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REVIEW

Translocation of rare plant species to restore Garry oak ecosystems in western Canada: challenges and opportunities[1]

David R. Clements

Abstract: Covering just 2000 ha, Garry oak ecosystems (GOEs) in western Canada contain about 10% of the Species at Risk Act listed species at risk in Canada, including 30 plants listed by Committee on the Status of Endangered Wildlife in Canada as endangered. Since European settlement ca. 1840, GOE sites have been largely degraded by human disturbance, habitat fragmentation, invasive species, overgrazing, and fire suppression. A key strategy to mitigate this loss of biodiversity is to translocate rare plants to GOE restoration sites. The Garry Oak Ecosystem Recovery Team provides advice on proposed translocations but strongly encourages restoration practitioners to focus on plant populations already present on a site. There is a need for a closer look at challenges and opportunities afforded by translocation. If the approach taken is too precautionary, some rare species in this highly threatened ecosystem may be jeopardized. Current translocation efforts are being spearheaded by Parks Canada for golden paintbrush (*Castilleja levisecta* Greenm.), seaside birds-foot lotus (*Lotus formossimus* Greene), and white-top aster (*Aster curtus* Cronq.). Translocations like these together with further research on the genetics and ecology of rare plant species are critical to species recovery efforts within GOE and other similarly compromised ecosystems.

Key words: translocation, species recovery, Garry oak ecosystems, *Lomatium* sp., *Castilleja levisecta*, *Viola praemorsa* ssp. *praemorsa*.

Résumé : Étendus sur seulement 2000 ha, les écosystèmes de Garry oak (EGOs) de l'Ouest canadien contiennent 10% de la loi sur les espèces à risque liste des espèces à risque au Canada, incluant 30 plantes listées par le comité sur le statut des espèces indigènes en danger au Canada. Depuis l'établissement européen ca 1840, les EGOs ont subi une forte dégradation par des perturbations humaines, une fragmentation des habitats, des espèces envahissantes, le surpâturage, et la suppression des feux. Une stratégie déterminante pour mitiger cette perte de diversité consiste à transplanter les plantes rares sur les sites EGOs en restauration. Le groupe de sauvetage des écosystèmes de Garry Oak fournit des conseils pour les transplantations proposées, mais encourage fortement ceux qui s'occupent de restauration de mettre l'accent sur les populations de plantes déjà présentes sur le site. On doit considérer de plus près les défis et opportunités que présente la transplantation. Si on accorde trop de précaution dab cette approche, on pourrait détruire certaines espèces rares de cet écosystème menacé. Les efforts actuels de transplantation sont promus par Parc Canada pour la castilléjie dorée (*Castilla levisecta* Greenm.) et le lotier splendide (*Lotus formossimus* Greene) et l'Aster rigide (*Aster curtus* Crong.). Des transplantations comme celles-ci accompagnées de recherche sur la génétique et l'écologie des espèces végétales rares sont vitales pour les efforts de rétablissement des espèces dans les EGO et autres écosystèmes semblablement compromis. [Traduit par la Rédaction]

Mots-clés : transplantation, rétablissement des espèces, écosystèmes de Garry Oak, *Lomathium* sp., *Castilleja levisecta*, *Viola praemorsa* spp, *praemorsa*.

1. Introduction

In the 1980s, the Canadian Botanical Society drafted a set of guidelines for deliberate human-mediated movement of plants, entitled "Position Paper on Transplantation as a Means of Preservation" (CBA 1991). At that time, there was much concern that rare pants would be translocated to different habitats without due consideration for the many complex factors that would determine the success of such an operation. The following text from the position paper exemplifies the tone:

> The Canadian Botanical Association is strongly opposed to the idea that transplanting is a reliable method of conserving rare species. Ecosystem preservation is the only viable means of maintaining a full range of genetic diversity and thus removal of some elements from natural communities to other locations is not a desirable conservation alternative. Not only may transplantation fail to perpetuate species, but degradation of natural areas may be accelerated in the process.
>
> (CBA 1991).

This risk of moving plants between habitats without due process is still a serious concern, but in the ensuing decades many rare plant species have either become rarer or better studied. Consequently there is a need to re-evaluate the Canadian Botanical Association (CBA) guidelines in light of the extremely endangered status of many of these rare plants in Canada, improved knowledge of plant biology and genetics, and the experience in translocation and development of translocation guidelines in other jurisdictions throughout the world (e.g., Birkinshaw 1991; Hodder and Bullock 1997; Hogbin et al. 2000; Hufford and Mazer 2003; Vitt et al. 2010; Lawrence and Kaye 2011).

Research conducted within Canada may also provide significant new insights. Through the development of recovery plans for species at risk in Canada and the formation of recovery teams for threatened ecosystems, researchers and restoration practitioners have gained valuable experience that should aid in the development of more comprehensive processes for species recovery processes, including the possibility of translocations. One of Canada's most threatened ecosystems is the Garry oak ecosystem (GOE) in

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D.R. Clements. Department of Biology, Trinity Western University, 7600 Glover Rd., Langley, BC V2Y 1Y1, Canada.

Corresponding author: David R. Clements (e-mail: clements@twu.ca).

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western Canada (Fuchs 2001; Lea 2006). It has also become one of the best studied of Canada's ecosystems, and the potential for translocation of rare plants within this ecosystem is highlighted in a British Columbia Ministry of Environment document on translocation of rare plants in British Columbia (BC) published in 2009 (Maslovat 2009).

A trend towards increased utilization of translocations to enhance declining plant populations throughout the world is evident. About one quarter of recovery plans for federally listed plants in the US entailed some form of translocation in the 1990s (Falk et al. 1996) and the percentage is much higher at present. In both Australia and Canada, at least 70% of recovery plans for species at risk recommended translocations or reintroductions (Monks and Coates 2002; Sinclair et al. 2004). The recent focus on potential impacts of climate change on species distributions has also sparked considerable interest, debate, and research on translocation of rare species as a mitigation tool (McLachlan et al. 2007; Richardson et al. 2009; Schwartz et al. 2012). Given this present impetus to promote translocations of plant species at risk, in combination with the perceived risks, a thorough assessment of the translocation process is critical. The objectives of the present review are to (*i*) demonstrate the value of the GOE as a model system for development of plant conservation measures such as translocation, (*ii*) describe how the rarity of many GOE plant species requires urgent conservation measures, (*iii*) summarize current translocation guidelines and policies in Canada and elsewhere, and (*iv*) provide a rationale for a more concerted examination of the opportunities afforded by translocation together with requisite research on the population genetics of rare plant species.

2. Garry oak ecosystems in Canada

Garry oak ecosystems occur in coastal British Columbia in the lee of the Olympic and Vancouver Island mountains in bioregions characterized by a mild, winter-wet, summer-dry Mediterranean climate (Lea 2006, 2011). The distribution of these ecosystem types includes the eastern coast of Vancouver Island and islands with elevations ranging from sea level to 550 m above sea level on ridge tops and mountains (Lea 2011). Garry oak (*Quercus garryana* Dougl. *ex* Hook.) is the keystone species (Jordan and Vander Gugten 2012 but see also Bjorkman and Vellend 2010), but the system is also characterized by a complex suite of perennial forbs and other understory plants.

Prior to European settlement ca. 1840, GOEs covered a much larger area but now the area has been reduced to less than 10% of its former range (Lea 2006, 2011). Comparing present habitat and community structure diversity with that depicted in historical records indicates a pronounced simplification of this historically diverse structure, including displacement by invasive species such as non-native grasses (MacDougall et al. 2004). The remaining GOEs in Canada comprise 2000 ha in southwestern BC featuring close to 10% of the Species at Risk Act (SARA) listed species at risk in Canada, including 30 plants listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as endangered (Vaino 2011). The province of BC has categorized 70 GOE plant species as either red (endangered, extirpated, or threatened) or blue-listed (of special concern but not endangered, extirpated, or threatened) (Vaino 2011).

Similar GOEs also extend southward through western Washington, Oregon, and to some extent, California, and collectively these North American systems face many of the same issues such as general habitat degradation, invasive species, and climate change (Dunwiddie and Bakker 2011). There are differences in the nature of the ecosystems occurring continually through the distribution based on a variety of physiographic and historical factors. Because the Canadian distribution represents the northernmost margin of the range, many plant species particular to these systems are at the northernmost edge of their range having migrated there since the last ice age, which has implications for population genetics and conservation (Bunnell et al. 2004; Tomimatsu et al. 2009).

As outlined previously, drastic changes have occurred in both the extent and the integrity of GOE in Canada since European settlement in the 1840s. This is only the latest episode in a dynamic history of the ecosystem involving both environmental change and human intervention (MacDougall et al. 2004). From 8000–6000 years BP, forests in BC had more hardwood composition, including oaks (Lea 2011). The advent of wetter, cooler climate 5000 years ago meant Garry oaks were only able to thrive via burning by aboriginal people (MacDougall et al. 2004; Lea 2011). This burning had a pronounced effect on plant communities and their succession; Europeans arriving in Victoria in early 1840s found a landscape drastically different than seen at present (Lea 2011). Although meadows and savannahs with Garry oaks frequently occur within the Greater Victoria area today, these are interspersed with conifer forests dominated by Douglas-firs. Furthermore, the understory of GOEs tend to be dominated by non-native grasses. Historically, the frequent fires would have promoted broadleaf plants, particularly perennial geophytes such as common camas (*Camassia quamash* (Pursh) Greene), that could survive mid- or late-summer burning as underground bulbs (MacDougall et al. 2004). Fire suppression and the absence of native burning have also promoted the encroachment of Douglas-fir and other conifers (Barnhart et al. 1996; Dunwiddie et al. 2011). Another key factor following European contact was the elimination or severe reduction of many large native carnivores such as wolves and cougars, resulting in high populations of black-tail deer in many areas (Gonzales and Arcese 2008). As in the cessation of burning regimes, increased deer populations have promoted non-native grasses over native perennial species, owing to preferential grazing on the latter (Gonzales and Clements 2010).

The degradation of these unique habitats has resulted in severe declines in both populations and occurrence of numerous plant and animal species in these historically diverse communities, along with severe habitat fragmentation (Lilley and Velland 2009). Although the diversity of GOEs prior to European arrival was maintained by human intervention, through both burning and soil disturbance, to favour species of value such as *C. quamash* to the aboriginal people (MacDougall et al. 2004), conservationists generally see this historically diverse system to be the desired target for restoration (Fuchs 2001; Polster 2011). Certainly many of the species at risk are endangered because of the widespread degradation of the Garry oak habitat. However, the story is much more complex. Even the historical extent of GOEs was relatively limited, and within the general category of GOE, many different types of ecosystems are recognized, with each hosting unique plant communities due to unique physiographic and biotic factors. Thus many of the rare plant species were likely never very common, and the restrictive niches they occupy are difficult to replicate through restoration. To attempt to demonstrate the challenges this creates for translocation and other restoration measures, I will present a more detailed view of four particular rare species found in these systems.

3. Rare species in Garry oak ecosystems

3.1 *Lomatium dissectum* (Nutt.) Mathias & Constance var. *dissectum* (fernleaf desert parsley)

Lomatium dissectum var. *dissectum* (fernleaf desert parsley) is a long-lived perennial herb in the carrot family with a distinctive umbel comprised of purplish-flowers (Thompson 1998). It possesses a thick taproot and is estimated to have a life span of about 10 years (Thompson 1998). However, the plant is very vulnerable to grazing. For example, on Salt Spring Island, BC, there is only one known occurrence of a small population on a ledge protected from grazing (R. Annschild, personal communication).

As of 2007 there were only 13 known occurrences of *L. dissectum* in Canada with 3–300 individuals in each population (GOERT 2007). Some of these populations are extremely vulnerable, e.g., as of 2007, there was a population in Victoria found in a heavily used urban park numbering only five individuals (GOERT 2007).

3.2 *Lomatium grayi* J.M. Coult. & Rose (Gray's desert parsley)

Gray's desert parsley is a perennial with a life span of 5–7 years (GOERT 2011*c*). In growth form it appears somewhat similar to *L. dissectum* but possesses yellow flowers and broader fruits. *Lomatium grayi* tends to occur primarily in remote cliff areas. Canadian populations are only confirmed for the following two islands: Salt Spring Island and Galiano Island, with a total Canadian population of 2166 plants. These British Columbian populations are 250 km away from the nearest extant population in Washington (GOERT 2011*c*). Because of this extreme isolation, there may be genetic issues threatening the long-term viability of the Canadian populations (COSEWIC 2008).

3.3 *Castilleja levisecta* Greenm. (golden paintbrush)

Castilleja levisecta is congeneric with other Indian Figwort paintbrushes, but with yellow flowers; the plant is also distinguished by sticky-hairy foliage. It is classed as a hemi-parasite, which complicates restoration efforts because of the need to match it with appropriate plant hosts (Adler 2003; Caplow 2004). Prior to recent translocation efforts beginning in 2002, there were only two locations for *C. levisecta* verified in Canada and nine in Washington State (Godt et al. 2005). The two Canadian locations were on small islands (Alpha Islet and Trial Island). The largest extant population covers 12 ha at "Rocky Prairie" in Washington and consists of more than 5000 flowering individuals (Godt et al. 2005). The species was extirpated from Vancouver Island and Oregon (Douglas and Ryan 1999; Godt et al. 2005). Godt et al. (2005) found that despite the relatively small size of extant populations of *C. levisecta*, genetic diversity was reasonably high.

3.4 *Viola praemorsa* ssp. Dougl. *ex* Lindl. *praemorsa* (yellow montane violet)

Viola praemorsa ssp. *praemorsa* is distinguished from other violets by solitary yellow blooms with five petals and distinctive lance-shaped elongate hairy leaves (GOERT 2011*a*). Six of the 14 remaining populations in Canada are very small (<50 individuals) and vulnerable (GOERT 2011*a*). A precipitous decline in the abundance of *V. praemorsa* spp. *praemorsa* was seen from 1960 to 1990 and has been attributed to habitat loss and invasion of woody shrubs such as Scotch broom (*Cytisus scoparius* (L.) Link) (GOERT 2011*a*).

3.5 Summary of threats to the four example species

Both of the rare *Lomatium* species are ephemeral vernal species blooming in May and the aboveground parts die off after seeds mature in June. The vulnerability of *L. dissectum* to predation or herbivory is well documented. For example, Thompson (1998) recorded heavy grazing by pocket gophers and other mammals; 99% of seeds were consumed by mammalian and insect seed predators.

As seen in the *Lomatium* species, available habitat for successful establishment and persistence of *C. levisecta* seems limited, given its extirpation from large portions of its former range (Douglas and Ryan 1999; Godt et al. 2005). Yet, as will be discussed later, reintroductions of *C. levisecta* to habitats undergoing various levels of restoration demonstrate the potential for the overall numbers of *C. levisecta* to rebound, if sufficient resources are available for habitat restoration and translocation measures. Similarly, because the relatively significant population of *V. praemorsa* spp. *praemorsa* on Mount Tuam on Salt Spring Island was enumerated and active restoration activities were engaged several years ago, prospects for its recovery on this site appear promising (D.R. Clements, personal observation). Still, these four species illustrate the precarious position of many of the at risk plant species in GOEs and the need for proactive recovery efforts, which may in some cases include translocations to establish new populations, especially when few thriving extant populations of a species exist.

4. Existing translocation guidelines

4.1 Garry Oak Ecosystems Recovery Team

The Garry oak ecosystem recovery team (GOERT) was formed in 1999 to "coordinate efforts to protect and restore endangered Garry oak and associated ecosystems" (GOERT 2012*a*). GOERT operates as a nonprofit entity with the following Recovery Implementation Groups (RIGs): Vertebrates at Risk, Invertebrates at Risk, Plants at Risk, Conservation Planning and Site Protection, Research, Inventory Mapping and Plant Communities, and Restoration and Management. Nearly all of these RIGs have a fairly significant role to play in the regulation of how rare plants are treated, and even the recovery groups dealing with animals inevitably have a strong relationship to floral issues. Thus, since 1999, GOERT has been a significant voice in policies governing treatment of rare plants in GOEs, including the potential role of translocation.

GOERT's handbook for gardeners (GOERT 2011*b*) recommends against planting species at risk, and focusing on planting common, locally available plants consistent with GOERT's "Ethical Guidelines for the Collection and Use of Native Plants". At issue is the risk of untrained propagators mishandling rare species and moving plant species beyond the region where they are locally adapted, so even though GOERT's aim is to protect species at risk, GOERT advocates avoiding planting species at risk unless experts are involved and all precautions are taken to avoid impacting existing rare populations. The GOERT policy is thus similar to the CBA (1991) policy and recovery strategies authored by GOERT refer to the CBA document and its highly precautionary stance.

"Restoring British Columbia's Ecosystems: Principles and Practices", a 520-page GOERT document likewise refers to issues surrounding translocation of rare plants (Clements et al. 2011). For instance, Hook and Costanzo (2011) discuss plant propagation in the process of restoration and recommend that once a restoration target is generated in terms of plant community structure, a list can be generated of native species that can either be reintroduced or enhanced to meet the target. Hook and Costanzo (2011) point out that although genetic diversity is important, utilizing plant material that is distantly related to that found at the site potentially creates outbreeding depression and (or) swamping. Vaino (2011) describes permitting requirements for translocations stipulated by Environment Canada. Environment Canada (2009) requires that alternatives to translocation be considered first, and if translocation is undertaken all possible measures must be taken to minimize impacts on species and habitat. According to Vaino (2011, p. 25): "Translocations are only to be used when the long-term survival of existing populations cannot be ensured and other management options have failed. It is important that translocations never come before the protection and management of plants in situ and are not viewed as a solution to their destruction at a site".

4.2 British Columbia Ministry of Environment Guidelines

A 65-page document entitled "Guidelines for Translocation of Plant Species at Risk in British Columbia" (Maslovat 2009) was prepared for the British Columbia Ministry of Environment in consultation with GOERT and funded by the Ministry (although the document includes a proviso stating that the document represents the views of the author and not necessarily the B.C. Ministry of Environment, it is posted on the Ministry Web site under "best management practices"). This landmark review pro-

Table 1. Risks and benefits of translocation in the British Columbian context (adapted from Maslovat 2009).

Risks	Benefits
Many transplantations of species at risk have low success rates	Potential to restore the natural historical range and/or historical abundance of species that have been extirpated from some locations
Translocations can be expensive and require money to research required background information, perform the translocation, manage invasive species, conduct monitoring, etc.	Introducing or reintroducing new populations may decrease fragmentation and allow genetic exchange between populations
Translocations are labour intensive	Augmentation may alleviate the risks associated with limited genetic diversity
Translocations require regular, long-term maintenance and long-term commitment for success	Augmentation may increase dwindling populations
Translocated populations often do not maintain a full range of genetic variability	Reintroductions may help restore plant communities to their former composition
Donor populations of species at risk may be harmed by soil disturbance and by removing propagules	Translocations may increase scientific knowledge of the biology, ecology, and genetics of plants at risk through experimental trials and may help inform translocations of other plant species
Introducing or reintroducing populations with maladapted genotypes may negatively affect adjacent populations of species at risk through gene flow	Experimental translocations may help determine management options for mitigating the threats faced by extant populations of plants at risk without directly subjecting extant populations to unproven management techniques
Mixing individuals from different populations can lead to outbreeding depression and loss of fitness	
Translocations may shift the social focus away from protecting existing populations	
Recipient plant communities may be harmed by soil disturbance, introduction of diseases, trampling, alteration of ecological processes, and/or displacement of other species	

vides a comprehensive set of recommendations around translocation as well as valuable links to relevant scientific studies.

Maslovat (2009) provides a thorough list of the risks and benefits of translocation (Table 1). A key limitation for undertaking translocations is the lack of scientific research that can be drawn upon to provide appropriate protocols. This in itself serves to heighten many of the associated risks (Maslovat 2009). For example, the lack of success observed in many previous translocation efforts may be attributed to a lack of knowledge of the dynamics of the translocated rare plants in a natural, community context as opposed to growing the plants ex situ (Austin 2004; Austin and Prior 2004; Maslovat 2009). The low success rate of translocations may stem from a large number of translocations that have been attempted without adequate planning or knowledge of the species involved (Coumbe and Dopson 2001; Vallee et al. 2004; McKay et al. 2005). Birkinshaw (1991) reviewed 144 translocation attempts between 1824 and 1991 and found that only 22% were successful.

An important argument on the benefit side of the ledger is that our knowledge of rare species, plant communities, and restoration techniques has improved greatly in recent times. Maslovat (2009) points out that the translocation operations in and of themselves may provide important knowledge on the biological and ecological characters of rare plants. This may be particularly useful when plants are propagated ex situ and translocated to areas where they do not occur at present, because this permits experimentation with rare plants in their ecological context without disrupting existing at-risk plant populations.

Knowledge of the genetics of rare plant species is key to overcoming potential risks of translocation. Ideally, the assessment of such risks should be done on a case-by-case basis. Maslovat (2009) advocated generating a list of possible candidate species for translocation. Many issues around the lack of genetic diversity of rare species could be addressed by translocation, such as restoring historical species ranges, reducing fragmentation of existing populations, reducing risks of the limited genetic diversity in isolated populations, and restoring community diversity (Table 1).

5. Garry oak ecosystem translocation experience

Despite the need for precautions, planning and a large allocation of resources inherent to translocations of rare species within fragile GOEs (Maslovat 2009; Vaino 2011), a number of translocations have been undertaken within GOEs in both the US and Canada since the year 2000. As Maslovat (2009) suggests, such efforts provide researchers with opportunities to gain valuable insights regarding both propagation techniques and the biology and genetics of rare plant species. I will attempt to assess lessons learned from these attempts thus far, particularly focusing on one plant species that has been the object of considerable attention in both the US and Canada, *Castilleja levisecta*, the golden paintbrush.

5.1 *Castilleja levisecta*

The recovery plan for *C. levisecta* developed by the U.S. Fish and Wildlife Service (USWFS 2000) called for the establishment of 20 populations of at least 1000 plants in each population on protected land and the concurrent development of a reintroduction strategy (Caplow 2004). The strategy identified a number of challenges to reintroduction of *C. levisecta* throughout its former range (Caplow 2004), particularly the following: (*i*) lack of suitability of habitats, (*ii*) variable germination or establishment rates, and (*iii*) high rates of herbivory at some sites. In Oregon, where *C. levisecta* has been extirpated since 1938, there are few habitats available in its former range (Caplow 2004; Lawrence and Kaye 2006). Nevertheless, considerable success has been achieved in establishing new populations in Washington state, including Whidbey Island (Dunwiddie 2011; D.R. Clements personal observation).

On Whidbey Island, golden paintbrush was originally limited to a population on Ebey's Landing with a 5-year mean population of 4353 individuals, as recorded in 2004 (Caplow 2004). The effective population size was 1851, according to an allozyme diversity study of the 11 existing populations in the early 2000s by Godt et al. (2005). Plants from Ebey's Landing have been transplanted to several sites on Whidbey Island, in conformation to the reintroduction plan. These translocations were accompanied by numerous other restoration measures at the planting sites. For example, at Smith Prairie, a native remnant prairie managed by the Pacific Rim Institute for Environmental Stewardship, transplanted *C. levisecta* and attained a population of nearly 1400 individuals by 2011 (Dunwiddie 2011). This success was achieved only after considerable effort over nearly a decade of propagation involving numerous challenges.

The first out-planting at Smith Prairie was conducted in 2002 and fewer than 10 of the 180 original plants were still living in 2011 (Dunwiddie 2011; P. Dunwiddie, personal communication). Further out-planting was done at various locations at Pacific Rim, primarily on the remnant prairie, in 2006 (100 plants), 2007 (991 plants), and 2010 (1030 plants). Survival of out-planted plugs of *C. levisecta* varied greatly with differing microsite characteristics, but where survival levels were relatively high (e.g., more than 50% in some cases), new recruits appeared, resulting in increased populations on favourable microsites (Dunwiddie 2011). The net result was a rapidly increasing overall population at the site, showing a 10-fold increase in flowering plants in 2011 as compared to 2010, and reaching a population higher than the recovery target for the first time (Dunwiddie 2011).

Experience in this Washington reintroduction effort has shown that the best way to evaluate site suitability for *C. levisecta* is to actually conduct an out-planting, after which the following three criteria can be used to decide whether or not it is a suitable site (Dunwiddie 2011): (1) a 3-year survival rate of at least 30%–50%, (2) evident recruitment of new individuals, and (3) production of flowering stems numbering about five stems per plant and flowering of new recruits within 2 years. Site characteristics favourable to successful establishment and plant vigour include relatively deep soils, presence of suitable host plants, minimal competition from other plants (especially invasive species), and low levels of herbivory. Many of these characteristics require intensive management; for example, burning has been used as an effective tool for site preparation and management (Dunwiddie et al. 2001; Caplow 2004; Dunwiddie 2011).

Through the course of the reintroduction program in Washington state, propagation techniques have continually evolved. Originally, only wild seed was used and planted in nurseries to produce plugs for out-planting; by 2011 very little wild seed was still used, and a transition was being made from primarily using plugs to sowing seed at reintroduction sites (Dunwiddie 2011). Using plugs is more labour intensive and expensive, and there is a delay of a year as plants are grown for out-planting. Much has been learned from these reintroductions, as follows; (*i*) it seems likely that characterization of sites where remnant populations of *C. levisecta* occurred do not provide sufficient background on microsite characteristics and parasitic requirements of *C. levisecta*; and (*ii*) the newly translocated populations may well occupy much more suitable habitats than the relict populations occupied (Dunwiddie 2011). This may in turn be a positive sign that it is possible to reintroduce *C. levisecta* in regions such as Oregon where the plant has been extirpated, and research is underway to facilitate such translocations, utilizing test plantings in a common garden experiment (Lawrence and Kaye 2011).

In Canada, efforts to translocate golden paintbrush began in 2008 with a goal from the recovery strategy to establish seven new populations and continue to maintain the two existing populations (N. Kroeker, personal communication). Out-planting began in 2009 and, as in the Washington experience, results were mixed in terms of survivorship and flowering. Fertilizer was found to enhance survivorship. Avian herbivory was a major source of mortality on the Mini D'Arcy Islet where the plantings were conducted and barriers were established to enhance survival. Out of the 243 plants out-planted in 2009, survivorship by the summer of 2012 was 16% (39 of the original plants) and 28 of the original plants were flowering. In 2011, 55 additional seedlings were planted in the existing plot structure, with 11 surviving to the summer of 2012 and only one producing seeds (N. Kroeker, personal communication).

5.2 Other plant species translocated in Garry oak ecosystems in Canada

The following two GOE plant species were translocated to the Fort Rodd Hill National Historical Site in 2011 in Victoria, BC: seaside birds-foot lotus (*Lotus formossimus* Greene) and white-top aster (*Aster curtus* Cronq.) (N. Kroeker, personal communication). A translocation plan is currently being produced for coastal Scouler's catchfly *Silene scouleri* Hook. ssp. *grandis* (Eastw.) C.L. Hitch. & Maguire (N. Kroeker, personal communication). It is evident that agencies such as Parks Canada are increasingly looking to the potential of translocation for augmenting populations of threatened plant species. Great strides have been made in understanding many of the species at risk through activities managed by GOERT, providing for a much more systematic, scientific approach than would have been possible several years ago.

5.3 Reintroduction of the western bluebird

Although a precautionary approach has been taken with respect to translocation of rare plants in GOEs in Canada and a somewhat less precautionary approach in Washington state, there has been a recent reintroduction effort on both sides of the border of a vertebrate that has been taken on with a great deal of enthusiasm. The western bluebird (*Sialia mexicana*) had been extirpated in these habitats through much of its historical coastal Pacific Northwest range for close to 50 years (Altman 2011; Vaino 2011). Bluebirds were translocated to San Juan Island, Washington, primarily from an extant population in Fort Lewis, Washington, 165 km away, with 80 adults and 26 juveniles released from 2007 to 2010 (Slater and Altman 2011). By the spring of 2012, over 200 juveniles had fledged and there was an established returning population of 38, marking the first successful migratory songbird reintroduction in the US (San Juan Preservation Trust 2012). The conclusion of a study reporting on the reintroduction was that not only did the reintroduction serve to advance conservation of the western bluebird itself, but it also achieved success in educating the public on broader restoration goals (Slater and Altman 2011).

Thus, there seemed to be no concern about potential negative impacts or unintended consequences of the reintroductions, either for the bluebirds themselves or for the ecosystems. Furthermore, the Canadian jurisdiction that generally takes a more precautionary approach has also embraced the prospect of reintroducing the western bluebird to its historic range. In April of 2012, two pairs were introduced from the Fort Lewis population to the Cowichan Garry oak Preserve, under the auspices of GOERT (GOERT 2012*b*). One of the pairs remained at the site, and as in the case of the San Juan introduction there is a great deal of confidence that the reintroduction of bluebirds is good for the restoration of the system. Birds do tend to have less local distributions than plants, and there are a number of other genetic and biological distinctions, but still it seems as if this unprecedented expense and scale of translocation might set a precedent for other rare organisms in this ecosystem and other ecosystems.

6. Challenges and opportunities for translocation in Garry oak ecosystems

Most issues for translocation in GOEs arise largely from the following three factors: (1) the dire state of these ecosystems, (2) the lack of resources available to address the issues, and (3) the need for more research on both specific organisms and the ecology of the various types of communities that make up GOEs. The dire state of these ecosystems, as already discussed, is what provides much of the rationale for considering translocations, but also contributes to the risks associated with translocations conducted without adequate forethought. When some of the populations of rare plants are less than 50 individuals, as is the case for species such as *Lomatium dissectum* (GOERT 2007), *Lomatium grayi* (GOERT 2011*c*), *Viola praemorsa* var. *praemorsa* (GOERT 2011*a*), *Castilleja levisecta* (Godt et al. 2005), and others, extreme caution is required. Resources required for GOE restoration constitute a spectrum ranging from human resources (e.g., botanical expertise, volunteer labour) to funding resources for the translocation itself, the accompanying restoration efforts, or the comprehensive background research required.

Table 2. Plant translocation issues and a range of possible recommendations varying from "most conservative", whereby a very precautionary stance is taken, through moderate to "least conservative", whereby translocations are actively pursued despite potential risks.

Translocation issue	Most conservative	Moderate	Least conservative
Rationale for translocation	No alternative means to promote recovery	Part of the historic species range	To produce new populations
Maximum translocation distance?	<10 km	Within the same ecosystem type	No limit
Required genetic information	Comprehensive research on particular species	Some species-specific information	General knowledge of plant genetics
Choice of translocation species	Well-researched species which are extremely rare	Reasonably well-known uncommon species	Any rare species
Choice of translocation locations	Only well-established restoration sites	Sites where some restoration attempted	Any site supporting plant survival
Planning requirements	Comprehensive planning with a high degree of accountability	Careful planning but recognizing the need for adaptive management	Plant first, plan later

Another key factor is how the purpose for the translocation is framed. For example, if the purpose is to mitigate negative impacts of development by moving rare plants or even whole communities, this raises serious concerns about ecological viability and ethics (Fahselt 2007). Two other main purposes for translocation efforts are restoration of communities and preservation of populations of rare species. With most of the GOE sites highly degraded (Lea 2006, 2011), some of the concerns about the challenges of restoring historic communities with precision are less applicable, though the aim should still be to restore to a reference state with a relatively high composition of perennial forbs characteristic of historic GOEs (McDadi and Hebda 2008).

There is a spectrum of potential strategies to respond to the benefits and risks of translocation of rare plants, ranging from the most conservative (i.e., cautious) through to the least conservative (Table 2). Although a given restoration ecologist might tend to consistently take a particular stance (most conservative, moderate, or least conservative), it is important to consider that the benefits and risks vary greatly depending on the particular plant species and the particular context. Each translocation project should consider the unique biological factors involved, the propagation methods to be employed, the suitability of recipient habitat, and the availability of personnel to supervise not only the translocation itself but also to conduct extensive monitoring (Maslovat 2009).

6.1 Rationale for translocation

Having an appropriate rationale for translocation is crucial to the ultimate success in species recovery. Opinions vary greatly on what should trigger the decision to embark on a translocation project, ranging from only conducting translocations when no other option is available to utilizing it to create new populations simply "because we can" (Table 2). The middle position, where the rationale is to establish populations within a species historic range, becomes challenging because information on historic ranges is often lacking or the habitat is so modified that survival in historic areas is questionable (Caplow 2004; Lawrence and Kaye 2006). A new twist on the question has developed in the restoration of Hawaiian ecosystems based on plant archeological work that advocates re-establishing native plants in locations they occurred in prehistoric times, i.e., prior to the arrival of the Polynesians in 500–1000 AD (Burney and Burney 2007).

6.2 Maximum translocation distance?

A fairly conservative translocation distance has been used as an approximate guideline by GOERT in some instances (P. Arcese, personal communication). The risk being addressed is the introduction or reintroduction of a plant ecotype beyond its home range, thus compromising the population genetics of the rare species. Ideally, genetic integrity can best be preserved by planting plants from nearby sites that would be expected to have a high level of genetic similarity, and avoiding the potential outbreeding depression from interbreeding of dissimilar stock (Booth and Jones 2001; Hook and Costanzo 2011). Still, with the looming prospect of losing populations of rare species within the fragmented Garry oak landscape, it may be necessary to perform translocations over a much greater scale than a few kilometres. GOEs have been divided into various community types (e.g., "Restoration Ecosystem Units" utilized in Clements et al. 2011), so it is possible to match these community types to reintroduce rare species to areas where it formerly occurred and for which it might intrinsically be adapted. Compared to more mobile organisms such as bluebirds, most plants have much more limited dispersal capabilities, so it is important to consider translocation distance for plants carefully, although it is important to assess the translocation of each species individually given that population genetic characteristics are species-specific.

6.3 Required genetic information

The lack of work on the characterization of the population genetics of rare plant species has been an impediment to restoration efforts, recently, however, fairly comprehensive studies have been done on particular GOE plant species (e.g., Godt et al. 2005; Tomimatsu et al. 2009). For translocation to be successful, the genetic structure of the translocated population should be resistant to demographic collapse and incorporate enough genetic variation to cope with dynamic changes in the new habitat (Vallee et al. 2004). Population genetic characteristics vary greatly among different species and the question becomes how much in depth knowledge of the species is needed to allow it to be translocated (Table 2). Types of studies needed to better assess rare plant genetics are listed by Maslovat (2009) as follows: common garden studies, controlled crossing experiments, molecular marker studies, and chromosome studies. She does not recommend other techniques such as reciprocal transplant studies for species at risk, for obvious reasons (Maslovat 2009).

As a general principle, small populations are more vulnerable because of lack of genetic variation (Gitzendanner and Soltis 2000; Leimu et al. 2006), so that regardless of the genetic structure of the reintroduced plant population, as a relatively small population it faces risks such as founder effects, genetic drift, and inbreeding (Maslovat 2009). In that the Canadian portion of the continuum of Garry oak communities is at the northern periphery, many Garry oak associates may also face the additional genetic challenges intrinsic to such populations on the edge of a species' range (Hamilton and Eckert 2007). More genetic information for many rare species of interest is desirable, but it is also important to ask whether there is enough time to conduct detailed studies when some species require immediate action.

Table 3. Planning and implementation process recommended for rare plant translocation (derived from Maslovat 2009).

Stage in the process	Documentation required	Personnel involved
1. Proposal development	Extensive justification and methodology	Translocation team member(s), reviewers: recovery team or other experts
2. Communication planning	Compile list of resources to support efforts	Plans by project coordinator to communicate with landowners, land managers, and others
3. Legal requirements	Necessary permits	Appropriate governing bodies and recovery team
4. Conducting the translocation		
(*a*) Site preparation soil testing, etc.	Land management plan	Personnel to conduct weeding, soil preparation
(*b*) Preparing plants	Details of the provenance, detailed phytosanitary plan	Personnel to cultivate plants, including phytosanitary measures
(*c*) Planting	Planting layout or/design	Personnel for planting and post planting care
5. Documentation	Submit to British Columbia Conservation Data Centre (or equivalent), regular reports, mapping	Translocation team member(s)
6. Post translocation monitoring	Pre translocation baseline, plant performance assessment	Data collection personnel
7. Evaluation	Short- and long-term assessment of biological and logistical factors	Translocation team member(s)

6.4 Choice of translocation species

Because there are risks and high costs associated with translocations, the choice of species to target must be carefully weighed. Maslovat (2009) provides a list of criteria for ranking species of interest as follows: endemism in BC or Canada, listed status, contribution to biodiversity, species whose populations have been diminished by habitat fragmentation, and high potential of translocation success and (or) relatively low cost of translocation. Another criterion concerns propagation methodology, as translocated plants are generally grown in a nursery prior to out-planting. As discussed for *C. levisecta*, years of research in propagation and out-planting methods may be the requisite for success. Maslovat (2009) also advocates prioritizing species that provide synergistic benefits that complement other ecosystem recovery efforts. Ultimately, ecological communities are the target of all restoration efforts and translocation projects should be part of a larger effort, thus making the choice of translocation locations critical.

6.5 Choice of translocation locations

Most types of natural ecosystems, including GOEs, are now fragmented and degraded (Lilley and Velland 2009). This fragmentation creates a potpourri of potential recipient sites, with varying levels of suitability. A systematic approach to site selection is required based on input from restoration experts (Maslovat 2009). Maslovat (2009) provides a number of critical questions to consider in such an approach.

The question of whether the species occurred historically at the site (Maslovat 2009) is not always easy to answer. Although comprehensive work is being conducted to unearth the historical ethnobotany and ecosystem dynamics of GOEs (e.g., MacDougall et al. 2004; McDadi and Hebda 2008; Tomimatsu et al. 2009), we may never know whether a rare species was ever found on a particular site. Consideration must also be made for potential impact of the translocation on the ecology of the recipient site via the planting operation itself or through negative interactions between the introduced species and the recipient community (Maslovat 2009). There is also the following fundamental question: if the habitat is suitable, why is the species of interest not there already? To answer this, a careful consideration should be made of the dispersal characteristics and other relevant attributes to further evaluate the plant's suitability for the site. Other important considerations include the capacity of the site for a large enough population and the restoration status of the recipient location.

The degraded state of most of GOE communities makes them somewhat hostile to rare plants. Such plants are generally sensitive to herbivory from ungulates, competition from non-native grasses and other means by which these communities have lost the capacity to host the assemblage of native plants that characterized pre-European community structure (MacDougall et al. 2004; Gonzales and Arcese 2008; Gonzales and Clements 2010; Vaino 2011). Initially, the best candidate sites for translocation possess communities relatively similar to historical GOEs such as small islets where grazing is absent. Alternatively, sites subject to concerted long-term restoration efforts, such as the Fort Rodd Hill National Historic Site in Victoria make good candidate habitats for translocations. If translocation efforts at these key reference sites are successful, in the future it may be prudent to broaden efforts to include other, less ideal, sites to provide more opportunities to increase plant population sizes.

6.6 Planning requirements

Much of what is developed in Maslovat (2009) is a template for adequate planning of translocation efforts. There are many complexities intrinsic to the reinserting of a puzzle piece into a landscape such as the GOE to consider. Even in its most pristine forms, the GOE is difficult to adequately characterize in terms of its community ecology with the combination of high levels of biodiversity and a history of anthropogenic influences (Maslovat 2002; MacDougall et al. 2004; Gonzales and Clements 2008; Lilley and Velland 2009). The process outlined by Maslovat (2009) is consistent with other efforts to encapsulate translocation planning, such as that developed by Kaye (2008) who has worked extensively on the US side of the Pacific Northwest ecoregion and has been involved in the translocation efforts for *C. levisecta*. The sequential planning process advocated by Kaye (2008) began with the setting of objectives, followed by seeking source material, propagating the plant material, selecting sites, preparing sites, monitoring, evaluation, and analysis, obtaining input to improve protocols, communicating with other restorationists, and maintaining the habitat and iterative translocation efforts should the initial attempt be inadequate.

Maslovat (2009) outlines a similar sequence for planning and implementing a translocation (Table 3), and provides fairly comprehensive guidelines for each stage of the process. Along with careful planning, documentation is recommended at each stage, including detailed reporting of the translocation to the British Columbia Conservation Data Centre, which follows all known populations of species at risk in the province. Involvement of the recovery team, if available for the particular species (or a group of experts if not), is also a given. Another key element advocated by Maslovat (2009) and others (e.g., Birkinshaw 1991; Monks and

Coates 2002; Vallee et al. 2004) is extensive long-term monitoring of the success of the translocation, looking at both biological success in terms of plant survival and reproduction and also the overall success in terms of logistics, economics, and community involvement.

6.7 Challenges and opportunities

It is clear that assessing translocation in any ecosystem involves balancing two "comparably unfortunate risks" (Schwartz et al. 2012, p. 734). In discussing the future prognosis for restoration of prairie-oak communities in the Pacific Northwest, Dunwiddie and Bakker (2011) ranked overall restoration strategies from most conservative to least conservative. The most conservative approach they listed was to manage the remaining habitats as "reference sites". Reintroducing species known to be extirpated from the site was seen as somewhat less conservative, followed by introducing threatened species regardless of known historical occurrence on the site. Next in the spectrum was reintroducing historical processes such as fire or native-plant harvesting. The least conservative approach was to introduce species suited for future climate scenarios. Certainly, the Canadian context at the northern limits of this system is worthy of some thought in terms of potential species shifts in response to climate change. Elsewhere, there are calls for serious consideration of translocation (otherwise referred to by other terminology such as "assisted migration" or "managed relocation") in response to climate change scenarios (McLachlan et al. 2007; Richardson et al. 2009; Schwartz et al. 2012). However, the current climate of caution in Canada regarding translocation makes it unlikely that species would be translocated unless their historical presence could be demonstrated.

The current translocation efforts underway for golden paintbrush, seaside birds-foot lotus, and white-top aster, spearheaded by Parks Canada, illustrate that efforts are being made to meet the numerous challenges intrinsic to the translocation process. Likewise, the recent western bluebird translocation efforts on both sides of the Canada–US border in the Pacific Northwest provide an example of how financial and community resources can be engaged in efforts towards recovery of extirpated populations. With numerous other extremely rare or extirpated species in GOEs in Canada, there are many other opportunities to engage in translocation activities, however, as clear from Maslovat (2009) and experience in other jurisdictions (McLachlan et al. 2007; Richardson et al. 2009; Schwartz et al. 2012), each translocation must be carefully planned and documented. Through such efforts there is a tremendous opportunity to develop the science of translocation beyond its present rudimentary state.

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