora translocations to gather opinions on how effectively monitoring is carried out on current projects.. The outcomes of this exploratory survey are an indication of thinking among a selection of practitioners and researchers, constrained by questionnaire format. They are not the whole story and are not in themselves an adequate basis for policy or prioritisation procedures. More detailed canvassing of a wider range of expertise holders, and deeper mining of the information sources, would be needed to provide that basis.

1.2 Aims and objectives of the survey

The aim of the monitoring section of the *Flora Translocation Survey, 2013*, was to investigate the possibility of formulating a general, cost effective monitoring guideline that can be adapted for individual flora projects. In addition, the survey was used to try and find commonalities between groups of species or species' traits that could lead to standardised monitoring.

1.3 What is a successful translocation?

Each translocation will have its own success criteria, but generally, success is measured by the establishment of a self-sustaining population of the focal species (Griffith *et al.*, 1989; Fischer & Lindenmayer, 2000). Successful flora translocations have also been described as the ability of the translocated population to persist and reproduce (Godefroid *et al.*, 2011). The Australian Network for Plant Conservation (ANPC) flora translocation guidelines further splits success into short-term and long-term objectives (Vallee *et al.*, 2004). The short-term goal is the successful establishment of the translocated individuals and the long-term goals are: the management and control of threats; the attainment of sufficient numbers to avoid both demographic and environmental stochasticity and successful reproduction and natural recruitment (Vallee *et al.*, 2004).

1.4 The importance of monitoring

Monitoring is a vital component of all translocation projects and is necessary for ensuring adaptive management and evaluating success (Vallee *et al.*, 2004;Menges, 2008; Maschinski *et al.*, 2012). Monitoring contributes to the success of translocations by (Menges 2008; Monks *et al.* 2012):

- increasing basic biological and ecological knowledge;
- enabling lessons to be learnt from past successes and failures by providing the ability to adopt adaptive management;
- allowing the evaluation of experimental approaches to translocation;
- allowing comparisons with reference populations.

Furthermore, monitoring allows the assessment of the growth and survivorship of the translocated population at regular intervals and permits the mitigation of threats as they occur, thus increasing the chances of success (Dimond & Armstrong, 2007). In particular, detailed long-term monitoring has been identified as a means to improve current low success rates of species relocations (Sheean *et al.*, 2012).

Implementation of a successful translocation project is dependent on long-term monitoring and therefore requires an allocation of resources over a sufficiently long period. The ANPC guidelines stipulate that a translocation should not proceed until sufficient funding is secured for post-translocation monitoring (Vallee *et al*., 2004).

The costs associated with translocations are not usually disclosed, however Sheean *et al.* (2012) reported the costs of three Australian fauna species relocation programmes: $190,000 with an additional cost of $25,000 per year for five years for an amphibian; $600,000 for a marsupial and $300,000 for the supplementation of an avian species (the time frame was included for the first project only). The amphibian example suggests that whilst initial translocation costs are high, on-going monitoring requirements also make a high proportion of overall costs. Reporting of on-going translocation projects shows that monitoring tends to be carried out for short periods (within three years), rather than 10+ years (Sheean *et al.*, 2012).

2. Survey design

2.1 Selection of survey respondents

The data for this study was derived from a section of the *Flora Translocation Survey, 2013*, that pertained only to practitioners and researchers who have been involved in Australian flora translocations and could nominate the specie(s) that they have translocated. Potential participants were identified by the project collaborators and included:

- Australian State and Territory threatened species project officers;
- Australian authors from the IUCN Reintroduction Specialist Group case study reports 2011, 2010 and 2008 (http://www.iucnsscrsg.org/index.php?option=com_content&view=article&id=192&Itemid=587;
- Case study presenters at past ANPC workshops (since 2004) on 'Translocation of Threatened Plants in Australia';
- Speakers at an Australian Association of Bush Regenerators seminar 3/10/13.
- Authors of papers that included the terms “assisted colonisation”, “managed translocation”, “plant” and “Australia” in titles or keywords accessed via the Scopus Database in 2013.

Further participation was sought by the distribution of the survey through the email networks of the Office of the Environment and Heritage (OEH) Threatened Species Network, the Australian Network of Plant Conservation (ANPC) and the Ecological Consultants Association of NSW.

2.2 Survey format

The survey was conducted on-line via SurveyMonkey and comprised two sections;

(1) Quantitative answers

(2) General opinions

In part (1) respondents were asked to identify flora species they have translocated and to answer specific questions regarding the monitoring of the translocation project for the identified species. The basis for these questions, from which a suite of monitoring variables was determined, was derived from the current literature (Vallee *et al.,* 2004; Godefroid & Vanderborght, 2011; Maschinski *et al.,* 2012). In particular, these questions sought to elicit opinions on which variables should be measured for translocated populations and at what duration. It is important to note that the information gathered in the survey is not a substitute for expert opinion, but rather seeks to complement already established protocols for flora translocation (namely Vallee *et al*., 2004).

Respondents were provided with a list of life-cycle variables and asked to identify the ideal duration of monitoring for each variable with a choice of: (1; 2; 3; 5; 7; 10; 10+ years, not important, not applicable). Life cycle variables included:

1. Survival;
2. Flowering plants;
3. Fruiting plants;
4. Seed production;
5. Abundance of naturally recruited (or regenerated) individuals;
6. Abundance of clonal offshoots (or ramet production)

To find commonalities between groups of species or species' traits, respondents were asked to categorize their species into the following groups:

- Habit (woody plant - short-lived < 10 years; woody plant - long-lived ≥ 10 years; non-woody plant – perennial; non-woody plant – biennial; non-woody plant – annual)

- Breeding system (sexual; asexual; can be sexual &/or asexual; other)
- Transplant method (seedling transplant; adult transplant; direct seeding)
- Taxonomic (genus and species)

In addition to the above, in regard to their nominated species, respondents were asked to provide details on the type of translocation undertaken, the conservation status of the species at the time of translocation, publication details of the project, the current status of the project (finished or not) and if finished, whether there is an informal interest group maintaining some involvement.

In part (2) questions on more general aspects of monitoring, including the effectiveness of volunteer groups and suggestions for simple, cost effective monitoring were also asked. Each question allowed room for comments in order to encapsulate any other monitoring variables the respondents deemed necessary.

2.4 Data analysis

For quantitative data, not every respondent answered each duration question for each life-cycle parameter. To calculate percentages of responses for each life-cycle measurement, where the individual measurements were skipped or allocated 'not applicable', these responses were removed. Therefore, the base percentage calculation is different for each parameter.

For the general opinion section, where closed-ended questions gave numerous answer options, a rating average was applied to each option. The rating average was calculated as follows:

$$\frac{w^1*n^1 + w^2*n^2+w^3*n^3}{T}$$

Where w = weight of the answer choice; n = the number of responses for that option; T = total number of responses.

3. Survey results: quantitative data

3.1 General information

Thirty-one respondents participated in the monitoring section of the survey, yielding data for 85 species. Thirteen species were identified more than once, two genera (acacias and eucalypts) and two vegetation communities were identified and these are not included in the number of (85) species. In addition, a bibliography of translocation reports was compiled from survey responses and is included as Appendix 1 to this report. 83% of the species were legislatively listed in one or more Australian jurisdictions at the time of their translocation.

Reintroductions were the most common type of translocation (32%), followed by introductions (22%) and ecological replacements (10%), as per the IUCN definitions that were attached to the survey (IUCN/SSC 2013). Two thirds of the projects are not finished in terms of the time frame set in their project plans.

Overwhelmingly, respondents think that all of the life cycle measurements suggested in this survey are important to monitor. Some respondents provided comments that their answer depends on the species and the circumstances. In particular, we note the comments from one respondent (who has translocated multiple species) that their answers ‘depends on what aspect of flowering/fruiting plants are measured (e.g. flowering or not, the number of flowers, flower to fruit ratio) and what goals/ success criteria is set and over what time frame’. There was no capacity within the survey to ask respondents what specific aspects of each monitoring parameter should be recorded for each species.

3.2 Monitoring duration by habit groups

The most frequently identified ‘habit’ for translocated taxa was *Woody plant - long-lived* ≥ *10 years* (Table 1). *Non-woody plant – biennial* and *non-woody plant – annual* were absent from survey responses.

Table 1. Preferred duration of monitoring of flora translocation projects for various plant growth habits. The first row in each cell identifies the number of years the life cycle parameter should be measured according to survey respondents and the percentage of total responses. The second row identifies the duration for the second highest percentage of responses. The number in brackets in the third row of each cell is the total number of responses. For instance for woody short-lived plants (< 10 years), 75% of respondents think that survival should be monitored for over 10 years (10+) and 25% think it should be for 10 years (4 responses).

	Woody plant - short-lived < 10 years	**Woody plant - long-lived ≥ 10 years**	**Non-woody perennial plant**
Survival	10+: 75% 10: 25% (4)	10+: 51% 5: 18% (52)	5: 45% 10+: 39% (44)
Flowering	5: 75% 10+: 25% (4)	**10+: 52% 5: 23% (49)	**10+: 44% 3: 32% (41)
Fruiting	*5: 75% 10+: 25% (4)	**10+: 54% 5: 27% (42)	**10+: 68% 5: 23% (22)
Seeding	5: 75% 10+: 25% (4)	**10+: 41% 5: 28% (47)	5+: 29% 5: 24% (41)
Recruitment	10+: 75% 10: 25% (4)	10+: 53% 10: 17% (48)	10+: 41% 5+: 27% (44)
Clonal	n/a (0)	2: 36% 5 & 10: both 18% (11)	***3: 50% 10 & 10+: both 12%(24)

*But would prefer 10 years. **A substantial proportion of these responses (all from one respondent) gave a caveat that ‘it depends on the situation.’ ***This question was not applicable to many species and the majority of the responses came from one respondent with a caveat that this measurement is not important. N.B. where responses are low, the majority of responses may be only one person’s view for multiple species.

3.3 Monitoring duration by breeding system

The most frequently identified breeding system was *sexual* (Table 2). Ten species were nominated as ‘sexual and possibly also asexual but not confirmed’. These responses were included in the *sexual* category.

Table 2. Preferred duration of monitoring of flora translocation projects for various plant breeding systems. The first row in each cell represents the number of years the life cycle parameter should be measured and the percentage of responses total responses. The second row identifies monitoring duration for the second highest percentage of responses. The number in brackets in the third row of each cell is the total number of responses. For instance, for sexual breeding systems, 49% of respondents think that survival should be monitored for over 10 years and 23% think it should be for five years (79 responses).

	Sexual	Asexual	Can be sexual or asexual
Survival (3)	10+: 49% 5: 23% (79)	10+: 100% (1)	5: 59% 10+: 32% (22)
Flowering	*10+: 48% 5: 22% (78)	10+: 100% (1)	3 & 5: both 30% (20)
Fruiting	*10+: 57% **5: 28% (55)	10+: 100% (1)	5: 43% 10+: 36% (14)
Seeding	*10+: 33% 5: 29% (74)	Only needs to be done once: 100% (1)	5: 39% 5+: 28% (18)
Recruitment	10+: 53% 5: 16% (77)	5: 100% (1)	5: 32% 5+ & 10+: both 26% (19)
Clonal	***3: 37% 2: 26% (19)	5: 100% (1)	***3: 46% 10 & 10+: both 23% (13)

*A substantial proportion of these responses (all from one respondent) gave a caveat that 'it depends on the situation.' **53% of responses nominated 5 years but would prefer 10 years. *** 2/3rds of responses (one respondent) noted that this measurement is not important.

3.4 Monitoring duration by planting method

The most frequently identified planting method was seedling transplant, followed by adult transplant (Table 3). For the purposes of this survey, the definition of seedling transplant was assumed to cover those plants grown by seed in a nursery or propagated by cuttings, and then transplanted as tubestock. However, this definition was not included in the glossary and whilst some respondents distinguished between the two, cuttings was included in the data as a tubestock transplant. It is possible that some respondents thought of a 'seedling transplant' as the digging up and transplanting of natural plants. A small number of respondents used a combination of planting methods and a very small number used tissue culture. Because the combination method cannot be further split and the sample size is small respectively, this data was not included in the analysis.

The results from the survey show that there is a large difference in monitoring duration, depending on the planting method. Monitoring is recommended for 10+ years where seedlings are planted but only 5 years if adults are planted. It is difficult to comprehend why there is a difference between the two groups for survival but perhaps for the other parameters, it is assumed that the plants planted as adults are already reproducing. Alternatively, unintended confusion surrounding the terminology of seedling transplant may have skewed the data one way or another.

Table 3. Preferred duration of monitoring of flora translocation projects by planting method. The first row in each cell represents the number of years the life cycle parameter should be measured and the percentage of responses. The second row gives the second highest percentage of responses is given. The number in brackets in the third row of each cell is the total number of responses. For instance 55% of respondents think that where adult plants were transplanted, survival should be monitored for five years and 22% think that it should be for more than 10 years (18 responses).

	Seedling transplant	Adult transplant
Survival	10+: 39% 5: 30% (56)	5: 55% 10+: 22% (18)
Flowering	*10+: 52% 3: 19% (52)	5: 50% 10+: 25% (16)
Fruiting	*10+: 69% 5: 11% (36)	5: 70% 10+: 20% (10)
Seeding	*10+: 38% 5+: 19% (52)	5: 60% 10+,5+, 3: 13% each (15)
Recruitment	10+: 46% 10 & 5+: both 18.5% (54)	5: 50% 10+: 19% (16)
Clonal	**3: 59% 10, 5 & 2: 12% each (17)	10+, **3yr & other: 22% each 10, 5 & 2: 11% each (9)

*A substantial proportion of these responses (all from one respondent) gave a caveat that 'it depends on the situation.' ** All responses from one respondent who nominated 3 years but said that this measurement is not important.

3.5 Monitoring duration by taxonomic groups

The largest family represented in the survey was Proteaceae. Monitoring data was recorded 23 times, for 15 species by 17 different respondents (some species were represented twice and some respondents nominated more than one species). The genera represented were: *Banksia, Grevillea, Lambertia* and *Persoonia*. All species were nominated as having a sexual breeding system (including three *Grevilleas* that were described as sexual and other, possibly selfing) and all but three *Grevillea*s as having a woody, long-lived (≥ 10 years) habit (two *Grevilleas* were woody, short lived and one was non-woody perennial).

Overwhelmingly for the Proteaceae, respondents thought that survival, flowering, fruiting, seeding and the abundance of naturally recruited or regenerated individuals should be monitored for 10+ years. However, it was also noted that for some of these answers, the monitoring time depends on what aspect is being monitored and what goals/success criteria are to be achieved. It should also be noted that there were only two *Lambertia* species and one respondent thought that monitoring for flowering, fruiting and seeded only needed to be for five years.

Orchids were represented by six species and one group “orchids” from six different respondents. The six species were described as non-woody perennial plants and all but one with sexual breeding systems. The ‘orchids’ group was described as woody, long-lived (≥ 10 years) plants that can have either sexual or asexual breeding systems. The majority of the respondents (2/3rds) thought that survival, flowering, fruiting and the abundance of naturally recruited or regenerated individuals should be monitored for five years. The remaining 1/3rd of respondents suggested 10+ years. There was no consensus on seeding monitoring duration with suggestions ranging from 3 - 10+ years and another comment that once seeding has occurred, there is no need to monitor again.

Four *Acacia* species were represented in the survey, from five respondents. Monitoring time for each parameter was variable but there was a slight preference for 10+ years. Accordingly, it is difficult to draw generalisations for monitoring guidelines for this taxon from the survey responses.

Unless the responses for a taxonomic group are large, caution should be applied to the formulation of general monitoring guidelines from the survey responses. Only the Proteaceae and orchid species as groups gave consistent time frames to consider using the data for general monitoring guidelines. However, the number of species analysed in the survey are small compared to their taxonomic groups. Furthermore, inconsistent responses were given for the same species. As an example, two different species were nominated by three and four different respondents for each species. For the same species, a different monitoring time for each parameter was suggested by the respondents.

3.6 Other life-cycle monitoring

3.6.1 Early survivorship

To assess how frequently survivorship should be monitored, we split 'survival' into three phases: (1) transplant shock (2) establishment success and (3) project success. The first two phases were answered on a general basis and the results are discussed below. The third phase was specifically for the respondent's case study species and these results have already been discussed.

Overall, for the early stages of survival (1 and 2), the largest percentages of respondents recommended that plants should be monitored weekly for the first month and then adjust for the particular species and then yearly for establishment success.

For transplant shock, the monitoring duration suggested by respondents varied but was most commonly cited as weekly for the first month, followed by various time periods thereafter. Most of the suggested time periods came with comments that it depends on the species, the environmental conditions and on-site threatening processes. Several respondents did not directly answer the question because they felt that it depended on too many circumstances to give a quantitative answer. It was also mentioned that it is important that monitoring also includes the cause of the mortality. For establishment success (the period after potential transplant shock), there was no clear consensus how long survivorship should be monitored. The largest percentage of respondents (35%) thought that establishment success should be monitored yearly but it is unclear from the survey results for how many years this should be applied.

3.6.2 Growth

Monitoring guidelines usually recommend that growth measurements are recorded (Vallee *et al.,* 2004; Maschinski *et al.,* 2012), but this variable is not always deemed necessary (Godefroid & Vanderborght, 2011). 65% of 26 respondents recommend that growth measurements be taken. Height was the most commonly mentioned trait, often in conjunction with width. However, growth measurements for grasses, orchids and herbaceous species were generally less important.

4. Interpretation of the quantitative data

4.1 Commonalities

There are several ways that the data can be interpreted to find commonalities. For example:

- Within categories. For sexual breeding systems, the survey respondents recommended that all monitoring is done for at least 10 years, apart from abundance of clonal offshoots (or ramet production).
- Between categories. Build a profile e.g. a woody long-lived, sexually reproducing plant should be monitored for flowering for 10+ years.
- Build a profile by taxonomic group. Monitoring duration suggested for the taxonomic groups should be cross checked with the results from the habit (Table 1) and breeding system (Table 2) data. The results should then be reviewed by practitioners and researchers experienced in the biology, translocation and revegetation of these groups. For example, a Proteaceae that is a long-lived and sexually reproduces should be monitored for survival for 10+ years. However, for non-woody perennial, sexually reproducing orchids, monitoring duration for survival is less definitive because the recommended monitoring duration for these three categories varied considerably.

4.2 Considerations for interpretation of the data

The following should be considered when interpreting the survey results:

- Magnitude of the largest response. More confidence should be allocated where the percentages of responses is large. For example, for recruitment (abundance of naturally recruited (or regenerated) individuals), 53% of respondents nominated a particular monitoring duration for *sexual* breeding systems compared to only 32% for *can be sexual or asexual*. More confidence is given to the sexual monitoring time frame.

- Number of responses: For breeding systems, there were 79 responses for *sexual* compared to 1 response for *other* for duration of survival monitoring. This does not mean that the response for *other* is wrong, but it represents only one person's view.

4.3 Other comments

Some additional comments from respondents on monitoring duration are added here because they may assist in the conversion of general guidelines into more specific ones.

- If actions recommended from the results are unlikely to be carried forward and resources aren't available, highly detailed monitoring is not important.
- Once it has flowered/fruited successfully, there is no need to re-monitor this parameter again assuming that nothing else changes.
- Monitor until regular seed set - 3 seasons in a row.
- To simplify monitoring, take photographs from fixed points at preferably regular intervals.
- If the aim is for a self-sustaining population, monitor for multiple generation times for short lived plants or for at least two generations for long lived plants to determine if recruitment is occurring and if those generations are reproductive.
- 'The survival and reproduction of new recruits should be followed until those new recruits produce new recruits. Time frame will depend for example on climate and frequency and timing of disturbance events.

5. Other monitoring considerations

5.1 Representative sampling

The majority of respondents believe that where the number of translocated individuals is large and time consuming to monitor, representative samples, from which inferences can be drawn, can be measured. This response applied to all of the life-cycle parameters listed in this survey, apart from survival where every individual should be measured. Two methods of representative sampling were suggested. The first method is a random selection of a representative suite of plants (minimum of 10 plants per site per species) and secondly, transects through populations.

5.2 Comparison to reference site

To measure the success or otherwise of a translocation project, the life-cycle measurements should be compared to those from natural populations of the species (Vallee *et al.* 2004). To gauge the level of the importance of this monitoring action, respondents were asked if their monitoring includes comparison(s) to a reference site (e.g. the source populations), and if so, its timing. Overall, there was support for this action but we note that a quarter of the respondents either do not make comparisons to the reference site and / or they do not think that this measurement is necessary (Figure 1). Of those who do compare, there was little difference between a monitoring duration of *each time the recipient site is monitored* and *when key phenological phases of the focal species occur.* One respondent opined that ‘comparisons should be made initially at each phase, but it becomes less important once translocated and reference site become similar’.

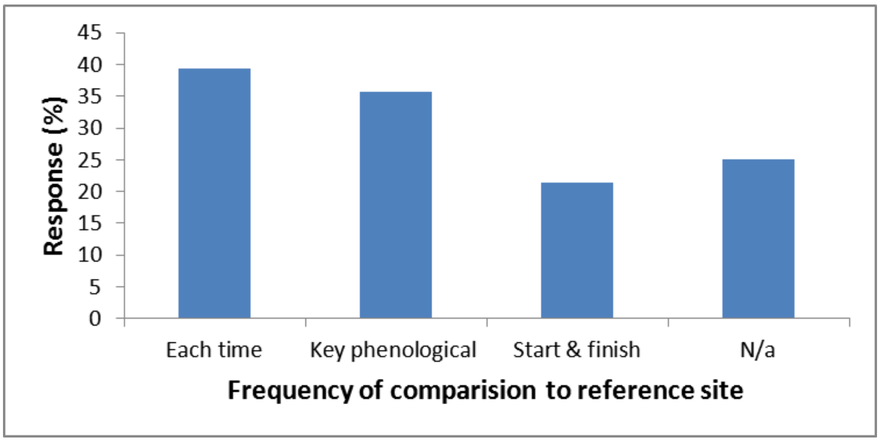

Figure 1. Frequency of comparisons of the transplant and donor sites – percentage of responses from the *Flora translocation survey* (2013).

5.3 Other monitoring variables

In addition to questions on monitoring duration, survey respondents were asked to rank several important monitoring factors that enable assessment of the success or failure of translocations. Respondents could nominate one of the following: *Unimportant, Not important, Important Very important; N/a*. The list is by no means complete but it provides a list of non-life cycle monitoring variables that may be useful for prioritization if resources are limited.

Table 4. Additional monitoring variables, rated by respondents of the *Flora translocation survey* (2013)

	Average rating
Make detailed notes of what went wrong	3.89
Competition from weeds and / or other natives	3.61
Disturbance(s) within the planting site (e.g. fire, storm damage)	3.46
Physical identification markers at the site are intact	3.43
Damage from disease / pathogens	3.43
Herbivory (leaf damage from both insects and grazers)	3.36
Keep the monitoring data in more than one format (e.g. enter digitally and keep hand-written notes)	3.32
Evidence that that translocated species may have facilitated the establishment or altered the trajectory of other species	3.21
Disturbance(s) in close proximity to the planting site	3.19
Weather conditions at the recipient site	3.11
The level of genetic variation of the translocated population compared to the source population	2.81

From the list of factors provided (Table 4), respondents believe that making detailed notes of what went wrong is the most important thing to monitor. Presumably, analysis of the detailed notes and its subsequent circulation would enable lessons to be learnt from past mistakes. As an example, a couple of comments referred to plants being trampled, particularly during monitoring visits. It was suggested that stepping stones or branches be positioned (at an early stage) to minimise damage to plants (and possible recruits) from multiple visits and from visitors to the site.

Comments throughout the survey also reinforced the importance of monitoring competition from weeds and /or other natives. The accumulation of biomass other than the transplanted species (particularly in grassland) was seen as detrimental to the ease of finding the location of transplants and their offspring. A regime of ecological burning was suggested as an action to help with the monitoring process and in some cases to provide a disturbance necessary for regeneration.

One useful suggestion for keeping the monitoring data in more than one format is to email the data. Presumably this suggestion refers to data obtained whilst still in the field. This action of course, relies on the availability of Wi-Fi connections.

Although taking *weather conditions at the recipient site* ranked relatively lowly, it was commented that it can be easily achieved by approximating data from the nearest BOM automated weather station. The usefulness of this data depends on the existence of micro-climates at the site but nonetheless, it gives an idea of trends across time.

Genetic considerations were poorly ranked. Comments accompanying the monitoring section of the survey shed some light on why genetic considerations ranked relatively poorly. Organizations often don't have the resources to investigate genetic factors and it is 'expensive and time consuming'. Even organizations with laboratories have found that one-off genetic testing is not done unless it is a large study. One respondent opined that the genetic comparison between the source and recipient sites is only important if large losses occur and it is known they have occurred from specific clonal lines or parent plants. The method suggested to obtain this information is to ensure that record keeping and tagging is of high standard. The importance of effective tagging and detailed site maps (including safe and secure GPS data) was also raised elsewhere in the survey as a means of effective monitoring via easy location of transplants and their recruits.

5.4 Suggestions for simple, cost effective monitoring of flora translocations

Respondent's suggestions of other ways to monitor translocations more efficiently centred around four main themes:

(1) Management

Strategic leadership, coordination and support for and with practitioners by senior federal and state ecological experts, was identified as a means to achieve a more effective approach to all aspects of translocations. In particular, co-ordination of translocations of threatened flora with similar biology and ecology was identified as a means to stop on-ground regional practitioners operating in isolation (and hence inefficiently). It was noted that projects can be highly dependent on motivated and interested OEH/NPWS staff and it was implied that turnover of staff is detrimental to project success.

(2) Circulation of reports and data

The importance of circulating all reporting aspects of translocations was evident in the survey. Public access to reports (both successes and failures) and data was seen as a viable way to enable learning. Where to publish to enable maximum coverage was not well defined but more detail is given in a separate document (Appendix 1) which lists publication details of many of the translocation projects that were used as case studies for this survey. More consultation within the 'translocation' community on the subject of where data and reports can be safely stored and easily circulated appears to be warranted. One respondent commented 'OEH were provided with reports and follow up monitoring reports, but from experience these can rarely be found'.

(3) Knowledge of the focal species

Detailed knowledge of biological and ecological data of the transplanted species was identified as very important to the success of the project. Detailed knowledge was identified as a means to facilitate more effective monitoring programs in the following ways:

- Context-specific monitoring sheets / programmes can be formulated.
- The duration of recruitment monitoring can be fine-tuned e.g. 'plant is long-lived (>100 years) and recruitment is sporadic' and seed bank knowledge e.g. seed may be stored in the ground and not germinate for some years.
- Success criteria can be more realistic.
- Along the lines of the previous comment, and mentioned indirectly in the survey, detailed species knowledge allows the correct 'state variable' to be monitored (Lindenmayer *et al.,* 2013). Two examples from the survey were given: 'If you are aiming for ecological replacement you should be measuring the function that you are trying to affect rather than the population of the

translocated species (you may want to do both)'. Another example given was where the aim of the project was the recombination of genets to facilitate pollen (and gene) flow to maximise the potential for fertile seed production. Therefore, the production of fertile seeds from recombination is the monitoring target.

(1) Volunteers

The use of volunteers was highlighted by several respondents as an area where project costs, including monitoring, can be reduced. The use of citizen science (where the general public participate in scientific research) is increasingly being recommended to aid in the collection of high quality empirical data (Vallee *et al.* , 2004; Willis *et al.,* 2009; Lindenmayer *et al.,* 2013). To test the practicality of this recommendation, survey respondents were asked their opinion on how effective volunteers could be in long-term monitoring (assuming appropriate motivation, training and supervision of volunteers). Respondents thought that volunteers would be most effective in increasing the awareness of the project, leading to better conservation outcomes (Figure 2).

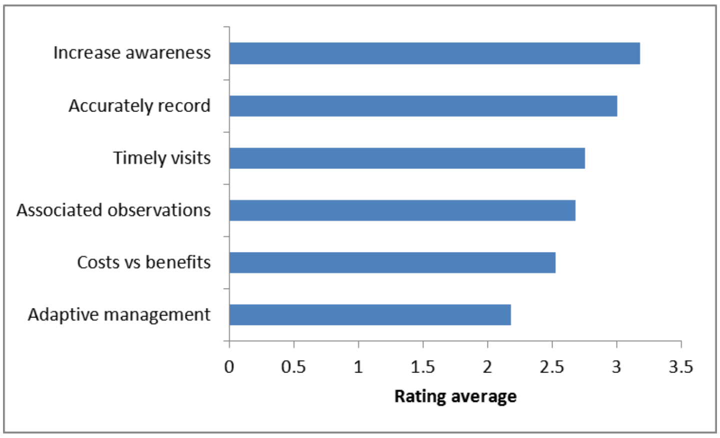

Figure 2. Effectiveness of using volunteers in long-term monitoring of flora translocation projects

Where the use of volunteers was thought to be problematic, was their inability to suggest where adaptive management is needed and their incapacity to make other associated observations than those on the monitoring sheet (examples given were: the presence of pollinator species and visitations; possible new threat processes; other ecological interactions). Failure to make these monitoring observations has serious consequences. Biodiversity monitoring programs that do not include trigger points that activate management actions when populations are declining, are thought to contribute to extinctions at a scale ranging from local through to global (Lindenmayer *et al.,* 2013).

The question of how effective volunteers can be in monitoring elicited many additional comments from respondents. Generally, the experience of those using volunteers has been good and the question of the cost of training compared to the benefit received produced many salient points. It was highlighted that volunteers need good training and preferably a paid worker should also be present at the site. Training must include protocols on the avoidance of the spread of pathogens and damage to plants and other experimental variables. Training may be expensive so care needs to be exercised when selecting and accepting volunteers to undertake project work. In addition, it is important to identify appropriate existing registration and insurance cover schemes that can take new volunteer groups under their umbrella, to avoid the difficulties of taking out a new policy and being a disincentive for particular projects. The goal is for highly trained and committed volunteers that develop into a long term monitoring resource. It was suggested that the Australian Network for Plant Conservation (ANPC) could train volunteers e.g. 1-2 day workshop in monitoring threatened flora. Outsourced training would alleviate the time constraint problems of government employees.

Volunteers should be engaged with the project to make the exercise worthwhile for all concerned. One respondent said that given some ownership of the site, volunteers have a greater capacity for undertaking monitoring and longer-term commitments to a project than some government agencies. This was especially the case where the tenure of the volunteer outlasts that of a ‘transient’ paid professional. To retain the enthusiasm and engagement of volunteers, it was suggested that support should extend to financial reimbursement such as fuel and other personal costs. There is perhaps a fine balancing act in giving volunteers too much ownership of a site and not enough. An example was given of a decision made by a ‘bureaucrat’ that resulted in the loss of volunteers from the system. A disagreement such as this could stem from either a bad decision from management or a volunteer disagreeing with the action.

Many volunteers currently involved in translocation projects are retired. Age of volunteers is a consideration because trips to remote sites and those longer than a couple of days may not be feasible. Retired (or any age demographic) volunteers are often not available for each field trip. If volunteers are tasked with recording data that is to be used in experimental analysis, an extra level of variability (operator error / bias) is introduced into the data. Under these circumstances, ideally the same volunteer should perform the monitoring each time.

Thirty two translocation projects (assuming that each species represents a different project) currently have an informal interest group that maintain some involvement. If citizen science / volunteering is pursued, these projects, in conjunction with existing programs such as Landcare, Bushcare and Bird atlasing, should be used as case studies to document and guide citizen science in monitoring.

A final comment from the survey on the subject of volunteers – 'Community science is a good thing. Abdicating responsibility is not'.

6. Conclusions

The purpose of this study was to investigate the possibility of formulating general flora monitoring guidelines by analysing the results of the *Flora translocation survey* (2013). Emphasis was on monitoring duration at different life-cycle events. The results from the survey found that whilst some generalities can be made on the duration of plant trait measurements, monitoring is context specific and any guidelines arising from this study need to be individually adapted to each project. However, where monitoring data is of adequate size for taxonomic groups that share the same habit, breeding system and other biological traits, it may be worthwhile pursuing general monitoring protocols with a working group of practitioners / experts. The working group may then find commonalities between 'state variables' that can improve the efficacy of monitoring, formulate a general monitoring guideline for the taxa and contribute to a centralized database. Monitoring can be done via representative sampling (for all life-cycle variables apart from survival) and the use of volunteers is recommended, albeit with adequate training and supervision.
In addition, to basic plant measurements, there are numerous other variables that should be monitored to confidently assess the success or otherwise of the

translocation project. The importance of these variables is also context dependant, particularly in regard to the focal species and the site(s), and the survey was therefore unable to find general commonalities. However, the survey results indicate that ‘what went wrong’ is one of the most important factors to record and circulate and that it is important to compare the source and transplant sites. Context specificity was clearly a problem for many survey respondents when asked to give their general views on monitoring.

SECTION 2 - Prioritisation of flora translocations

1.1 The need to prioritise

There is an acute need to be able to prioritise candidate species for translocation projects. This need is present for projects with relatively short-term goals (e.g. stabilising populations under direct threat from habitat loss) or projects with longer-term goals (e.g. providing the ability for species to adapt to changing climates by moving outside their current range – i.e. assisted colonisation). Funds available for translocation are limited, and therefore, it is important to select candidate species that have the highest likelihood of successfully established self-sustaining populations in recipient sites.

1.2 Decision tool for prioritising candidate species

Figure 3 provides a set of guiding questions, arranged in a decision-making framework, which were developed with close reference to the recommendations for prioritising flora translocations developed by the *Australian Network for Plant Conservation* (*Guidelines for the translocation of threatened plants in Australia*; Vallee *et al.*, 2004). The questions are applicable to all forms of translocation, however, where special consideration may be needed for cases of assisted colonisation for climate change adaptation additional questions have been provided. It is recommended that the use of this decision tool is conducted by referring to the relevant sections of Vallee *et al.* (2004).

Figure 3. Decision tool for prioritising candidate species for translocation

Q1. Is a translocation necessary to ensure the survival of the species? This question applies in the short-term (<10 years; e.g. acute need to translocate due to impending loss of habitat from development) or long-term (>100 years e.g. current climate envelope of species projected to shift entirely outside current range and species has traits associated with poor ability to adapt to climate change (see PART A, Section 4)).

YES ………………………………… move to Q2 if: all alternative strategies for managing the population decline of the species have already been undertaken.

NO ………………………………… identify appropriate alternative management action to translocation. Actions may include: habitat protection/rehabilitation or removal of threatening processes, or active management involving manipulations of habitat or biotic processes (see section 2.2.1 *Alternatives to translocation* in Vallee *et al*. 2004).

Q2. Is the taxonomic status of the species certain?

YES ………………………………… move to Q3 if: the taxa is an undisputed, formally described species.

NO ………………………………… clarification should be sought from experienced taxonomists or population geneticists. Uncertainty may arise if: inadequate taxonomic work has been conducted on a species complex, the taxa is a hybrid, subspecies or variant (see section 2.2.2 *Taxonomy* in Vallee *et al*. 2004).

Q3. Is the distribution of the taxon adequately understood?

YES ………………………………… move to Q4 if the following has been completed: (1) collation of all known records for the species via herbaria, museum collections or published plot-based studies; (2) targeted surveys of known distribution have been conducted to identify potential additional populations.

NO ………………………………… conduct desktop study to collate distribution records in conjunction with targeted surveys in the field (see section 2.2.3 *Distribution* in Vallee *et al*. 2004).

Q4. Are threatening processes understood?

YES ………………………………… move to Q4a if the following has been completed: a comprehensive assessment of the threats affecting all remaining populations.

NO ………………………………… conduct a pre-translocation assessment to identify key threatening processes and options for mitigation (see section 2.2.4 *Threatening processes* in Vallee *et al*. 2004).

Q4a. Can threatening processes be controlled? For many threatened species, the removal or management of threatening processes may be sufficient to ensure population stability and may lead to an increase in population size, hence negating the need for translocation. For assisted colonisation, climate change will be the primary threatening process and it is assumed that although this cannot be controlled, predictive tools can be used to assess the feasibility of this conservation strategy (see PART A, Section 4 for further details).

YES ………………………………… move to Q5 if the following has been completed: (1) active management or removal of threatening processes such as weed invasion, or reinstatement of appropriate disturbance regimes.

NO ………………………………… conduct a pre-translocation assessment to identify key threatening processes and options for mitigation (see section 2.2.4 *Threatening processes* in Vallee *et al*. 2004).

Q5. Have potential suitable recipient sites been identified?

YES ………………………………… move to Q6 if: (1) a number of potential sites with secure, long-term tenure have been identified and landholders or custodians approached for pre-approval, (2) Existing threats to the focal species has been removed or minimized and preparation (e.g. fencing) has been factored into the decision, (3) sites representative of future climate requirements

NO ………………………………… identify potential suitable sites for translocation (see section 2.2.5 *Availability of suitable recipient sites* in Vallee *et al*. 2004).

Q6. Have you considered the success of any previous translocation programs? Translocations of taxonomically or functionally similar species can help to guide the process of designing and implementing new programs.

YES ………………………………… move to Q7 if: a thorough search of the literature and resources on translocations has been conducted and, where relevant, primary reports have been sourced and used to aid in the design of the current project. (N.B. Appendix 1 of this report lists previous flora translocations conducted in Australia).

NO ………………………………… identify previous studies or reports of previous translocations for similar taxa; talk with experts (see section 2.2.8 *Success of past translocation projects* in Vallee *et al*. 2004).

Q7. Has a source of long-term financial funding been secured to complete all aspects of the translocation?

YES ………………………………… proceed with translocation if all questions in this checklist have been answered 'yes'.

NO ………………………………… identify a secure source of funding for the design, implementation and monitoring of the project (see section 2.2.9 *Resource availability and cost* in Vallee *et al*. 2004).

1.3 Practitioner and researcher opinions on pre-translocation assessments

As part of the *Flora Translocation Survey 2013* (detailed in Section 1) practitioners and researchers working on flora translocations in Australia were asked their opinion on the importance of pre-translocation requirements and prioritisation methods. Three questions were asked in this section and details of responses are given below.

Question 1: Can a translocation proceed before the following parameters are known for a taxa? (n = 43 respondents). Respondents could nominate one of the following: *Important but translocation can proceed without this information; No opinion*; *Translocation should not proceed without this information.* Responses are provided in Table 5.

Table 5. Responses (%) from survey participants regarding factors that should be known before proceeding with translocation

	Proceed (%)	No opinion (%)	Should not proceed (%)
Reason(s) for in-situ decline	27.9	2.3	69.8
Disturbance factors necessary for regeneration are known and can occur at the recipient site	39.5	0	60.5
Ecological relationships of the taxon (incl. mutualisms and dependent species)	48.8	4.7	46.5
Breeding system	53.5	4.7	41.9
Seed biology and seed storage responses	62.8	2.3	34.9
Risks of inbreeding depression and / or outbreeding depression	65.1	4.7	30.2

	Proceed (%)	No opinion (%)	Should not proceed (%)
Dispersal distance of seed and pollen	72.1	2.3	25.6
The genetic structure among populations	69.8	6.9	23.3
Population viability analysis (PVA) outcomes for source population	79.1	9.3	11.6
The genetic structure within the existing source population	83.7	0	16.3

Approximately 70% of respondents think that translocations should not proceed if the *reason(s) for the in-situ decline* of the taxa is unknown (Table 5). The second most important parameter was that disturbance factors that are necessary for regeneration are known and can occur at the recipient site. Conversely, a large majority of respondents think that knowledge of the genetic structure within the existing source population and that population viability analysis outcomes for the source population, while important, are not necessarily essential for translocations to proceed. As a summary, ecological knowledge was rated relatively more important than genetic information.

Question 2: Should a translocation proceed before the following preparatory measures have been undertaken? (n = 42 respondents).
Respondents could nominate one of the following: *Important but translocation can proceed without this information; No opinion*; *Translocation should not proceed without this information.*

Table 6. Responses (%) from survey participants regarding preparatory measures that should be undertaken before proceeding with translocation

	Proceed (%)	No opinion (%)	Should not proceed (%)
Existing threats at the recipient site(s) have been removed or minimized	7.1	0	92.9
Site-preparation requirements have been factored into the project (e.g. fencing and weed removal at the recipient site)	7.1	0	92.9
A Translocation Proposal is prepared and expertly assessed	19.1	0	81.0
The project has a clear monitoring structure to assess reasons for success / failure	23.8	0	76.2
It is determined that the translocated species will not negatively affect species at the recipient site(s) (physically or genetically)	31.0	7.1	61.9
It is reasonably assured that the recipient site will be legally protected for the foreseeable future	35.7	0	64.3
Pollinators and dispersal agents are present at the recipient site	42.9	0	57.1
The performance of the plants at the recipient site can be compared to a reference site e.g. the source population or another wild population	52.4	2.4	45.2
A trial planting/seeding has been undertaken	57.1	0	42.9
The recipient site(s) reflect environment conditions expected in the future	57.1	11.9	31.0

	Proceed (%)	No opinion (%)	Should not proceed (%)
Multiple suitable recipient sites are available	64.3	0	35.7
The translocation is set up as an experiment to test specific hypotheses (for example an experimental factor could be planting with and without fertilizer)	69.1	11.9	19.1
There is public support for the translocation	73.8	11.9	14.3
Multiple source populations are available	76.2	11.9	11.9

93% of respondents nominated that translocations should not proceed unless site preparation requirements have been factored into the project (e.g. fencing and weed removal at the recipient site) and that existing threats at the recipients site(s) have been removed or minimized. Conversely, 76% of respondents think that translocations can proceed without the availability of multiple source populations, closely followed by 74% nominating that translocations can proceed without public support.

Question 3: Please rank the level or urgency of the following situations in order to prioritise for translocations approval (assuming all factors being equal). Respondents were asked to rank the level of urgency (*most urgent, urgent or least urgent*) for the following situations:

(a) The species is extinct in the wild and ex-situ material is available and can/has been propagated;

(b) Populations of the species are few, small and declining;

(c) The species' population(s) are currently stable but has a high risk of extinction without human intervention;

Of the three possible situations, translocations that involve populations of species that are few, small and declining were thought to be the most urgent (Figure 3). Populations that are currently stable but have a high risk of extinction without human intervention were considered to be the least urgent.

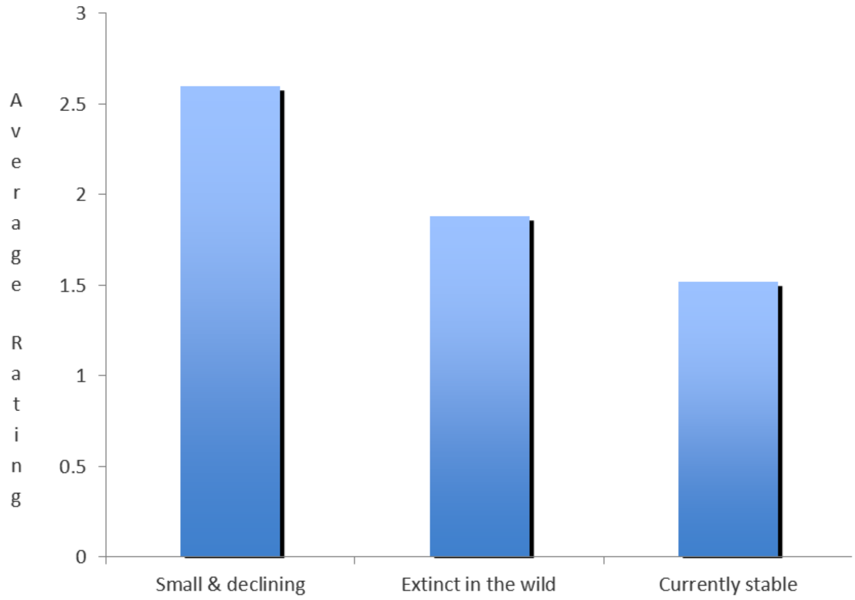

Figure 3. Level of urgency for prioritization of translocation approval

Respondents commented that their answers to this question were based on assumptions such as:

- threats are adequately controlled at the new site;
- focal species is not naturally rare in the wild;
- funding is available;
- ex-situ population can continue to be maintained;
- confident with climate predictions prior to utilizing ex-situ material;
- no ex-situ material for (b);
- acceptable systems to translocate into.

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