Appendix F Translocation Methods and Analysis

Methods

Pilot-scale translocations of 56 Tahoe yellow cress (TYC) in 2005 and 68 TYC in 2006 demonstrated that previously outplanted TYC would survive being moved within and between sites (Stanton and Pavlik 2009). Experimental translocations in 2008 and 2009 were designed to test the null hypothesis that rates of survival and reproduction between container-grown and naturally occurring TYC would be the same after translocation. The experiments utilized a paired-design of one container-grown plant for each naturally occurring translocated plant, with 50 replicate pairs per site. For each pair, a naturally occurring plant from the donor location was translocated to the receptor location and a container-grown plant was outplanted one half meter away at the same elevation.

For the container-grown plants, all procedures for seed collection and greenhouse propagation found in Appendix B were followed. Site selection followed the same criteria. Translocation in 2008 occurred at two sites. On June 17th, 50 plants were moved with the UTE enclosure from the east end to the west end. On June 18th, translocation occurred at Edgewood Golf Course, private property in Nevada, where a total of 50 donor plants were extracted from an eroded pit on the beach adjacent to the green and moved about 150m down the beach just south of the mouth of Edgewood Creek. Lake level was 6,225.5ft LTD, the peak for the season.

The 2009 translocation occurred at four sites: the U.S Forest Service (USFS) sites at Pope, Ebright, and Nevada beaches and Upper Truckee East (UTE). At UTE and Ebright Beach the translocation was included as a treatment within the block design of the outplanting to test timing and compared against the June cohort of container-grown plants. At Pope Beach, the translocation was also included within the block design of the outplanting to test timing, but the translocation had to be conducted in May. At Nevada Beach, the experimental block contained only 50 translocants and 50 container-grown plants. Donor plants were naturally occurring and from previously outplanted cohorts. A total of 50 donor plants from the 2006 cohort at Tallac Creek were translocated directly north to the temporary enclosure at Ebright and 50 of the 2006 cohort at Pope Beach were moved about 5m away into a new fence. At UTE, naturally occurring plants present just outside of the enclosure were moved inside the enclosure and at Nevada Beach donor plants were obtained from the eroded pit at Edgewood Golf Course.

To begin the translocation at a donor site, a "sharp-shooter" shovel was inserted into the sand several centimeters away from the above-ground canopy. Care was taken to cut outside of the zone of the perceived root mass. The researcher then grasped the above ground cluster of stems and plant canopy and the root mass was slowly extracted with a rocking motion of the shovel to capture as much root structure as possible and minimize damage. Very little soil clung to the roots once exposed because of the sandy nature of the substrate. The plant and bare root mass was placed in a moist plastic bag, labeled and kept in the shade. After the last plant was extracted from the donor site, plants were immediately transported to the receptor site.

Each planting area at the receptor site was pre-watered to allow digging of a hole approximately one foot deep to accommodate the extended root mass. Each plant was carefully secured in the ground with sand before more water was applied. All plantings were hand watered for three days following the translocation. The phenology and canopy size was monitored on a monthly basis through September.

Data analysis

Canopy size and seed output were evaluated with ANOVA with a Tukey's honest significant differences post-hoc test for each cohort and for each site. For some of the subsets of data analyzed, the assumption of normality required of ANOVA was mildly violated as evidenced by examination of QQ plots. Several data transformations were explored (including square root, and log10 transformations) and model fit was slightly improved, however the benefit of transformation was marginal. Given that ANOVA is robust to such mild violations of normality, and that data transformation reduces the interpretability of results, no data transformation was used. Repeating analysis of several subsets of the data using a Kruskal-Wallis approach confirmed the results of the ANOVA.

Results

Experimental translocations conducted at two sites in 2008 and three of four sites in 2009 were successful. In September 2008, survivorship to reproduction was 80% or greater in all but the container-grown plants at Edgewood (ED; Table 1). The reason for the lower survival is unclear. The measured canopy area (and therefore estimated seed output) of reproductive container-grown TYC was identical to translocated TYC at both sites, indicating that the methods can work equally well. However, the large size of plants at Edgewood was likely a result of unintended sprinkler spray from the golf course that watered the installation later in the growing season.

Table 1. Survivorship to reproduction, mean canopy size, and mean seed output of container-grown and translocated TYC planted in June, 2008 in September, 2008.

Site	Source	Number planted	# Live	# Fruit	% Repro	Canopy (cm2)	seeds/ plant
ED	Container	48	27	27	56	436	1463
ED	Translocated	48	43	42	88	426	1458
UTE	Container	50	45	40	80	270	986
UTE	Translocated	50	48	43	86	270	1018

In the 2009 experimental translocation and outplanting, reproduction failed completely at Ebright Beach, but at Nevada Beach and UTE, container-grown TYC grew significantly larger and hence produced more seeds/plant than container-grown TYC (Table 2). Growth was identical at Pope, but plants were much smaller and produced less seed. In 2010, all of the first year survivors returned with no mortality and additional plants became reproductive. Container-grown TYC were significantly larger than translocated TYC at Nevada and UTE, but similar at Ebright and Pope.

Table 2. Mean seed output of container-grown and translocated TYC planted in June, 2009 in September of 2009 and 2010. Within in a row for each year, different letters are significantly different (ANOVA with F ratio and p value for each site, Tukey HSD).

2009 Cohort	Year 1				Year 2			
	seeds/ plant (cm2)							
Site	Translocated	N	Container	N	Translocated	N	Container	N
Ebright	0	0	0	0	116a	9	241a	19
Nevada	375a	20	961b	39	551a	23	825b	38
Pope	240a	28	244a	32	494a	38	645a	39
UTE	896a	32	1884b	42	1600a	43	2913b	47

Discussion

The null hypothesis in the test of the planting techniques of container-grown plants against translocation of naturally occurring plants is that rates of survivorship and reproduction will be the same. However the process of uprooting a naturally occurring TYC is an excavation that gradually exposes a bare root structure composed of one to many root stems and some degree of fine root network. Eventually the main root stem breaks, sometimes after only 10 cm of root have been exposed, other times after more than 50cm is visible (Stanton and Pavlik 2011). The clonal growth of the plant makes it virtually impossible to manually remove the entire root from the ground. In contrast, container-grown plants are placed in the ground with the soil from the potting tube still intact because the roots are holding it together in a conical shape. In some instances the soil tube will fall apart if there is poor root development, but in most cases one would expect that the intact soil tube in container-grown plants would help buffer from transplant shock by providing a "sponge" that holds more water than the surrounding sand substrate. The protective action of the soil-less potting mix would give container-grown plants an advantage in establishment and subsequent growth would be expected to exceed that of translocated plants.

Although total survivorship and reproduction did not vary in any definitive way between container-grown and translocated plants among the sites, two years of data from two different experimental cohorts suggests that container-grown plants perform significantly better than translocated plants, especially in optimal habitats where there is a shallow depth to water table, no competing vegetation, and a sandy substrate. The lack of significant effect of planting technique in sub-optimal habitat conditions on seed production may be masked by poor growth or it may be that lower resource availability negates any potential benefit that the soil tube might provide to container-grown plants.

The implication for mitigation and restoration seem to be that translocation is a viable option. Translocated individuals will survive if habitat conditions are good to optimal, but using container-grown stock gives a greater pay-off of increased growth and seed output. Under sub-optimal conditions the plant source might not make much difference but container-grown plants could be used in a greater numbers and therefore could insure a higher probability of success.

References

Stanton, A., and B. Pavlik. 2009. Implementation of the Conservation Strategy for Tahoe Yellow Cress (*Rorippa subumbellata*): Annual Report 2008. Prepared for the Tahoe Yellow Cress Technical Advisory Group and Executive Committee. 80 pp.

Stanton, A., and B. Pavlik. 2011. Implementation of the Conservation Strategy for Tahoe Yellow Cress (*Rorippa subumbellata*): Annual Report 2010. Prepared for the Tahoe Yellow Cress Technical Advisory Group and Executive Committee. 70 pp.