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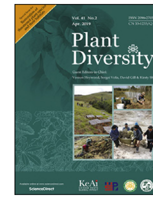

Translocation of *Otostegia bucharica*, a highly threatened narrowly distributed relict shrub

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ABSTRACT

Translocation is a recognized means of rescuing imperiled species but the evidence for the long-term success of translocations is limited. We report the successful translocation of reproductive individuals of a critically endangered shrub *Otostegia bucharica* from a site facing imminent habitat destruction into a nearby natural population of the species. The relocated plants were visited the year after planting and 13 years later to assess short- and long-term plant survival. Significant percentage of plants that survived transplanting shock and very dry spring following transplanting (around 36%), and further decrease of this number in the next 12 years by only 14%, indicated that *O. bucharica* is amenable to translocation using reproductive plants. Based on results of species distribution modeling, and failed attempts of *ex situ* cultivation, we propose introduction of this species into areas with suitable climatic and soil conditions. However, because there is currently no nature reserve in Uzbekistan having suitable conditions for the species under the present climate and that expected in the near future, and because all known habitats of *O. bucharica* are exposed to the very strong anthropogenic pressure, establishment of a new protected area, awareness building and involvement of local community in conservation activities are required to prevent extinction of this extremely rare species.

1. Introduction

Translocation is a recognized means of rescuing imperiled species by introducing them into location within their potential niche (IUCN/SSC, 2013). In the analysis of 181 Recovery Plans for endangered plant species done by Hoekstra et al. (2002), 72% of species required some form of translocation. Assessment of the translocation success requires long-term demographic monitoring of the introduced populations because true population viability can be evident only in recruitment of subsequent generations, and the latter takes time. Long-term monitoring is also important because increase in monitoring duration increases the likelihood that extreme events having impact on the population will be detected. Often true population trends can be detected only many years after translocation. For example, in *Grevillea calliantha* translocation trial 55–95% of outplants survived the first year, then the survival rate decreased to 68% after four years, and dropped to 18% after 10 years apparently as a result of drier-than-average years (Monks et al., 2012).

Currently, the evidence for the long-term success of translocations is limited (Maunder, 1992; Seddon et al., 2007; Godefroid et al., 2011; Dalrymple et al., 2012; Drayton and Primack, 2012) with the reasons for their failure in apparently suitable habitat usually unclear (e.g. Morgan, 1999; Holl and Hayes, 2006; Bottin et al., 2007; Drayton and Primack, 2012; Menges et al., 2016).

In this study, we present the results of translocation of reproductive individuals of a threatened shrub having very narrow ecological niche. Plants of *Otostegia bucharica* were rescued from a site of imminent habitat destruction, and transplanted into the nearby natural population of the species. The relocated plants were visited next year after planting and 13 years later to assess short-vs. long-term plant survival. Based on results of translocation, and species distribution modeling, we propose a conservation strategy for *O. bucharica*.

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2. Study species

O. bucharica B. Fedtsch (Lamiaceae) is an endemic to Uzbekistan shrub reaching 120–150 cm in height. The species is included in the national Red Data Book (Tojibaev, 2009b) under the category 1 (critically endangered, disappearing species), but it never has been assessed using the IUCN Red List criteria. It differs from the other *Otostegia* species by orbicular or rounded-ovate sessile leaves and flower structure (Tulaganova, 1987).

Plants flower in July–August. The fruit is a cenobium comprising four indehiscent dry nutlets (seeds). Upon maturation in September–October, fruits get easily detached from the plant and fall within a vicinity of the mother plant. Although some plants flower every year, seed production is very low (Belolipov, 1980; Tojibaev, unpublished data). Most of the produced seeds are undeveloped for unknown reasons, and a majority of the developed seeds are consumed by beetles (*Longitarsus* spp.).

O. bucharica is a Tertiary relict species with very narrow habitat requirements, represented by two small populations in Baysun mountain range that grow on gypsum outcrops and occupy the total area less than 3 km^2. One population is located in the vicinity of Shurob village (N38.21119, E66.96522), and the second is situated in the watershed of the river Machai close to Gurhoji village (N38.25733, E66.92630) (Fig. 1). The total number of plants does not exceed 4800 (Tojibaev, 2009a). Monitoring of the population located in the watershed of the river Machai revealed the 30% decrease in population size from 1977 to 2005 (from 2860 to 1974 individuals). Both known populations of *O. bucharica* have very low number of plants younger than 3 years old (Levichev, unpublished data; Tojibaev, unpublished data).

O. bucharica grows in arid climatic zone (less than 200 mm of rainfall), in specific habitat (variegated Mesozoic-Cenozoic deposits rich in gypsum and soluble mineral salts). The habitat of *O. bucharica* is exposed to the strong anthropogenic impact. Both populations, and especially the one close to Gurhoji village, are under high grazing pressure, and because of the latter flowering plants are very rare. Most of the reproductive plants are located on the steep slopes and gypsum rocks inaccessible to livestock. Unfortunately, the whole species range is outside any existing nature reserves, and the whole habitat is under serious threat.

Attempts to introduce *O. bucharica* into cultivation in botanic gardens have failed despite an intensive care and usage of the gypsum soil as a substrate (Belolipov, 1980).

Fig. 1. A view of the relocated population.

3. Species distribution modelling

We used species distribution modeling to predict the geographic distribution of suitable habitat for *O. bucharica*. For climate, we used the 19 “Bioclim” variables (Hijmans et al., 2005) summarizing temperature and precipitation dimensions of the environment. These were obtained from WorldClim 1.4 (Hijmans et al., 2005) with a resolution of 30″ latitude/longitude (ca. 1 km^2 at the ground level). For topographic variables, i.e. altitude, slope stipness and aspect, we accessed the Harmonized World Soil Database (Fischer et al., 2008). The MAXENT v3.3.3 (Phillips et al., 2006; Phillips and Dudik, 2008) was used to generate an estimate of probability of presence of the species that varies from 0 to 1, where 0 being the lowest and 1 the highest probability. In the analyses, we withheld 25% of the occurrence data for model evaluation, set number of iterations to 1000 and used ten replicates under the ‘bootstrap’ option. Model predictions in ASCII grid layer format were loaded into ArcGIS 10.2 to produce the species predicted distribution maps.

The Maxent model was then “projected” by applying it to the climatic conditions expected in year 2070 to assess the impact of climate change on *O. bucharica's* future distribution. The values for 19 climatic variables were those developed under the framework of the Coupled Model Inter-comparison Project Phase5 (CMIP5), using Representative Concentration Pathways 2.6 (RCP2.6) and 8.5 (RCP8.5) (Moss et al., 2008) and General Circulation Model CCSM4 (US National Center for Atmospheric Research). The RCP2.6 and RCP8.5 were chosen among the four existing Representative Concentration Pathways (RCP2.6, RCP4.5, RCP6, and RCP8.5) because they assume the lowest and the highest CO_2 concentrations in 2100 relative to the current CO_2 baseline of 1986–2005, i.e. predict the least and the most extreme future climate change. The produced maps of area suitability identified the suitable for the species range under the present and expected in the future climate (Fig. 3). In addition, because *O. bucharica* is edaphically specialized, growing exclusively on gypsum outcrops, we produced a map of gypsum outcrops in Uzbekistan, and overlaid it on the above projected climatic suitability range. This allowed identification of the areas suitable for the species not only climatically and topographically, but also edaphically.

4. Relocation procedure and assessment of its success

To rescue plants of *O. bucharica* from the area designated for railroad construction works, the latter were dug out on November 5th, 2005 and planted the same day within the natural population of this species near Shurob village, one km from the site of origin. All plants of manageable size (less than 1.5 m in height), 96 in total, were dug out with the soil surrounding the root as shown in Fig. 2a. Each of these plants was carried carefully by several people to, and then out of the truck as shown in Fig. 2b. Planting has been done only in sites where *O. bucharica* was naturally growing, with the distance of 2–10 m to the nearest individual of *O. bucharica* (Fig. 2c). The planted specimens were marked with a peg (Fig. 2d). Assessment of relocation success was done next year after transplanting, in June 2006, and then in 2018, thirteen years later.

Although spring of 2006 was very dry, 35 individuals of *O. bucharica*, mostly young plants, survived transplanting, and exhibited vigorous resprouting in a new location. Fifteen individuals have died. Sixteen shrubs disappeared from the transplanting plots with signs of digging, apparently being removed by local shepherds because no public awareness activities or protection measures (fencing, etc.) have been provided by the railway company which managed the translocation of *O. bucharica*. Other transplanted individuals were not found. They could have been

Fig. 2. The four steps of the relocation procedure.

washed away by the mud floods frequently occurring in that area in spring.

In the last assessment, conducted in April, 2018, 21 transplanted individuals were still alive. The surviving plants were 6–10 cm in diameter (main stem, 5–10 cm above soil level). During this visit, unknown number of cuttings ca. 10 cm long were taken from apical part of branches. These cuttings were planted in a greenhouse of Tashkent botanical garden into soil of unknown composition. Root formation was detected in some (unknown number) of these cuttings, but all cuttings subsequently died due to poor care and ignorance of the garden staff.

5. Conclusions and recommendations

O. bucharica is the top priority species for conservation in Uzbekistan. All known habitats of this plant experience strong anthropogenic pressure, the natural reproduction is very low, and number of individuals is steadily decreasing. The species requires urgent efforts to prevent its extinction, but the available options are limited. As cultivation *ex situ* in botanical garden living collections turned out to be unsuccessful, *in situ* conservation is the only alternative for this species. However, the locations of two populations are unprotected and the populations are depressed and declining. Thus the only viable option is translocation into a protected area with suitable for the species conditions. The results of SDM indicate that there is one nature reserve in Uzbekistan (Hissar NR) with suitable climatic and topographic but not edaphic conditions. Besides, the climatic conditions within the reserve will become unsuitable for *O. bucharica* in less than 100 years. This means that Hissar NR can not be used as a translocation site for this species. Thus, unless a NR is established within an area denoted on Fig. 3 with an ellipse, and *O. bucharica* is translocated there, this species is doomed to extinction.

Significant percentage of plants that survived transplanting shock and very dry spring following transplanting (around 36%) indicate that *O. bucharica* is amenable to translocation using reproductive plants. Therefore a limited number of reproductive plants of manageable size can be translocated to a suitable location

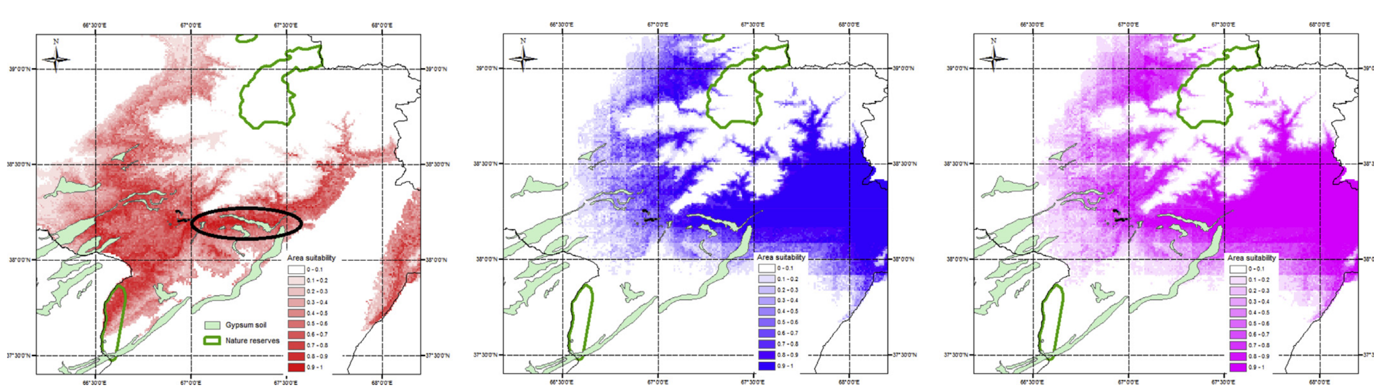

Fig. 3. The predicted suitable species range under current (left) and expected in year 2070 under RCP2.6 (middle) and RCP8.5 (right) scenarios climate. Suitability corresponds to intensity of color. Ellipsoid contour denotes the area where a new nature reserve should be established.

given care to retaining the soil around the roots of dug out plants, fencing and watering of translocated plants for some time after planting. However, the vegetative propagation by cuttings and usage of rooted cuttings for translocation is potentially a better, but not tested yet option. Although preliminary test revealed root formation in the cuttings obtained from reproductive plants' branches and grown in the greenhouse, exact time of taking cuttings, soil medium and other details of successful propagation are not known. In the future, both methods can be tried for translocation and/or restoration of *O. bucharica* populations. Establishment of a new protected area, the awareness building and involvement of local community in protection and monitoring of populations also are required for effective conservation of this extremely rare species.

Conflict of interests

Authors declare no conflict of interests.

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