Conservation Strategy for

Tahoe yellow cress (*Rorippa subumbellata*)

Prepared by
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and the
Tahoe yellow cress
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Executive Summary

Tahoe yellow cress (TYC) is a rare member of the mustard family known only from the shores of Lake Tahoe in California and Nevada. Impacts from recreation and development led to conservation concerns as early as 1974; therefore, TYC was listed as endangered by the State of California and as critically endangered by the State of Nevada in 1982. In 1999, after a period of sustained high lake levels in which suitable habitat was inundated and the number of sites occupied by TYC declined, the U.S. Fish and Wildlife Service placed the species on the candidate list under the Endangered Species Act of 1973, as amended. In response, a multi-agency and private interest group task force was formed to develop and implement a Conservation Strategy (CS) to promote the recovery and conservation of TYC through adaptive management and cost sharing. Representatives of these entities have been meeting quarterly since 2002 as the Tahoe yellow cress Adaptive Management Working Group (AMWG), under the oversight of the Tahoe yellow cress Executive Committee (Executives).

In August 2002, the *Conservation Strategy for Tahoe yellow cress* (CS2002) was finalized, and it has guided the adaptive management and conservation of TYC for over 12 years. In January 2003, 13 entities signed a Memorandum of Understanding (MOU)/Conservation Agreement (CA), agreeing to cooperatively implement the CS on a voluntary basis, consistent with their own governing authorities and decision making processes. The 2003 MOU/CA expired on January 29, 2013, and a new MOU/CA (Appendix A) was signed on June 1, 2013, by all 13 original entities. The current MOU/CA is active for 10 years, with an expiration date of June 1, 2023, and it allows CS2002 to be modified by consensus vote of the Executives. The Executives approved revision of CS2002 in 2012 with expectations that this revised *Conservation Strategy for Tahoe yellow cress* (CS2015) will improve TYC adaptive management and continue the cooperation and conservation initiated by CS2002.

CS2015 builds upon CS2002 and represents both a synthesis and significant expansion of TYC information. In 2002, it was concluded that extirpation of TYC populations had occurred three times as often as colonization during the survey period from 1979 to 2000. The continued collection of data from lake-wide surveys has shown that the number of colonizations is now equal to or greater than extirpations and suggests the species is resilient to fluctuations in lake elevation, by either persisting or re-colonizing when conditions become favorable. A field research program conducted from 2003 to 2010 has provided further information that has increased understanding of TYC ecology and informed the habitat management and restoration actions described in CS2015. The suite of actions provide options for avoiding, minimizing, and mitigating impacts to TYC and its habitat on public and private lands. CS2015 also recognizes the critical role of private landowners in ensuring the long-term survival of TYC and presents the TYC Stewardship Program aimed at gaining landowner participation and implementing strategies that respect private property rights.

TYC management goals and objectives have been modified in CS2015 to accommodate the different management approaches required on public and private property and to reflect a shift away from promoting the metapopulation dynamic of the species and toward managing persistence. The goals are as follows:

Goal 1: Protect TYC plants and habitat on public lands

Goal 2: Promote stewardship, protection, and awareness of TYC on private lands

Goal 3: Manage TYC populations to promote persistence

Goal 4: Utilize key management questions (KMQs) to direct research that supports management and conservation

Goal 5: Continue long-term monitoring using an adaptive survey strategy

Goal 6: Utilize an adaptive management framework

At public beaches, actions that protect TYC include fences and/or enclosures, refuge areas, visitor education, and measures that reduce competition with other vegetation (Goal 1). On private sites, a stewardship approach is required to raise awareness and foster participation in the Stewardship Program. The Stewardship Program offers a suite of AMWG developed conservation practices including outplanting of container-grown TYC (Goal 2). A total of 45 TYC survey sites have been ranked to prioritize management of the most persistent, abundant, and least variable sites. The six Core sites have the highest conservation value. High-, Medium-, and Low-ranked sites have lower priority, but are important in maintaining the viability of the species. All of the Core and Highsites have a creek mouth or outflow from culverts; these sites are the most persistent and should be the first targets of management actions (Goal 3).

Knowledge gaps about TYC continue to be addressed by a key management question framework that has successfully brought new information from research into management direction (Goal 4). The lack of understanding surrounding TYC colonization (dispersal, recruitment, seedbank dynamics, rootstock longevity) and gene flow may be addressed with further research on microsatellite DNA. Continuing the adaptive survey strategy will yield more information, but will likely require new elements to evaluate impacts to TYC from recreation since threats from recreation are likely to continue to increase (Goal 5). Likewise, assessing potential impacts to TYC stems and habitat from shorezone projects requires guidelines for analysis methods, significance thresholds, and uncertainties and these needs to be incorporated into the adaptive management framework (Goal 6). Implementation of this strategy and continued commitment to the adaptive management process will allow new information to be incorporated to improve management and provide a mechanism for an unprecedented level of cooperation between regulatory agencies, resource agencies, and private entities in the Lake Tahoe basin.

1.0 Introduction

1.1 Background

Tahoe yellow cress (TYC, *Rorippa subumbellata* Roll.) is a low-growing perennial plant with small yellow flowers that occurs only on the shores of Lake Tahoe in California and Nevada. TYC is listed as endangered by the State of California (California Fish and Game Code 2050 *et seq.*) and as critically endangered by the State of Nevada (NRS 527.260 *et seq.*). The U.S. Fish and Wildlife Service (USFWS) identified TYC as a Category 1 candidate in 1980. Candidate species are plants and animals for which the USFWS has sufficient information on their biological status and threats to propose them as endangered or threatened under the Endangered Species Act of 1973, as amended (ESA), but for which development of a proposed listing regulation has been precluded by other higher priority listing activities (USFWS 2014). USFWS removed TYC from the candidate list in 1996, after a prolonged regional drought exposed large expanses of shoreline and lake-wide surveys indicated high rates of site occupancy. In 1999, after a period of sustained high lake levels in which TYC habitat was inundated and occupied sites declined, USFWS again placed TYC on the candidate list.

That same year, a multi-agency and private interest group task force was formed to respond to the potential federal listing of TYC. The *Conservation Strategy for Tahoe yellow cress* (CS2002) was finalized in 2002 and provided an adaptive management framework for conservation of the species with an emphasis on precluding the need to federally list TYC (Pavlik *et al.* 2002). Referred to in this document as CS2002, it has guided TYC adaptive management and conservation over the last 12 years.

In 2003, the following entities signed a Memorandum of Understanding (MOU) and Conservation Agreement (CA) to commit to long-term protection of TYC and cooperatively implement CS2002:

- California Department of Fish and Wildlife;
- California State Lands Commission;
- California Department of Parks and Recreation (California State Parks);
- California Tahoe Conservancy;
- League to Save Lake Tahoe;
- Nevada Division of Forestry;
- Nevada Division of State Lands;
- Nevada Division of State Parks;
- Nevada Natural Heritage Program;
- Tahoe Lakefront Owners' Association;
- Tahoe Regional Planning Agency;
- U.S. Fish and Wildlife Service; and
- U.S. Forest Service.

Representatives from these entities have been meeting quarterly since 2002 as the Tahoe yellow cress Adaptive Management Working Group (AMWG), under the oversight of the Tahoe yellow cress Executive Committee (Executives). The 2003 MOU/CA expired on January 29, 2013; a new MOU/CA was signed by these entities on June 1, 2013, and will be effective until 2023 (Appendix A). Additionally, the Executives approved revision of CS2002 with the expectations that the revised *Conservation Strategy for Tahoe yellow cress* (CS2015) will improve adaptive management and continue the cooperative commitment to protect TYC and its habitat.

TYC is one of 250 candidate species included in a lawsuit initiated by the Center for Biological Diversity and WildEarth Guardians to compel the USFWS to comply with statutory deadlines for endangered species determinations. The 2011 multidistrict litigation settlement agreement (*Center for Biological Diversity* v. *Salazar*; *WildEarth Guardians* v. *Salazar*) stipulated that USFWS will submit for publication (in the Federal Register (FR)) a proposed listing for TYC or withdraw its candidate status no later than Federal fiscal year 2016. Based on the successful conservation record of the AMWG and Executives, USFWS announced a "not warranted" 12-month finding for listing TYC and removed the species from the ESA candidate species list on October 8, 2015 (80 FR 60834).

1.2 Purpose

CS2015 builds upon CS2002 and represents both a synthesis and significant expansion of the information included therein. It is intended to supersede CS2002 and provide guidance on the adaptive management of TYC for the duration of the current MOU/CA into 2023.

CS2015 includes the following information:

- A scientific review and analysis of the species ecology, habitat, and population dynamics;
- Descriptions of current and future threats to TYC;
- Goals and objectives to coordinate conservation efforts among stakeholders to adaptively manage the species and integrate new information on the species' biology into future conservation and management activities;
- Actions for TYC management that are informed by scientific research and provide the basis for avoiding, minimizing, and mitigating the effects of human activities on TYC habitat and plants;
- Presents the TYC Stewardship Program to recognize the critical role of the private landowner in ensuring the long-term survival of TYC, to gain landowner participation, and to implement strategies that respect private property rights; and
- Summaries of the codes, policies, and laws that protect TYC.

2.0 TYC Ecology

2.1 Species description and taxonomy

Numerous collections of TYC dating back to 1891 were originally identified as spreading yellow cress (*Rorippa sinuata* (Nutt.) Hitchc.). It was not until 1941 that herbarium specimens from Meeks Bay in El Dorado County, California, were identified as the distinctive species *Rorippa subumbellata* (Rollins) associated only with Lake Tahoe (Rollins 1941). The species has remained a valid taxon ever since (Mason 1957, Munz and Keck 1959, Hickman 1993, Skinner and Pavlik 1994, Al-Shehbaz 2010, Baldwin *et al.* 2012).

TYC is a member of the mustard family (Brassicaceae), and is a low-growing, herbaceous perennial that branches profusely. These branches often appear circular in outline, giving the impression of a rosette growth form. TYC can form mats up to 3.28 feet (ft; 1 meter (m)) in diameter, although typically they are much smaller (Figure 2.1). The leaves are fleshy, generally oblong shaped, and deeply pinnately lobed. Flowers are yellow and the fruits, called siliques, are small with a plump, round shape.

Figure 2.1. The mat growth form of TYC growing in July 2004 in sandy beach habitat at the Upper Truckee River meadow in South Lake Tahoe, California.

The current treatment of the genus *Rorippa* recognizes 85 species worldwide, with 17 native to North America north of Mexico and five more introduced to the continent (Al-Shehbaz 2010). Members of the genus can be found on every continent except Antarctica, with centers of diversity in temperate North America and Europe. There is a concentration of taxa, some common and some rare, associated with the mountainous regions of the western United States (Stuckey 1972). California has nine species, one of which is introduced from Europe (*Rorippa austriaca* (Crantz) Besser; Austrian field cress) (Baldwin *et al.* 2012), while Nevada has eight species (Al-Shehbaz 2010). All are associated with open, damp, or wet habitats (springs, marshes, meadows, mudflats, playas, and the shores or banks of lakes, streams, and rivers) that are often naturally disturbed by flowing water. Anthropogenic wetlands also provide habitat, especially irrigation ditches, farm ponds, and road culverts.

A second *Rorippa* species can be found growing alongside TYC on the shores of Lake Tahoe. Western cress (*Rorippa curvisiliqua* (Hook.) Bessey ex Britton) is widespread in the western United States (Baldwin *et al.* 2012). TYC is distinguished by its plump round fruits, fleshy leaves, and a compact growth form (Figure 2.2A), while western cress is often taller, the fruits are elongated and narrow, and the leaves are less fleshy and turn purple with age (Figure 2.2B).

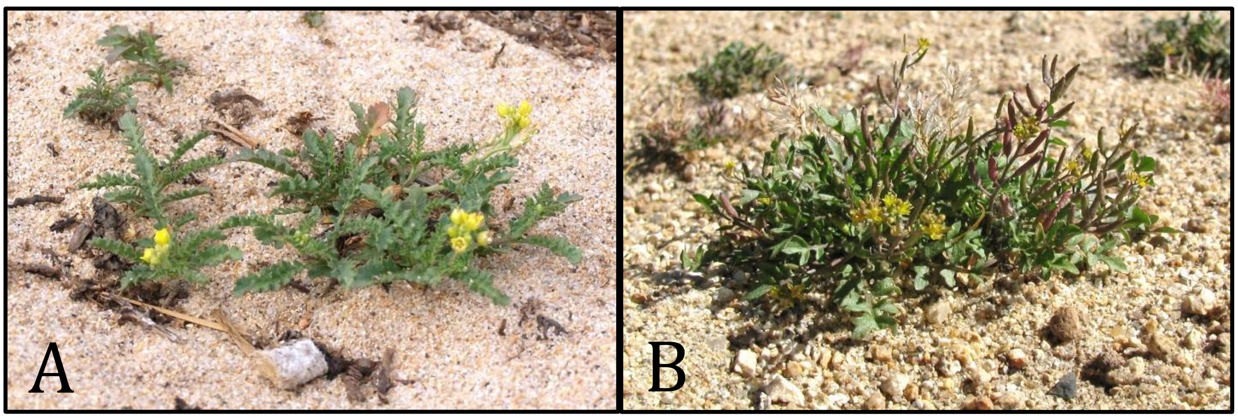

Figure 2.2. TYC (A) and western cress (B) growing in July 2007 in sandy beach habitat at the Upper Truckee River meadow in South Lake Tahoe, California.

2.2 Growth and reproduction

Unlike many rare plants, TYC is both a prolific seeder and exhibits vigorous clonal growth. Fruit and seed development are continuous during the growing season from May through October. TYC fruits are small siliques (<0.2 inch (in), 5 millimeters long), with a plump, round to oblong shape. At maturity, the silique opens (dehisces) and expels from 10 to 50 tiny dark brown seeds (Pavlik *et al.* 2002a). The fruits mature starting at the base of the stem and progress toward the tip.

A variety of generalist pollinators have been observed visiting TYC, mainly flies and bees, but there is no evidence that pollinators are required for successful seed production (Gordeev 1997). The high proportion of flowers that produce fruit suggests that the species can self-fertilize (Pavlik *et al.* 2002). In the summer, large accumulations of seed have been observed under and around TYC plants, and seeds are likely transported by both wind and water (Pavlik *et al.* 2002a; Pavlik and Stanton 2004, 2005, and 2006).

Vegetative reproduction results from a complex network of underground roots that segment and give rise to aerial stems (Figure 2.3). These stems appear on the soil surface to be individuals, but are connected below the surface by an extensive system of lateral and vertical roots (Figure 2.4). In winter, the aboveground stems of TYC die back and the rootstocks go dormant until conditions allow them to re-sprout. Rootstocks are also able to tolerate flooded conditions for an unknown period of time. The vegetative growth form makes it impossible to distinguish an independent individual of TYC, so observers in the field have long referred to the number of TYC "stems" counted as a measure of abundance rather than the number of plants (Knapp 1980a; California State Lands Commission (CSLC) 1994, 1999; Pavlik *et al.* 2002).

Figure 2.3. An excavated TYC at Taylor Creek showing the exposed root network in June 2003.

Figure 2.4. Lateral root system with vegetative ramets from a TYC plant excavated at Taylor Creek in June 2003.

TYC germination ecology has been characterized with respect to several factors: Light, temperature, stratification, storage time, and floatation in water (Ingolia 2006, 2008). Seed did not germinate in the dark, indicating a requirement for light. Species in seasonally-flooded habitats often have light requirements for germination to ensure emergence in shallow and/or clear water so that seedlings may access light for growth (Baskin and Baskin 1989). In addition, a light requirement ensures that TYC seedlings do not emerge in shady environments where there is strong competition with other plants. TYC became chlorotic (pale leaves due to lowered chlorophyll production) and etiolated when grown in 50% shade in greenhouse experiments (Ingolia 2008). The same response occurred in container-grown TYC planted near the mouth of the Upper Truckee River in California as the density of bigleaf lupine (*Lupinus polyphyllus* Lindl.) increased through the growing season (Pavlik and Stanton 2005).

Optimal germination rates in a growth chamber (approximately 70%) were achieved with a 14/10 hour light/dark cycle under the warmest temperature regime tested (24°/10°C) (Ingolia 2008). Cold stratification decreased germination rates to 50%, and the germination rate continued to decline with increasing stratification time. In greenhouse studies, seed older than 5 years have been used to successfully propagate TYC (Stanton and Pavlik 2009, 2010). Fresh seed had the highest germination rate under the warm temperature regime (24°/10°C), but the lowest rates under the colder regimes of 18°/14°C and 13°/-1°C, indicating a cold-induced dormancy (Ingolia 2008). In contrast, 3-year-old seed germinated much more readily under cold regimes (38 and 20%, respectively) while less than 10% of the fresh seed germinated. Seed dormancy and longevity are often encountered in species that support a soil seedbank (Baker 1989, Baskin and Baskin 1989). As such, TYC may support a soil seedbank.

Ingolia (2008) investigated the ability of TYC to germinate after floatation in water and found that 65–70% of seed were still floating after 1 or 4 weeks, indicating that TYC seed have a water-repellant surface, possibly similar to that found in bog yellowcress (*Rorippa palustris* (L.) Besse) (Klimesova *et al.* 2004). During floatation, 2–4% of TYC seed germinated on the surface of the water before sinking. These seedlings were still alive at the end of the flotation interval, but were not assessed further. Seed floated for 1 week and 1 month were still viable, but had low germination percentages (11 and 5%, respectively) when sown in Petri dishes. Ingolia (2008) speculated that these seed could be ecologically viable as colonizers along with seedlings transported by floatation. Further study is required to understand how hydrochory (water dispersal) may aid TYC colonization.

The prolific seeding of natural TYC was mirrored in experimental plantings of container-grown TYC in 2003 through 2006. Plants from the 2003 cohort produced an average of 352–574 seeds per plant at the three sites where canopy size was measured (Table 13, Appendix B). Together, the 2003–2006 cohorts produced over 1.5 million seeds during the monitoring period (Table 22, Appendix B). Without information on the seedbank dynamics of the species, the fate of these seeds is unknown, but such prodigious seed production suggests that the experimental plantings may have enhanced existing occurrences. However, sowing TYC seed on the beach surface was not effective in a 2004 precision seeding experiment (Pavlik and Stanton 2005). In that study, less than 2% of seed germinated.

2.3 Genetics

The National Forest Genetics Electrophoresis Laboratory first assessed genetic variation in TYC using isozyme and DNA techniques. Saich and Hipkins (2000) found that 95% of the individuals sampled shared a common genotype and discussed the possible causes of the low levels of variation including genetic bottlenecks, clonal reproduction, and a mating system displaying high rates of selfing. A subsequent study also found low levels of variation (98% of 553 samples had the same isozyme genotype), and the low levels of change in genetic structure between the two studies indicated that gene flow among TYC populations might be rare (DeWoody and Hipkins 2004). DeWoody and Hipkins (2004) emphasized the possibility of losing the limited variation through genetic drift and concluded that maintaining patterns of genetic differentiation among TYC populations may be less critical than capturing genetic variation in seed collection and *ex situ* propagation activities. A third study found evidence that at least two previously-observed alleles may have been lost to genetic drift, but that new alternate alleles were observed at four sites, indicating that gene flow was occurring (DeWoody and Hipkins 2006).

Microsatellite DNA analysis has become the preferred tool in the field of conservation genetics for questions regarding population genetic structure and source-sink dynamics because, compared to allozymes, microsatellites exhibit greater variability and afford a finer level of genetic resolution. The Lab for Ecological and Evolutionary Genetics at the University of Nevada Reno conducted microsatellite DNA analysis of TYC (Peacock and Kirchoff 2010). Primers were developed for 84 microsatellite loci and only 5 of the 84 were variable. Preliminary analyses of 243 leaf samples collected in 2006 and 2007 from 18 sites around Lake Tahoe showed low levels of variation across populations at these 5 loci which suggests that most populations are not differentiated from each other. This could be due to either low genetic variation or a small sample size that did not sufficiently capture each population's variation. Because of the clonal growth of TYC, there is no way to ensure that each leaf sample represented a distinct genetic individual. Five distinct breeding groups were identified, but there was no general pattern of isolation-by-distance (*i.e.*, populations that were further apart were not genetically dissimilar). However, small sample sizes precluded any robust conclusion for these analyses.

On the whole, these four studies suggest a low level of genetic variation across TYC populations. However, further work is required to more fully characterize genetic resources and determine TYC dispersal patterns. Study of the similarities and differences in both the number and frequencies of genetic variants per genetic marker could be used to estimate an average rate of gene flow, determine the direction of gene flow across populations, and test hypotheses about the underlying causal mechanisms of observed variation. Understanding patterns of gene flow and dispersal is important for knowing how to maintain connectivity among populations and preserve existing genetic variation.

Managing this limited genetic variation is important in restoration outplantings. DeWoody and Hipkins (2006) concluded that TYC outplanting efforts during 2003 through 2005 had captured the genetic variation observed in native populations and were successfully managing the limited genetic variation observed in this species. Seed source was generally not a predictor variable in the multivariate analysis of the factors impacting the survival, survival to reproduction, and growth of container-grown TYC planted at multiple sites around Lake Tahoe in 2003, 2004, and 2006 (Tables 6–12, Appendix B). In the three instances where seed source was a significant predictor variable (survival of the 2006 cohort (Table 7); canopy size of the 2004 cohort (Table 11); and canopy size of the 2006 cohort (Table 12)), the model fit was poor and the difference from the reference value was small. The poor predictive power of seed source in explaining outplanted TYC performance concurs with earlier data analysis. In 2003, seed sourced from Taylor Creek, Tahoe Meadows, and Upper Truckee East (UTE) were utilized to propagate container-grown TYC because they had shown genetic variation in isozyme analysis (Saich and Hipkins 2000); however, the percent survival of outplanted TYC was similar among the seed lots at three of four planted sites (Figure 8, Pavlik and Stanton 2004). In 2004, the mean survival of outplanted TYC sourced from those three seed lots plus four others at UTE and Nevada Beach was not significantly different (Figures 11–13, Pavlik and Stanton 2005). In 2006, the mean survival to reproduction of TYC sourced from UTE and Taylor Creek was nearly identical across 14 plots (Figure 10, Pavlik and Stanton 2007).

Taken together, these results indicate that seed source likely does not play a biologically-significant role in determining the success of container-grown plantings of TYC, and suggest that multiple or geographically stratified seed sources or seed transfer guidelines are not likely required for TYC restoration efforts. This runs counter to the substantial body of literature advocating caution in restoration with non-local genotypes (Falk and Holsinger 1991, Hufford and Mazer 2003, McKay *et al*. 2005), though opinions are changing regarding the use of local genotypes in restoration (*e.g.*, Broadhurst *et al.* 2008). Nonetheless, for TYC there appears to be limited genetic variation across populations (DeWoody and Hipkins 2004, 2006; Peacock and Kirchoff 2010), and outplanting efforts should utilize seed from multiple sites when possible, in order to preserve unique alleles.

2.4 TYC distribution

Knowledge of TYC distribution has been developed through systematic lake-wide surveys that have been conducted in targeted parts of the Lake Tahoe shorezone since 1979 (Knapp 1980a, CSLC 1994, Pavlik *et al.* 2002, Stanton and Pavlik 2005, 2006, 2007, 2008, 2009a, 2010). Monitoring data are available from 1979 through 2014, with no surveys conducted in 1984, 1985, 1987, 1989, 2010, or 2013 (Appendix C). Surveys prior to 2000 followed a general methodology (Knapp 1979, 1980a) and were conducted at various times during the summer (CSLC 1994, 1998, 2000). Beginning in 2001, surveys have been conducted in the first week of September and have followed a standard protocol (Appendix D). Most surveys have included stem count estimates as a measure of TYC abundance instead of the number of plants. Recreation impacts have also been noted in most surveys, but no quantitative data have been collected. Trampling is probably the most important factor that determines if TYC occupies a given location within suitable habitat, but without quantitative data it is difficult to understand how recreation influences TYC distribution. Instead, the analysis of TYC distribution presented here is based primarily on the effects of lake level, which has far less uncertainty than recreation.

During the survey period from 1979–2014, the level of Lake Tahoe (as measured at U.S. Geological Survey (USGS) gage 103370000 Tahoe City, California) has fluctuated from 6,222 ft (1,896 m) above mean sea level, Lake Tahoe Datum (LTD), to 6,228 ft (1,898 m) LTD (Figure 2.5). Since 2000, the strong cyclic pattern of sustained periods of high and low lake levels apparent through the 1980s and 1990s has been replaced by a more erratic pattern. Despite timing differences that may have occurred in the early surveys, only whole integers from the lake level in the first week of September are reported in the analyses here.

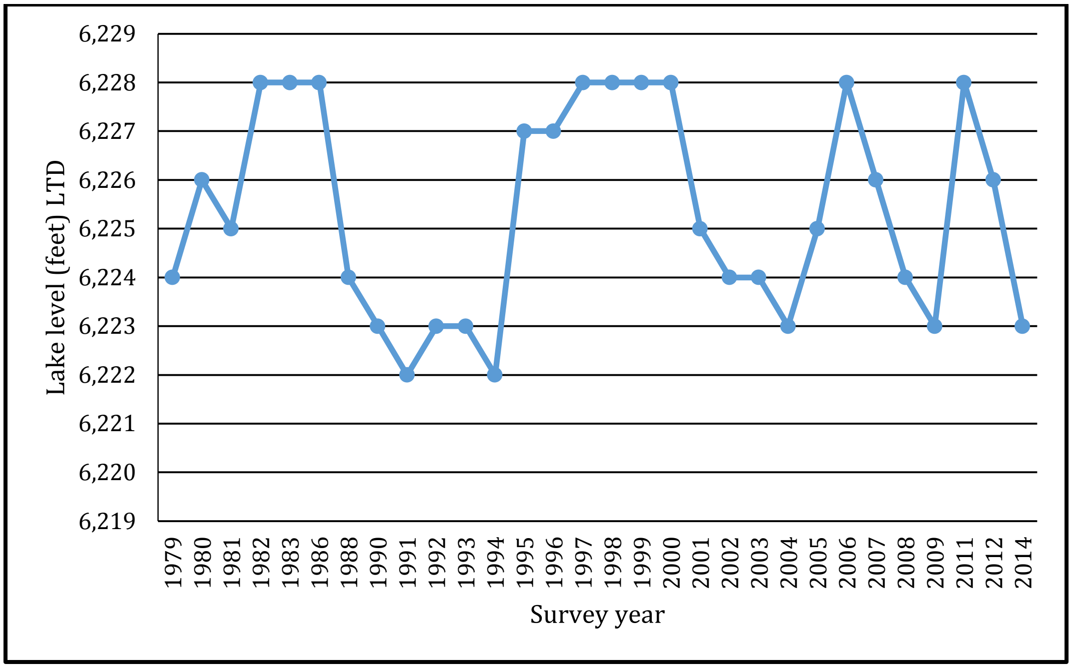

Figure 2.5. The surface elevation of Lake Tahoe in feet (Lake Tahoe Datum), as measured in September (USGS Tahoe City gage 103370000) in TYC survey years from 1979 to 2014. Surveys were not conducted in 1984, 1985, 1987, 1989, 2010, or 2013. Only whole integers were utilized for the analysis.

The natural rim of Lake Tahoe occurs at 6,223.0 ft (1,896.8 m) and the high water line at 6,229.1 ft (1,898.6 m) LTD. TYC has been found at elevations lower than the natural rim, but occurrences above the high water line are rare. With respect to TYC monitoring data from the lake-wide surveys, the level of Lake Tahoe is characterized as low (≤6,224 ft (1,897 m) LTD), in transition (6,225–6,226 ft (1,897–1,897 m) LTD), or high (6,227–6,228 ft (1,898–1,898 m) LTD).

During the first survey in 1979, 32 TYC sites were surveyed; this grew to 46 sites by the early 1990s and eventually to 55 sites (Appendix C). Figure 2.6 shows the location and type of land ownership of the TYC survey sites.

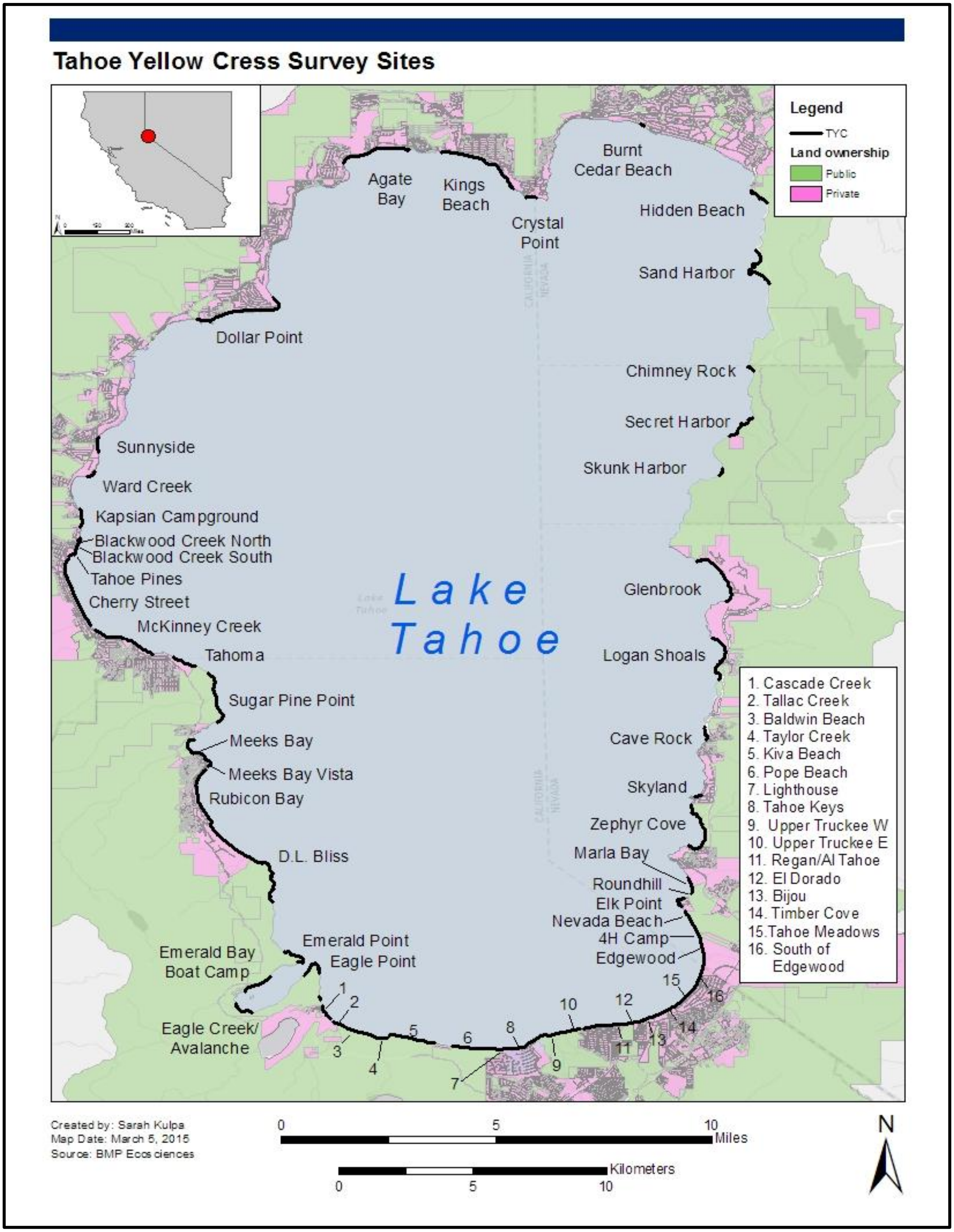

Figure 2.6. Locations of the 55 survey sites for TYC at Lake Tahoe by land ownership.

A survey "site" has been defined as a stretch of public beach, adjacent private parcels grouped by a place name or landmark, or adjacent parcels under a combination of both private and public ownership. The boundaries and names of some of the sites have shifted since CS2002 was implemented. One site was combined (Eagle Creek/Avalanche) because management is the same; three sites were spilt into two because of differences in access or management (Tahoe Keys/Lighthouse, Pope/Kiva, and Bijou/Timbercove); and six new survey sites were found (Hidden Beach (Nevada Division of State Lands (NDSL)), Sugar Pine Point (CSP), Tahoe Pines/Fleur de lac and South of Edgewood (private in California), and Marla Bay and Burnt Cedar Beach (private in Nevada). As of 2014, there are 55 survey sites, although some are now considered historic and are no longer surveyed (see Table 2.1). Each site has been surveyed between 10 and 28 times in the 36-year period from 1979 to 2014 (Appendix C).

As first described in 2002, the amount of available shorezone habitat for TYC fluctuates widely with changes in lake level (Pavlik *et al.* 2002). Large amounts of shorezone habitat are exposed at the lowest lake levels, and as Lake Tahoe rises, these areas are inundated due to the geometry of the filling basin. During the survey period (1979–2014), the percentage of occupied TYC sites (the number of occupied sites/the number of sites surveyed*100) fluctuates inversely with lake levels (Figure 2.7). TYC occupancy measures spatial variation in TYC occurrence and is synonymous with geographical frequency. This is in contrast to persistence (the number of years a site is occupied/the number of years surveyed*100), which measure temporal variation in occurrence (discussed in section 2.6).

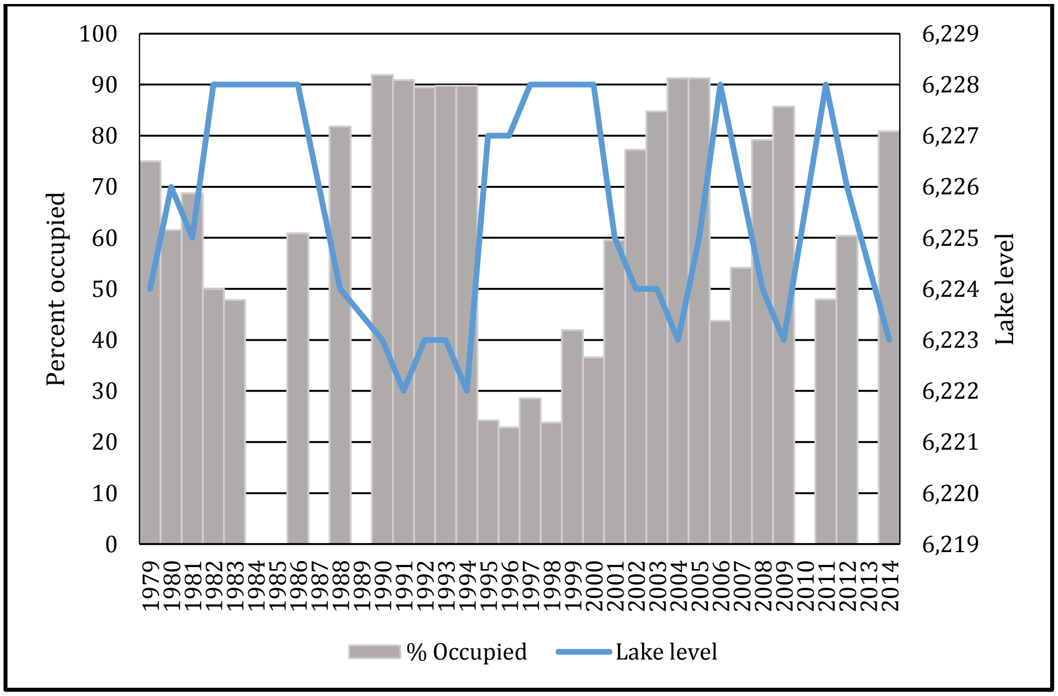

Figure 2.7. Percent occupied TYC sites surveyed from 1979 to 2014 and corresponding surface elevation of Lake Tahoe, as measured in September (USGS Tahoe City gage 103370000). 50 sites were surveyed. Six years have no survey data.

In 2002, the relationship between lake level and TYC occupancy was evaluated with linear regression (Pavlik *et al.* 2002). Here, that linear regression approach is repeated with the larger available dataset, but a more conservative non-parametric test (Spearman's rank correlation coefficient) was utilized to test the significance of the relationship between lake level and TYC occupancy (Appendix E contains the methods for the analyses of monitoring data). Over the 28 year survey period, the number of occupied TYC sites declines significantly with increasing lake levels (Figure 2.8). A perfect Spearman correlation of -1 would result if the relationship between number of occupied sites and lake level were perfectly linear, so a correlation of -0.80 ($p<0.0001$) indicates a very strong negative relationship. The line in Figure 2.8 shows an average loss of nine sites for every 2 ft rise in lake level (*i.e.*, from 41 sites at 6,222 ft to 32 sites at 6,224 ft). Analysis in 2002 detected a loss of 7 sites for every 2 ft rise, but there were only 40 sites included in that analysis, compared to the 50 sites included here (5 historical sites have been excluded from all analyses).

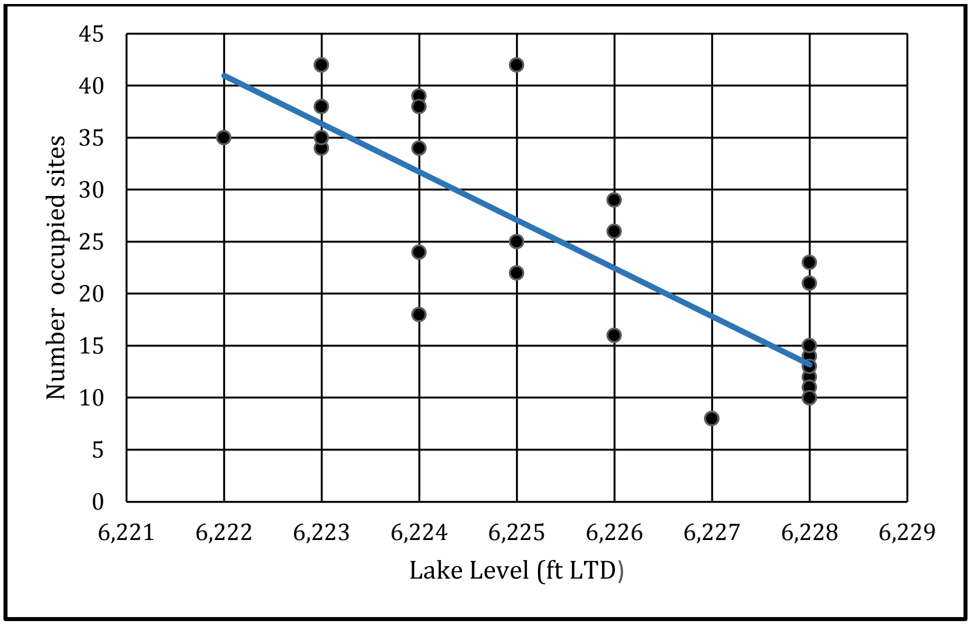

Figure 2.8. The absolute number of occupied TYC sites surveyed from 1979 to 2014 as a function of lake level, as measured in September (USGS Tahoe City gage 103370000). Spearman's rank correlation is -0.80, p<0.0001. 50 sites were surveyed. Six years have no survey data, and two years with <60% survey effort were excluded.

The proportion of occupied TYC survey sites also declines significantly with increasing lake level during the survey period (Figure 2.9) with a higher Spearman's correlation of -0.87 (p<0.0001). The slope of the line indicates that, on average, over 70% of surveyed sites will be occupied when the lake is at or below 6,225 ft (1897.4 m) LTD in September, but less than 40% will be occupied when lake level is at or above 6,228 ft (1898.3 m) LTD in September. Occupancy below 40% has not been observed since Lake Tahoe remained above 6,228 ft LTD from 1995 through 1999. The greater scatter of points at the highest level (6,228 ft) may reflect the ability of sites with a wide range of topographic diversity to retain TYC even during periods of rising lake levels.

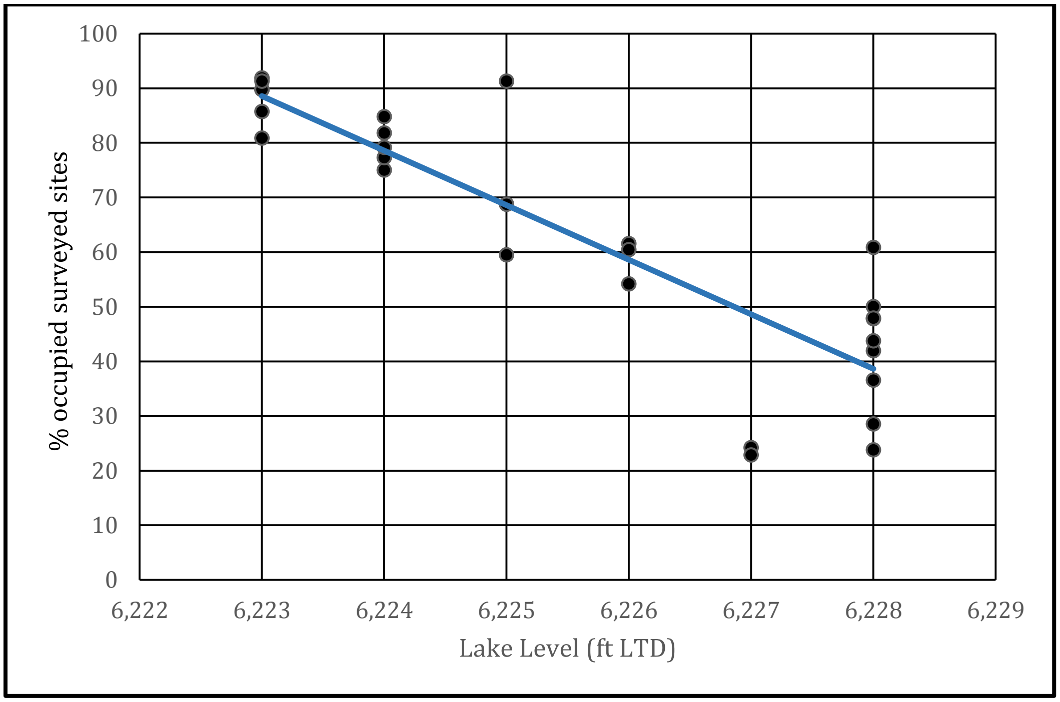

Figure 2.9. The percentage of occupied TYC sites that were surveyed from 1979 to 2014 as a function of lake level, as measured in September (USGS Tahoe City gage 103370000). Spearman's rank correlation is -0.87, p<0.0001. Six years have no survey data, and two years with <60% survey effort were excluded.

In 2002, it was suspected that land ownership might play a role in the occupancy of TYC (Pavlik *et al.* 2002). However, with additional data from subsequent surveys, the strong inverse relationship between occupancy and lake level is similar regardless of ownership (Figure 2.10). The negative correlation between occupancy and lake level is highly significant (Spearman's rank correlation is -0.74, -0.83, and -0.83 for U.S. Forest Service (USFS), state, and privately-owned sites, respectively; all at p<0.001). The strength of the relationship is slightly weaker on USFS sites (and the slope of the line is less steep), suggesting TYC occupancy is slightly less sensitive to lake level at those sites, but this could be because many USFS sites have fences installed above the high water line that support plants under all lake level conditions. For the entire survey period, the average occupancy of TYC in any given year at state-owned (59%), private (71%), or USFS sites (63%) was not significantly different (Kruskal-Wallis test, p=0.12), further indicating that ownership does not play a role in TYC occupancy.

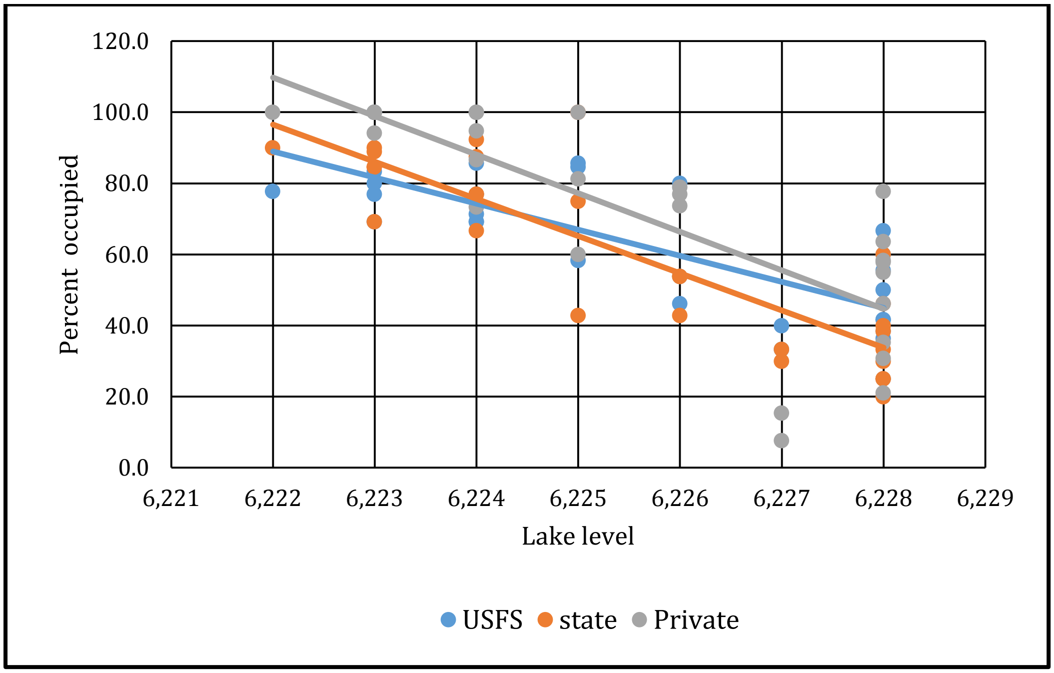

Figure 2.10. The percentage of occupied TYC sites, by ownership, that were surveyed from 1979 to 2014 as a function of lake level, as measured in September (USGS Tahoe City gage 103370000). Spearman's rank correlation is -0.74, -0.83, and -0.83 for USFS, state, and privately-owned sites, respectively; all at p<0.001. Six years have no survey data, and two years with <60% survey effort were excluded.

2.5 TYC population dynamics

A metapopulation may be described as a set of spatially separated populations of the same species that interact at some level, generally through processes of migration, colonization, gene flow, and extirpation (Hanski and Gilpin 1991, Hanski and Simberloff 1997). In 2002, it was hypothesized that TYC exhibited a metapopulation dynamic characteristic of the "mainland-island" type first described by Harrison and Hasting (1996) (Pavlik *et al.* 2002). The hypothesis was supported by an analysis of the available survey record that revealed that some TYC sites persisted—both temporally and spatially—while others seem to appear and disappear across survey events. In other words, TYC appeared to persist over time because local extirpations were countered by colonization. The survey record further suggested that mainland (or source) populations of TYC were those that could tolerate a wide range of lake levels and, therefore, had a low probability of extirpation and a high potential for creating emigrant propagules. In contrast, island (or sink) populations of TYC were transient, with a higher probability of extirpation and lower probability of creating emigrant propagules.

In 2002, the available survey record revealed 8 colonization/re-colonization and 24 extirpation events. Extirpation was defined as an absence of TYC at a site for 6 or more years, based on the assumption that TYC roots could not tolerate inundation for that long. Colonization of new sites or re-colonization of formerly-occupied sites was inferred from the record, but no direct observations of dispersal or colonization were made. It was concluded that extirpation events were about three times as common as colonization or re-colonization events.

Lake level fluctuated widely during subsequent surveys conducted from 2001 to 2014 (Figure 2.5). In post-2000 surveys, TYC was observed at 16 previously-occupied sites and at 8 sites that had not been previously surveyed (Appendix C). In addition, no TYC plants were observed at the 7 sites that were classified as extirpated in 2000, and no additional extirpations were observed. If the re-appearance of TYC at 16 previously-occupied sites and the appearance of TYC at 8 new sites resulted from the dispersal of new TYC seed or rootstock, then the total number of re-colonization (16) and colonization (8) events from 2001 to 2014 is 24, and the number of observed extirpations remained at 24. Adding in the 8 colonization events observed pre-2000, the colonization to extirpation ratio from 1979 to 2014 is 32:24, or 1.3.

A colonization to extirpation ratio greater than 1 indicates a positive dynamic and the recovery of TYC since 2001 from the sustained high lake levels from 1995 through 2000. A positive dynamic suggests that the population is increasing, but it may simply reflect that there have been more low water years since 2001, and thus more re-colonization opportunities. Lake level in the current dataset from 1979 to 2014 was low in 11 years, in transition for 6 years, and high in 11 years. In contrast, the 1979–2000 dataset was skewed toward high lake levels with 5 low; 2 transition; 9 high) (see Appendix C; some years were not surveyed or were excluded for low survey effort).

Analysis of the colonization to extirpation ratio is a critical part of evaluating the trend of a species' metapopulation dynamic, but there are inherent difficulties in observing or measuring metapopulation events in plants that have cryptic life stages of dormant rootstock and/or seedbanks (Freckleton and Watkinson 2002, 2003; Ehrlen and Eriksson 2003). For TYC, temporal analysis problems exist when plants are observed at a site that has never before been surveyed; new observations cannot strictly be considered colonization events due to a lack of prior surveys. This analysis has assumed that they are (if those 8 newly-observed sites are removed from the analysis, the colonization to extirpation ratio is 24:24). There are also spatial analysis problems resulting from the coarse scale of the survey methodology that consolidates spatially separated occurrences on many different parcels into a single occurrence or "site". Reappearance of TYC after an absence at a "site" may result from: 1) re-spouted rootstock (*e.g.*, that survived 6 years of inundation (1995–2000)); 2) recruitment from a seedbank; or 3) dispersal of new seed or rootstock. However, there is no way to know which of these processes are at work.

A light requirement for germination suggests that TYC can support a seedbank and the seed may have a water repellant surface that allows for germination after floatation in water (Ingolia 2008), but little is known about seed longevity or tolerance to inundation of seeds or roots. In 2002, it was assumed that TYC rootstock could not survive 6 years of inundation because inundated substrates would become anoxic and "there do not appear to be any specialized oxygen-transporting tissues in TYC rootstock, [so] tolerance to flooding in the species must be metabolically based and relatively limited in duration" (Pavlik *et al.* 2002). While this is likely true, it has not been tested and the lack of information about the modes of dispersal and recruitment makes it difficult to confidently measure or categorize metapopulation events.

Given the difficulty in measuring or detecting TYC colonization or extirpation events, it has not been possible to apply a metapopulation approach to management actions and define in quantitative terms what it means to "Promote conditions that favor a positive metapopulation dynamic"—CS 2002 Management Goal 3. Doing this requires the ability to identify potentially suitable habitat, an understanding of how to manage it to increase the probability of colonization, and the ability to observe colonization events. Systematic searches of suitable but unoccupied habitat have not been conducted, so our knowledge of the attributes of unoccupied sites that might be manipulated to promote colonization are lacking. In terms of central TYC conservation goals, this necessitates shifting focus from managing metapopulation dynamics to promoting site persistence (see Management Goal 3 in Section 5).

2.6 Population size and persistence

In general, the number of individuals in a population is related to its ability to respond to environmental change. Population size is one of the best predictors of the extirpation rate of isolated populations (MacArthur and Wilson 1967, Pimm *et al.* 1988). For TYC, measurement of this important biological metric—population size—is complicated by the fact that the below-ground vegetative growth of TYC makes it impossible to distinguish individual plants. Stem count has been used as a proxy, but may not correlate with the number of individuals in a population (discussed further below).

In 2002, it was hypothesized that TYC occurrences with large stem counts have a greater probability of persisting across all lake levels (Pavlik *et al.* 2002). Persistence is defined by the ability of TYC to maintain itself at a given site through time. It is calculated as the number of years TYC was present/the number of surveyed years*100. Persistence therefore measures temporal variation in occurrence.

Mean stem counts for 29 sites were analyzed for their relationship with the percentage of time they persisted (Pr) over the 1979–2000 monitoring period A logarithmic relationship emerged, where persistence increased rapidly with mean stem count, but then flattened out and slowed considerably (Figure 13 and 14 in Pavlik *et al*. 2002). The relationship was significant and stem count explained approximately 63% of the variance in persistence—a relatively strong relationship for an observational (non-manipulative) ecological field study (Gotelli and Ellison 2013). Stem counts were estimated for three probabilities of persistence, based on the logarithmic relationship and the equation derived to characterize the relationship: 1,200 stems for 90% persistence; 300 stems for 75%; and 30 stems for 50% persistence. These minimum viable population (MVP) stem counts were set as management and restoration targets in CS2002 to provide indicators of biological and project success (Pavlik 1996).

The use of regression analysis in 2002 to estimate a MVP for TYC was a novel approach. More typically, the demographic processes that determine the long-term viability of a population are projected into the future using size/stage matrix models that depend on realistic transition probabilities developed from empirical studies (Guerrant 1996). These were not available for TYC and it was acknowledged at the time that population size had not been truly assessed in TYC because of the unknown relationship between stem count and number of individuals and also that clonal growth "probably dampens changes in true population size over time" (Pavlik *et al.* 2002). The vigorous clonal growth of TYC was not fully appreciated in 2002; there is no way to determine a transition probability or assess the relationship between stem count and population size because stems may represent vegetative growth or sexual reproduction, but there is no way to make a distinction between these life stages. In addition, stem counts may result from repeated annual immigration and so do not reflect the persistence of an individual through time.

The regression analysis approach from CS2002 was repeated for the larger dataset from 1979 to 2014 for 49 sites with sufficient data (Figure 2.11) (see Appendix E for methodology). The mean stem count for UTE (4,632) was excluded as an outlier. The relationship was still significant, but indicates that stem counts explained only 39% of the variation in persistence from 1979 to 2014, compared to 63% for the smaller dataset (1979–2000). The weakening of the relationship between stem count and persistence observed in the larger dataset, along with the unknown relationship between stem count and population size, casts doubt on the validity of the MVP approach to set estimated stem counts as management targets. However, it does appear that stem counts are positively correlated with persistence when a more conservative approach than regression analysis is utilized. A Spearman's rank correlation (ρ= 0.62 ($p<0.001$) on the dataset shown in Figure 2.11 indicates a relatively strong relationship between stem count and persistence.

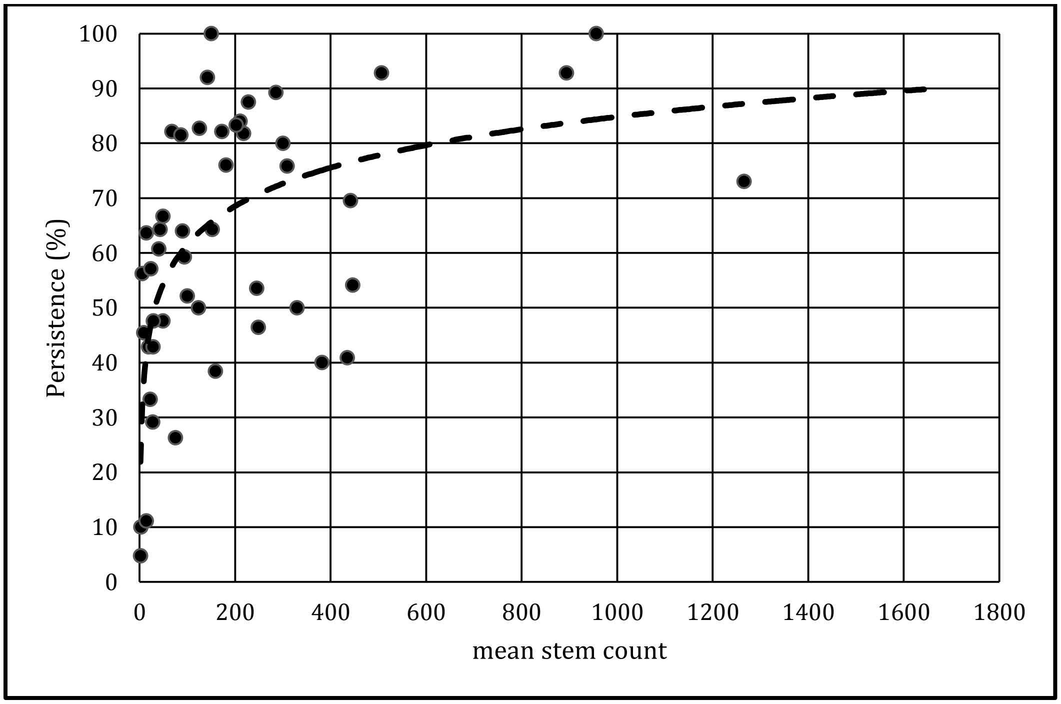

Figure 2.11. The relationship between mean stem count (for a site across the survey period) and persistence (# of years occupied/# of years surveyed*100) of 49 TYC sites surveyed from 1979 to 2014 (Upper Truckee East was excluded as an outlier). Spearman's rank correlation is -0.62, p<0.001.

The role of lake level cannot be overlooked when evaluating the relationship between stem counts and persistence because lake level so strongly controls the amount of available habitat. In 2002, the relationship between mean stem count of all occupied TYC populations for a given year and lake level was depicted as a parabola, with the highest mean stem counts observed at both low and high lake levels (Figure 12 in Pavlik *et al.* 2002). This was apparently an artifact of a limited data set that contained only 9 years of survey data with estimates of stem count available. With 23 years of data now available it appears that on average TYC populations have greater stem counts under lower lake levels (Figure 2.12). A Spearman's rank correlation (ρ= 0.69 (p<0.002) on the dataset indicates a relatively strong negative correlation between stem count and lake level.

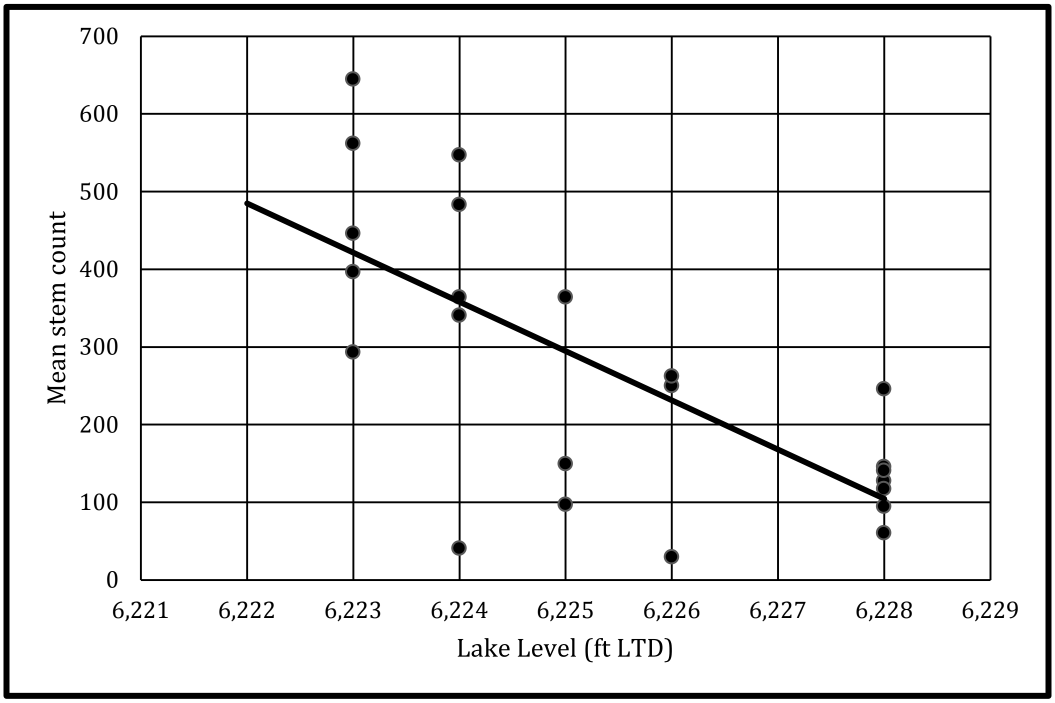

Figure 2.12. The relationship between mean stem count (of all occupied sites in each survey year) and lake level surveyed from 1979 to 2014 (Upper Truckee East was excluded as an outlier). Spearman's rank correlation is -0.69, p<0.002.

That a TYC population would have more stems when the level of Lake Tahoe is low and there is more habitat available makes intuitive sense. Likewise, it makes sense that populations with larger stem counts could be more resilient in the face of fluctuating lake levels. However, recreation patterns on the beaches probably dampen these relationships because TYC may be trampled under all lake levels. Taken together, the positive correlation between TYC stem counts and persistence and the negative correlations between lake level and site occupancy and stem counts indicate that at high lake levels (when the risk to the small number of occupied sites is greatest), those sites with the greatest degree of topographic diversity are most likely to support higher stem counts and therefore have a higher probability of persistence.

2.7 Ranking TYC populations for conservation

One of the most challenging aspects of rare plant conservation is the decision of how to prioritize populations. In many cases, multiple stressors, including development, recreation, invasive species, pathogens, pests, or predators, may be simultaneously acting on populations in different ways and to varying degrees. With TYC, the situation is somewhat simplified because the level of Lake Tahoe determines how much habitat is available and strongly influences population distribution. Trampling can decrease the number of stems, and recreation patterns likely determine which sites actually support

TYC in any given year and how many stems are present, but none of the other factors listed above appear to have such strong roles in TYC distribution or abundance.

A central paradigm in conservation biology is that larger populations tend to have greater amounts of genetic variation and habitat diversity and are therefore less susceptible to random events and catastrophe (MacArthur and Wilson 1967, Primack 1998). For TYC, the positive correlation between stem count and persistence, and the strong inverse relationship between lake level and the number of occupied sites (Figure 2.8) and stem counts (Figure 2.12), means that TYC sites with higher stem counts are more likely to persist under both low and high lake levels. Though stem count may not correlate with population size, as discussed above, it is still reasonable to infer that the most persistent TYC populations with higher stem counts are of highest conservation priority.

In 2002, TYC sites were evaluated for purposes of conservation and restoration based on persistence, stem counts, and variation in stem count based on the 1979–2000 survey records (Pavlik *et al.* 2002). To be ranked, sites had to have at least 7 years of survey data and have at least 3 recorded stem counts (with 2 exceptions, El Dorado and Sand Harbor had only 1 stem count each). The following formula was used to calculate each site viability index (SVI):

Viability Index = Ra + (-1*CoVar) + Pr

Where:

Ra = relative abundance (mean stem count per site/sum of mean stem counts of all sites*100

-1(CoVar) = the negative coefficient of variation (-1*the coefficient of variance of mean maximum stem count at a site*100)

Pr = persistence (number of years TYC was present/number of surveyed years*100

With this equation, persistence contributes the greatest positive value to the SVI score, but it can be offset completely by a large negative value of the co-variance of stem count. In CS2002, this methodology provided an empirically derived SVI with values ranging from 97 to -77 for 29 sites with sufficient data. Sites were categorized as Core (6), High (6), Medium (12), or Low (5) and 16 sites could not be ranked.

The adaptive management process recognizes that site ranks may need revision as more data become available. The dataset from 1979 to 2000 was skewed toward high lake levels with 9 years of high and only 5 years of low levels (Section 2.5). In 2003, the AMWG revised the ranks when the number of low and high lake level years in the survey record had equalized (9 years each) and the number of sites that met the ranking criteria had risen from 29 to 38. To be ranked, sites had to have 10 years of consecutive survey data and have at least 3 recorded stem counts. The revised ranks ranged from 96 to -116 and included 10 Core, 6 High, 13 Medium, and 9 Low sites. The AMWG agreed to maintain those ranks until another cycle of low and high lake levels occurred.

In 2014, the number of low and high lake level survey years became equal again with 11 years each. As of 2014, 45 of the survey sites met the criteria for SVI ranking. Calculated SVIs ranged from 103 to -83 and a natural breaks optimization determined that 5 categories resulted in the biggest separation; a frequency histogram was used to visualize the breaks between the ranks (Figure 2.13).

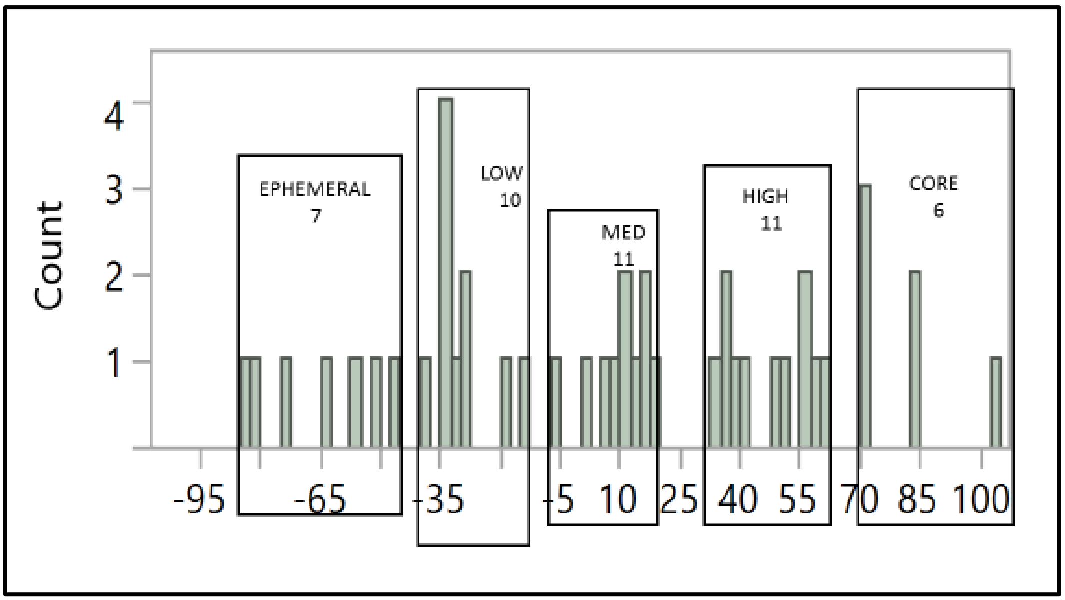

Figure 2.13. The frequency distribution of calculated SVI for the 45 ranked sites for the period from 1979 to 2014.

The revised rankings include 6 Core, 11 High, 11 Medium, 10 Low, and 7 sites in the new category of Ephemeral (Table 2.1). Five sites had too few survey years or stem counts and are Unranked until they meet the ranking criteria. An additional 5 sites that were previously tracked are now considered Historical because TYC has not been observed at any of them for more than 20 years and in most cases there is only a single observation in the survey record (Appendix C).

Table 2.1. TYC survey sites categorized by rank and including owner and Site Viability Index (SVI).

SVI	SITE	OWNER	SVI	SITE	OWNER
CORE			**LOW**		
103	Upper Truckee East	CTC	-14	Dollar Point	Private
84	Taylor Creek	USFS	-20	Marla Bay	Private
84	Nevada Beach	USFS	-29	Hidden Beach	NSP
72	Blackwood South	Placer Co	-30	Eagle Point	CSP
71	Ward Creek	Private	-32	Tahoe Pines (Fleur Du Lac)	Private
70	Edgewood	Private	-33	Cave Rock	NSP
HIGH			-33	Pope Beach	USFS
60	Tahoe Meadows	Private	-34	Bijou (Timber Cove Lodge)	City SLT
59	Lighthouse	Private	-34	Secret Harbor	USFS
57	Blackwood North	Private	-38	McKinney Creek	Private
57	Tallac Creek	USFS	**EPHEMERAL**		
50	Rubicon Bay	Private	-47	Sugar Pine Point State Park	CSP
48	4-H Camp/City Pump House	UNR	-52	DL Bliss State Park	CSP
42	Eagle Creek/Avalanche	CSP	-56	Emerald Bay Boat Camp	CSP
39	Logan Shoals/Vista	Private	-65	Sand Harbor	NSP
36	Meeks Bay	USFS	-73	Meeks Bay Vista	Private
35	Cascade Creek	Private	-82	Kiva Beach/Valhalla	USFS
34	Upper Truckee West	CTC	-83	Skyland	Private
MEDIUM			**UNRANKED**		
19	Baldwin Beach	USFS		Burnt Cedar Beach	IVGID
18	Tahoe Keys	Private		Chimney Rock	USFS
15	Regan/Al Tahoe	Private/ City SLT		Elk Point	Private
15	Zephyr Cove	USFS/private		Skunk Harbor	USFS
13	Emerald Point	CSP		South of Edgewood	Private
11	Cherry St/Tahoe Swiss Village	Private	**HISTORIC**		
10	Tahoma	Private		Agate Bay	Private
8	Kaspian Campground	USFS		Kings Beach	CSP
5	Timber Cove	Private		Crystal Point	Private
2	Glenbrook	Private		El Dorado	City SLT
-6	Roundhill	USFS		Sunnyside	Private

The ranking categories reflect important differences in the biological characters of TYC populations. Core sites have the highest conservation priority because they support relatively large, invariant, and persistent populations of TYC that play an important role in maintaining the species. All 6 Core sites are located at the mouths of large creeks where a high degree of topographic diversity consistently provides favorable habitat conditions across a wide range of lake levels. On average, Core sites persisted 87% of the time from 1979 to 2014 and had the highest stem counts (Table 2.2). High sites are less persistent (71%) than Core sites, but are capable of supporting TYC in most years across most lake levels. Many of the High sites have lower recreational pressure and/or high topographic diversity and are capable of supporting large numbers of stems in some years. Medium sites persisted about half of the time (46%) during the survey period, but have similar stem counts and relative abundance as High sites (Table 2.2). The persistence of Low (31%) and Ephemeral (33%) sites was not different from one another, but the stem counts at Ephemeral sites were much more variable. Most of the Low sites only have habitat in low lake level years, but some are very heavily used and trampling may be an important factor in the variability of stem counts. The Ephemeral sites include five public sites with intense recreation and two private sites with limited access and survey data.

Table 2.2. Mean calculated site viability index (SVI) with its three components; persistence (Pr), relative abundance (Ra), and Coefficient of variation (CoVar) and mean stem counts of TYC survey sites for the period from 1979 to 2014. Forty-five sites meet the ranking criteria. Within a column, sites with different superscript letters are significantly different at p=0.05 with Kruskall-Wallis test.

Rank	N	SVI	Std Dev	Pr	Std Dev	Ra	Std Dev	CoVar	Std Dev	Mean stem count	Std Dev
CORE	6	80.7^{a}	12.7	86.8^{a}	7.5	8.3^{a}	11.9	-14.3^{a}	8.6	1227.0^{a}	1701
HIGH	11	47.0^{b}	10.2	71.4^{b}	9.6	1.4^{ac}	0.8	-26.0^{b}	11.4	208.7^{b}	108.4
MEDIUM	11	10.0^{c}	7.4	46.2^{c}	15.9	1.9^{ac}	2.5	-38.2^{c}	13.5	266.1^{bc}	357.8
LOW	10	-29.7^{d}	7.2	31.7^{d}	10.8	0.4^{b}	0.7	-62.0^{d}	14.2	74.2^{c}	97.5
EPHEMERAL	7	-64.4^{e}	14.4	32.9^{d}	13.9	0.9^{bc}	1.1	-99.3^{e}	13.5	129.7^{bc}	145.2

While the rank of these 45 TYC survey sites reflects a quantitative assessment of performance (based on persistence, relative abundance, and variation) for the period from 1979 to 2014, these ranks are not static. In the 2015 ranking, the rank of 20 of the 36 sites that were also ranked in 2003 changed (Table 2.3). Sites could change ranks for at least 4 reasons: 1) more data, 2) management change, 3) recreation pressure, or 4) change in beach morphology.

Table 2.3. Rank in 2003 and in 2015 of 36 TYC survey sites.

SURVEY SITE	2015 Rank	2003 Rank	2003 UNRANKED SITES	2015 Rank
Blackwood South	Core	Core	Burnt Cedar Beach	
Edgewood	Core	Core	Chimney Rock	
Taylor Creek	Core	Core	Crystal Point	Historical
Upper Truckee East	Core	Core	El Dorado	Historical
Nevada Beach	Core	High	Elk Point	
Ward Creek	Core	High	Skunk Harbor	
Blackwood North	High	Core	South of Edgewood	
Lighthouse	High	Core	Meeks Bay Vista	Ephemeral
Tahoe Meadows	High	Core	Skyland	Ephemeral
Tallac Creek	High	Core	Sugar Pine Point State Park	Ephemeral
Upper Truckee West	High	Core	Agate Bay	Historical
Cascade Creek	High	High	Kings Beach	Historical
Eagle Creek/Avalanche	High	High	Bijou (Timber Cove Lodge)	Low
Meeks Bay	High	High	Hidden Beach	Low
4-H Camp/City Pump House	High	Medium	Kaspian Campground	Low
Logan Shoals/Vista	High	Medium	Marla Bay	Low
Rubicon Bay	High	Medium	Roundhill	Low
Zephyr Cove	Medium	High	Tahoe Pines (Fleur Du Lac)	Low
Regan/Al Tahoe	Medium	Low		
Tahoma	Medium	Low		
Baldwin Beach	Medium	Medium		
Emerald Point	Medium	Medium		
Glenbrook	Medium	Medium		
Tahoe Keys	Medium	Medium		
Timber Cove	Medium	Medium		
Cherry St/Tahoe Swiss Village	Low	Low		
Dollar Point	Low	Low		
McKinney Creek	Low	Low		
Pope Beach	Low	Low		
Cave Rock	Low	Medium		
Eagle Point	Low	Medium		
Secret Harbor	Low	Medium		
Kiva Beach/Valhalla	Ephemeral	Low		
Sand Harbor	Ephemeral	Low		
DL Bliss State Park	Ephemeral	Medium		
Emerald Bay Boat Camp	Ephemeral	Medium		

As an example of the effect of more data, the 3 sites that increased in rank from Medium to High (4H, Logan Shoals, and Rubicon Bay) consistently supported TYC stems counts in the last 9 surveys that were within the range of historic variation. In contrast, the 3 sites that decreased in rank from Medium to Low (Cave Rock, Eagle Point, and Secret Harbor) only supported TYC under the lowest lake levels over the last 9 surveys. Only 2 sites changed more than one rank; DL Bliss and Emerald Bay Boat Camp, both changed from Medium to Ephemeral and in both cases it was due to the additional 9 years of survey data which showed increased variability in stem counts and decreased persistence. In 2015, the change in rank of Sand Harbor and Kiva beach/Valhalla from Low to Ephemeral was also due to similar information.

A change in management may have also changed site ranking. For example, the TYC population at Nevada Beach (USFS) supported over 500 stems in the mid 1980's but fewer than 100 stems from 1990-2006. During 2004–2006, just over 1,300 container-grown TYC were outplanted in the enclosure and from 2007–2009 the site supported over 700 stems. The increase in stem counts, decrease in variability of the stem counts, and long persistence at the site contributed to an increase in SVI and a change in rank from High to Core.

Changes in recreation pressure also could change the rank of a site, through its likely effect on stem counts. While greater stem counts are correlated to lower lake levels (Figure 2.12), trampling can reduce the number of TYC and prevent establishment across all lake levels. Raking has a similar effect and may be correlated to use at some sites (raking increases with use). The change in rank of the TYC population at Secret Harbor (USFS) from Medium to Low may be due to an increase in recreational use and associated raking by the beach users (observed in lake-wide surveys) that decreased persistence (TYC was present in only 2 of the last 7 surveys). Finally, outplantings of TYC in multiple years at Zephyr Cove and Blackwood North identified changes in beach morphology as a likely cause in decreased habitat suitability. Both sites decreased in rank because of reduced persistence and highly variable stem counts. The change at Zephyr Cove is described in section 2.8.2 and illustrated in Figure 2.15. At Blackwood Creek, the shifting of the stream mouth over the winter of 2008 eroded away a planting from that same summer on the north side and decreased the limited amount of habitat for the naturally occurring TYC. In contrast, the TYC on the south side of Blackwood Creek have benefited to a greater degree from the swales and complex topography, and Blackwood South has maintained its Core ranking despite high recreational use.

Ownership does not appear to have a role in how sites ranked. There are 19 privately owned ranked sites and 26 with public or mixed ownership. Multiple comparison analysis revealed that mean SVI and persistence did not differ statistically by ownership type (Table 2.4). The average stem counts were not significantly different between privately-owned or public sites. In any given year, TYC occurrences on private property account for about half of the total number of occupied sites and anywhere from 13 to 60% of the total lake-wide stem counts (Appendix C).

Table 2.4. Mean calculated site viability index (SVI), persistence (Pr), and mean stem count of TYC survey sites from 1979 to 2014 by public/mixed and private ownership (Wilcoxon signed rank test, α=.05).

Mean value	Public/mixed N=26	Private N=19	p value
Pr	51	53	p=.765
SVI	3	14.5	p=.364
stem count	263	185	p=.102

It is important to note that regulatory protections of TYC occurrences are not based on this ranking, and actions must adhere to all laws and regulations pertinent to each site. Site ranking is intended to assist land managers in identifying which of the sites they manage are of higher conservation value than others and in prioritizing limited staff and funds as effectively as possible. The ranking framework also allows agencies to see how sites they manage fall within the regional conservation context for this species. For example, NSP only has low ranked sites whereas the USFS has a diversity of sites across all rankings.

Site rankings may be especially relevant in an imminent extinction scenario (as described in section 4.2.2). Core and High sites are targeted for increased fencing when the extinction risk increases to Moderate. The responsibility for protecting ranked sites on public lands is shared among the agency stakeholders (CTC, CSP, USFS, NSP), which have the ability to work together to implement any of the available actions in the management toolbox (section 5). The large number of ranked sites on private lands (19) highlights the need for a strong Stewardship Program that actively promotes conservation among individual landowners. The AMWG may retain these site ranks until there has been another cycle of low and high lake levels.

2.8 TYC habitat in the Lake Tahoe shorezone

2.8.1 Shoreline geomorphology

Shoreline topography and geology play a role in the amount of available habitat for TYC. The Tahoe Regional Planning Agency (TRPA) categorized the entire shoreline of Lake Tahoe into 8 shorezone tolerance districts (Orme 1973). The map of the tolerance districts is useful for understanding the distribution of TYC around Lake Tahoe (Figure 2.14). Tolerance districts are defined by substrate and slope, and TRPA has created specific development standards and regulations for each (Chapter 83, TRPA 2012).

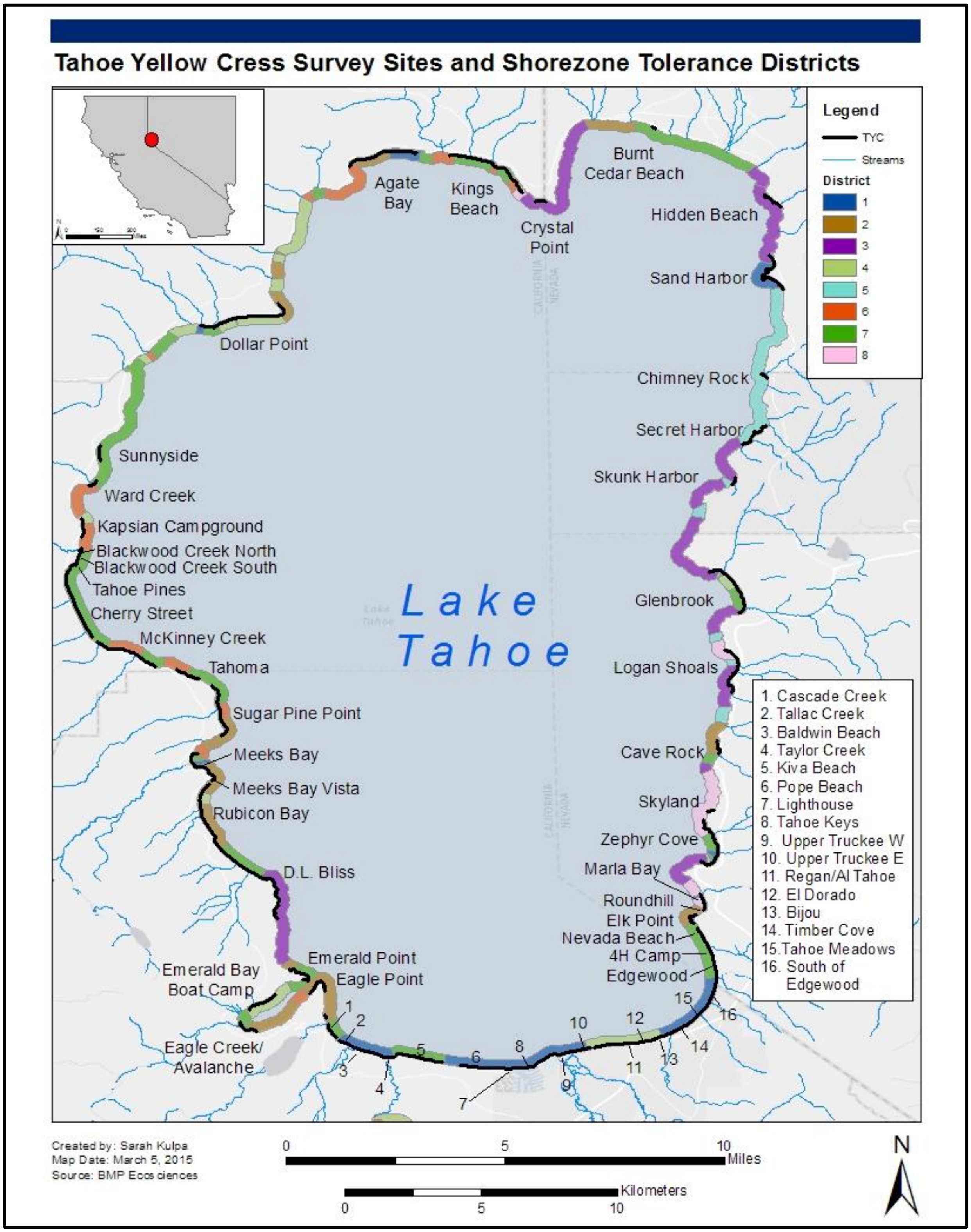

Figure 2.14. Locations of 55 TYC survey sites, TRPA shorezone tolerance districts (1–8), and 66 tributary streams to Lake Tahoe. TYC can occupy sandy beach in all districts, but habitat is extremely limited in Districts 3 and 5.

An overlay of TYC survey sites with each tolerance district was analyzed using a Geographic Information System (GIS) to ascertain a relationship between the two. While the data type and precision prohibited statistical analysis, the overlay revealed that the most optimal TYC habitat is typified by District 1—the sandy barrier beaches adjacent to wetlands and marshes where TYC occupies 94% of the linear miles of shoreline (Table 2.5). TYC does not appear to have as strong of an affinity to any other shorezone tolerance district. There are 3 districts with which TYC survey sites have very little overlap and can therefore be considered lower quality habitat for TYC: District 5 (17%), District 3 (28%), and District 6 (29%). Districts 3 and 5 are both relatively steep with slopes greater than 15% and shorelines comprised of armored granite, while District 6 has less steep slopes (5–15%) composed of volcanic parent material. In Districts 3 and 5, TYC has been found very rarely and in low numbers in small sandy pockets of beach that are exposed only under low water conditions at D.L. Bliss State Park, Skunk and Secret Harbors, Chimney Rock, Hidden Beach, and Crystal Point (Appendix C). These two districts are far more prevalent in Nevada (17.7 mi (28.5 km)) than in California (2.9 mi (4.7 km)). The three districts combined comprise 36.8% (26.7 mi (42.9 km)) of the 72 mi (115.9 km) of Lake Tahoe shoreline.

Table 2.5. Brief description of TRPA shorezone tolerance districts, their length in miles on the Lake Tahoe shoreline in California and Nevada, and the length and percent of overlap with TYC survey sites (TRPA 1979).

District	Description	Length (miles)				% overlap
		CA	NV	Total	Overlap with TYC survey site	
1	sandy barrier adjacent to wetlands	6.16	1.23	7.39	6.91	94
2	alluvial soils, slopes 9–30%	7.62	2.27	9.89	5.00	51
3	armored granite slopes >30%	2.91	10.02	12.93	3.56	28
4	volcanic shoreline, variable	6.29	0.33	6.62	3.88	59
5	armored granite, slopes 15–30%	0	7.7	7.7	1.34	17
6	volcanic debris, slopes 5–15%	6.13	0	6.13	1.80	29
7	alluvial material, slopes 0–9%	13.62	5.09	18.71	10.75	57
8	armored granite, slopes 0–9%	0.26	3.02	3.28	1.21	37
	Total	**42.99**	**29.66**	**72.65**	**34.45**	**47**

The concentration of District 3 and 5 tolerance types (armored slopes >15%) on the eastern Nevada shoreline may account for the relative dearth of TYC occurrences on that side of the lake. There is also a pronounced precipitation gradient from west to east in the Lake Tahoe basin because of the Sierra Nevada rain shadow effect. On the west shore at

Tahoe City, California, mean annual precipitation is 31 in (78.7 cm) while on the east shore at Glenbrook, Nevada, it is only 18 in (45.7 cm) (Western Regional Climate Center 2014). Temperatures are also warmer on the east shore with mean high/low temperatures in July and August of 80/49°F (26.7/9.4°C) at Glenbrook and 77/44°F (25.0/6.6°C) at Tahoe City. These naturally drier and warmer conditions may contribute to the occurrence of fewer TYC sites on the east shore compared to the west shore.

Within the shoreline zone, TYC is found on a variety of substrates, including pure sand, sand mixed with silts and clays, sand mixed with gravel and boulders, and organic materials such as litter and beach wrack (CSLC 2000). During the lake-wide surveys, TYC have been observed growing out of cracks in large boulders, in interstices of un-grouted rock retaining walls, at the periphery of irrigated lawns, in cobble and gravel, and under piers and staircases. Substrate was only recorded anecdotally in the experimental outplantings and translocations, but appeared to be associated with differential survival rates (Stanton and Pavlik 2009, 2010). For instance, the substrate in the planted areas at Blackwood Creek and Sugar Pine State Park turned out to be very rocky and it was difficult to install the container-grown TYC. The survival and reproduction of the cohort installed in 2008 was low at both sites. Rockier substrates were also noted as an important factor in decreasing the survival of plantings at other sites in other years. It is important to consider that substrate surface appearance can be deceiving and what looks sandy may be cobbles or gravel below the surface.

2.8.2 Hydrology

Based upon the results of experimental plantings conducted from 2003 to 2006 that addressed differences in survival of container-grown TYC in relation to lake level (section 4.4.1), access to subsurface water is one of the key factors affecting TYC establishment and reproduction (Pavlik and Stanton 2004, 2005, 2006, 2007). The initial hypothesis was that nearshore microhabitats (those closest to the lake) have a shallow depth to the water table and would allow better survival compared to upslope microhabitats. Based on the assumption that the groundwater table is at the level of Lake Tahoe, TYC were planted on the beach at different elevations and, therefore, the height of a plot above the lake elevation is equivalent to the depth to groundwater.

Elevation (depth to the water table) was a top predictor variable in the multivariate analysis of survival of the 2003, 2004, and 2006 cohorts (Table 6-12, Appendix B). The general pattern across all years and within sites was that TYC performance (measured as percent survival to reproduction and plant size) declined as planting elevation above Lake Tahoe increased. Performance during both low and high lake level years was better at lower elevations on the beach compared to higher elevation microhabitats in the experimental plantings. However, plants installed closest to the lake were subject to wave impact and inundation, and TYC performance at lower elevations was quite variable.

The shallow water table created at creek mouths with wet sand only a few inches below the surface have been postulated as optimal for TYC growth (Ferriera 1987). Large numbers of TYC stems have been counted in lake-wide surveys around the mouths of Taylor, Tallac, Blackwood, and Ward Creeks and at the mouth of the Upper Truckee River and the outflow of the Tahoe Keys (Appendix C). These sites appear to offer optimal habitat for recruitment. A total of 21 of the survey sites have a creek that enters Lake Tahoe within the survey boundary, 10 sites include one or more stream outflows that discharge through a culvert or some other water diversion (*e.g.*, storm drain), and 14 sites have no surface water flow occurring (Table 2.6). It is of note that all of the Core and High rank sites have creeks or outflow from culverts. These sites are the most persistent and should be the first target of management actions.

Table 2.6. TYC survey sites associated with a creek or other outflows.

SITE NAME	RANK	OWNER	SITE NAME	RANK	OWNER
Creek present			**Creek present**		
Ward Creek	Core	Private	McKinney Creek	Low	Private
Blackwood South	Core	Public	Hidden Beach	Low	Public
Taylor Creek	Core	Public	Secret Harbor	Ephemeral	Public
Upper Truckee East	Core	Public	Sugar Pine Point State Park	Ephemeral	Public
Edgewood	Core	Private	Kiva Beach/Valhalla	Ephemeral	Public
Nevada Beach	Core	Public	**Outflow present**		
Logan Shoals/Vista	High	Private	Rubicon Bay	High	Private
Blackwood North	High	Private	Lighthouse	High	Private
Meeks Bay	High	Public	Tahoe Meadows	High	Private
Eagle Creek/Avalanche	High	Public	Kaspian Campground	Medium	Public
Cascade Creek	High	Private	Cherry St/Tahoe Swiss Village	Medium	Private
Tallac Creek	High	Public	Dollar Point	Low	Private
Upper Truckee West	High	Public	Tahoe Pines (Fleur Du Lac)	Low	Private
4-H Camp/City Pump House	High	mixed	Bijou (Timber Cove Lodge)	Low	Public
Glenbrook	Medium	Private	Roundhill	Low	Public
Tahoe Keys	Medium	Private	Marla Bay	Low	Private

Analysis of the survey data shows that the 21 sites associated with a creek were significantly more persistent over the survey period (1979–2014) than the 10 sites associated with stream outflow discharged through a culvert or some other water diversion (*e.g.*, storm drain), and the 14 sites with no surface water flow (Table 2.7). Stem counts were not significantly different, likely due to very high standard deviations. The 5 Historical sites and 5 Unranked sites with poor survey records were excluded from the analysis.

Table 2.7. Mean persistence (Pr) and stem count of 45 TYC sites surveyed from 1979 to 2014 associated with a creek, other outflows, or no water flow. Within a column, sites with different letters are significantly different at p=0.05 with Kruskall-Wallis test.

Water flow	N	Pr	Std Dev	Stem count	Std Dev
Creek	21	68[a]	12.7	270[a]	271
Outflow	10	38[b]	1.5	131[a]	137
None	14	41[b]	6.4	143[a]	134

The greater persistence of TYC occurrences near creeks may be influenced by topographical and hydrological factors. Outflow from large perennial creeks often cuts through beach zones and creates swales that appear to provide dual benefits to TYC. First, the depression allows plants to access the groundwater more easily. Second, recreational beach users tend to avoid swales and place their chairs and towels on higher, drier beach. Swales at Taylor Creek, Lighthouse, and Blackwood Creek have collectively supported some of the highest TYC stem counts and appear to provide refuges from recreation impacts because they are less desirable for sunbathing and other beach activities. The environment at a creek mouth is one of deposition and continual movement of substrates and the meandering of the streams may also maintain the surrounding beach in open early successional vegetation stages that reduce competition with TYC (CSLC 1998). However, in high run-off years, flooding can destroy TYC plants near dynamic creek mouths.

It is important to consider that site topography may change over time. For example, at Zephyr Cove, two experimental plantings of container-grown TYC were conducted in 2003 and 2009. In 2003, the beach had a low grade slope and was wide enough to accommodate a low elevation experimental plot with temporary fencing (Figure 2.15A) and a higher plot with permanent fencing (Figure 2.15B) that were separated by 16 ft (5 m). Each plot contained more than 150 container-grown TYC. The majority of the plants had extremely high survival and reproduction in the first 2 years (Pavlik and Stanton 2004, 2005). In 2009, at the same location, the beach could only accommodate one plot (Figure 2.15C). Only about 30% of the 2009 plants survived and reproduction failed completely (Stanton and Pavlik 2010).

The level of Lake Tahoe was similar in 2003 and 2009 and management and recreation pressure did not change in any obvious aspects over the 6 years. Instead, the apparent cause of the change in habitat suitability was the high lake level in 2006. Lake Tahoe reached the legal maximum level in January 2006 as a result of a series of intense storms. The high waves produced during or after those storms appear to have altered the beach topography and made it steeper. The substrate also became rockier, and it was more difficult to install plants in 2009 compared to 2003.

Figure 2.15. Research planting of container-grown TYC in an enclosure at Zephyr Cove, a USFS beach in Nevada—in July 2003 in the lower (A) and upper plot (B) separated by a 16 ft (5 m) walkway and in June 2009 (C).

2.8.3 Competition

Competing vegetation can reduce microhabitat suitability. As mentioned in section 2.2, container-grown TYC planted near the mouth of the Upper Truckee River in California became chlorotic and etiolated as the density of bigleaf lupine increased through the growing season (Figure 2.16); the same response occurred in TYC grown in 50% shade in greenhouse experiments (Ingolia 2008). However, competition between lupine and TYC is not common as there are few beaches that support dense stands of lupine.

Figure 2.16. Container-grown TYC planted among lupines. The TYC next to the red stake was etiolated, chlorotic, and produced few fruits.

Many different species can compete with TYC, including both native and non-natives. Common mullein (*Verbascum thapsus* L.) is one of the most prevalent non-natives that occurs on the shore of Lake Tahoe. The species makes a small basal rosette and has a towering inflorescence that produces copious seed. Mullein poses a threat to TYC as the density of an infestation increases. Several thistle and knapweed species, including bull thistle (*Cirsium vulgare* (Savi) Ten.), grow on the beach, and Dalmatian and yellow toadflax (*Linaria dalmatica* (L.) Mill. *and L. vulgaris* Mill.) can also grow in the sand. These noxious weeds have been noted in lake-wide surveys, but not in dense infestations that would outcompete TYC.

The ability of TYC to establish in native habitats that support upland or meadow vegetation was evaluated at several sites in experimental plantings from 2003 to 2006. In 2006 when the lake reached maximum storage capacity, it was hypothesized that semi-arid habitats (scrub and meadow) would be capable of supporting TYC since the high lake level would produce a shallow depth to the groundwater table. Scrub habitat was characterized by stabilized, upland vegetation and has not generally supported naturally-occurring TYC. Plantings of TYC in scrub in 2006 at D.L. Bliss State Park, Ebright, and Nevada Beach all failed to reproduce and indicated that these dry upland habitats cannot provide a TYC refuge during high water years. The permanent enclosure at Nevada Beach had supported TYC before hydrological modifications type-converted it to semi-arid vegetation. The plot at Ebright was more typical of scrub habitat conditions present at other sites around the lake, and it did not support TYC prior to the planting.

Plantings of TYC in the meadow microhabitat at Taylor Creek were unsuccessful in low lake years (*e.g.,* 2003, 2004), but when the lake rose and reached capacity in 2006, plants had high survivorship and moderate amounts of seed output. This demonstrates that meadow habitat may offer a refuge where TYC can persist when the lake is high, habitat is limited, and shorezone recreation is intensified. However, persistence into subsequent years was low and reproduction ceased when lake level dropped, likely due to the associated drop in the groundwater table.

2.8.4 Effect of fencing on persistence

In most instances, trampling is probably the primary reason why TYC cannot establish or persist in apparently suitable habitat. Fencing provides protection from trampling; there are a total of nine TYC enclosures (Table 2.8). Persistence of these sites has been 100% during the period they have been fenced, except for Nevada Beach (Pr=77%) and Meeks Bay (Pr=82%). At Nevada Beach, the fencing period has not been continuous.

Table 2.8. TYC survey sites that have protective fencing.

Site	Owner	Year fenced
Tallac Creek	USFS	1986
Taylor Creek	USFS	1988
Baldwin Beach parking lot	USFS	1988
Baldwin Beach restroom	USFS	2002
Upper Truckee East	CTC	2000
Meeks Bay	USFS	1981
Nevada Beach	USFS	1991
Sugar Pine Point State Park	CSP	2004
Tahoe Meadows	private	unknown

In the 2003–2006 experimental plantings, all sites were partially or fully fenced except for the remote planting at Avalanche Beach where there were many natural barriers to human access. TYC planted outside the fence at Taylor Creek in 2003 did not survive through the year (Pavlik and Stanton 2004). When the experimental plantings fence at Pope Beach was later moved as part of a translocation research project in 2009, some of the experimental TYC plants left outside but adjacent to the fence did survive through the 2009 season, but were gone the next year (Stanton and Pavlik 2010, 2011). None of the experimental plots were ever vandalized, and these observations and the survey record strongly suggest that fencing works to promote the persistence of TYC.

3.0 Threats to TYC

3.1 Water management

Lake level strongly influences TYC distribution and abundance—with more suitable habitat available and greater site occupancy at lower levels (see Figures 2.8 and 2.9). Lake level is controlled—in part—by the operation of the dam at the outlet of Lake Tahoe in Tahoe City, California, where the lake flows into the Truckee River. Dam operations add 6.1 ft (1.9 m) of water storage above the natural rim of Lake Tahoe (USDI/CA 2004). The dam was originally constructed for a private timber crib in 1870 and was reconstructed between 1909 and 1913 to its current configuration. The 1915 Truckee River General Electric Decree gave the Bureau of Reclamation (Reclamation) the right to operate the Lake Tahoe Dam (U.S. Department of the Interior and State of California (USDI/CA) 2004). In accordance with the 1935 Truckee River Operating Agreement, Reclamation must avoid dam operations to the extent practicable that would exceed a lake elevation of 6,229.1 ft (1,898.6 m) LTD and must also satisfy the 1944 Orr Ditch Decree to maintain Floriston rates in the Truckee River and comply with flood control and dam safety requirements (USDI/CA 2004). The lake's Truckee River outflow is fully allocated to numerous downstream users in California and Nevada through valid water rights.

Despite intense regulation of the reservoir storage portion, lake level is primarily controlled by environmental factors. Several studies of the water budget of the lake have concluded that stream runoff and precipitation together account for approximately 93% of the total volume with direct runoff contributing most of the remaining percentage (Reuter and Miller 2000). Water losses from the lake are largely the result of evaporation (61%), but 38% occurs through outflow to the Truckee River. Measurements of the outflow and elevation of Lake Tahoe have been recorded daily since 1900 (USGS gage 103370000). The highest lake level ever recorded was 6,231.3 ft (1,899.3 m) LTD in July 1907, while the lowest was 6,220.3 ft (1,895.9 m) LTD in November 1992. Since the 1915 decree, Lake Tahoe only exceeded 6,229.1 ft (1,898.6 m) LTD after an extreme storm over the New Year in 1997 raised the lake over the limit for almost the entire month of January (USGS gage 103370000).

Although lake level strongly influences TYC habitat availability, it is unlikely that manipulation of lake level will ever be available as a TYC management tool. Legally-binding agreements have precedence in dam operations and control the use and distribution of water at Lake Tahoe. Likewise, alterations to runoff and precipitation substantial enough to alter lake level are not likely within the scope of human control. Therefore, management concerns are focused on reducing impacts from human disturbance, especially at high lake levels when shoreline use is concentrated.

3.2 Recreation

Recreation and land management practices on the beaches of Lake Tahoe constitute the greatest manageable threat to TYC and its habitat. Trampling—resulting from human foot traffic and dogs—may directly destroy plants, roots, and/or seeds and inhibit germination and recruitment of seedlings. Many beaches are maintained via regular raking by hand or machinery to keep the sand free of pine needles and cones, rocks, driftwood, vegetation, and other debris deposited by wave action along the strand line. Storing boats on the beach and pulling boats in and out of the water can kill plants. Beach furniture can reduce the amount of suitable habitat. However, TYC stems have been observed under chairs, picnic tables, and other beach furniture that provide a refuge from trampling (Figure 3.1). The threats from all activities in the shorezone intensify when the level of Lake Tahoe is high (6,226 ft (1,897.7 m) LTD or greater) because less beach is exposed and recreational use is concentrated.

Figure 3.1. TYC growing around chairs and an umbrella stand on Blackwood Beach in Placer County, California, in September 2014.

The TYC lake-wide surveys have noted impacts from recreation, but there has not been any systematic assessment. Early survey protocols asked surveyors to assess the percent cover of footprints in TYC habitat (5 possible categories) or to rank recreation impact as low, medium, or high, but these qualitative data have not been compiled (CSLC 1999, 2002, 2003). In general, beaches that receive the heaviest use appear less likely to support large TYC stem counts unless the plants are fenced (*e.g.*, Nevada Beach, Baldwin Beach).

However, a few of the heavily-used beaches that occur at stream mouths have periodically supported some of the highest stem counts. For instance, the swale that forms on the beach from the outflow of Blackwood Creek and the outflows from the marinas at the Tahoe Keys appear to provide a refuge from recreation impacts; both sites have supported large TYC stem counts intermittently.

Fencing provides important protection for TYC from recreation impacts on several public beaches as well as an opportunity for public outreach. USFS installed the first fence at Meeks Bay in 1981; a second one was installed at Tallac Creek (Baldwin Beach) in 1986 (USFS 1981, 1986). Two more enclosures were installed at Baldwin Beach in 1988 (USFS 1987a, 1987b) and one at Nevada Beach in 1991 (USFS 1991). A fourth enclosure was installed at Baldwin Beach in 2002. All of the fences have interpretative signage. A 2011 internal USFS assessment of the fences showed that, due to the movement of sand from wind and stream processes, all four fences were in need of annual maintenance and some fenced areas no longer included suitable habitat (C. Rowe, USFS Forest Botanist, pers. comm., 2014). USFS is in the process of evaluating alternative protection measures and analyzing the effects to other resources from these alternatives. Proposals include passive fencing through the use of vegetation and seasonal temporary fencing, in particular from Tallac to Taylor Creek as part of the Taylor-Tallac restoration project (C. Rowe, USFS Forest Botanist, pers. comm., 2014).

CSP installed a fence at D.L. Bliss State Park in 1988 and a smaller one at Sugar Pine Point State Park in 2001. The fence at D.L. Bliss was removed in 2008 because it no longer enclosed suitable habitat due to the encroachment of willow (*Salix* sp.) and greenleaf manzanita (*Arctostaphyllos patula* Greene) that stabilized the beach. Fenced plants at Sugar Pine Point State Park continue to persist (S. Yegorova, CSP Environmental Scientist, pers. comm., 2014).

CTC installed a fence to the east of the mouth of the Upper Truckee River in 2000. Up to 18,000 TYC stems have been counted in the enclosure. Since it was installed, the enclosure has supported 42% of the total lake-wide stem counts on average. The adjacent unfenced area to the east generally supports many fewer stems. Beginning in 2002, there has been an Upper Truckee Marsh Land Steward. The Land Steward educates users of the marsh about sensitive resources, including TYC, and encourages users to remain out of the TYC enclosure and to keep their dogs leashed at all times. A summary of annual reports from 2003 to 2007 includes numbers of visitors and dogs, recreational activities, dog leash compliance, and overall observations of use for the 5-year period (Rozance 2007). The report suggests that there was a dramatic increase in use of the marsh over the 5-year period.

TYC cannot persist on beaches that are regularly raked. For example, the North Tahoe Public Utilities District operated Kings Beach on the north shore of Lake Tahoe from 1978-

2014and had permits for beach raking and grading activities. TYC has only been observed at the site once, in 1979, and the survey site is now ranked as Historical. Kings Beach became a State Recreation Area when operation was transferred to CSP in May 2014. Other public sites are hand raked by users, such as the USFS beaches at Skunk Harbor and Chimney Rock, where TYC was only observed in1990-1992. Both beaches are accessible only by foot and support small pockets of sandy beach only at low lake levels and are now ranked as Historical because TYC has not been observed for more than 20 years.

TRPA issues permits to public entities on a case-by-case basis to carry out beach raking for public health and safety purposes and for continued access to public recreational facilities. TRPA also issues permits for beach replenishment and maintenance filling in support of recreation. Adding sand to a beach raises the elevation and would reduce the ability of potential TYC colonizers to access the water table. No TYC monitoring has been conducted in association with such projects because most occur in high use areas where no TYC have been observed. Beach raking guidelines are found in Appendix G and public outreach and education on the impacts of beach raking are a vital part of the Stewardship Program described in section 6.0).

3.3 Development

TRPA regulations, described in detail in section 7.2, limit the types and amount of development that can occur in the shorezone of Lake Tahoe. Significant development in the shorezone occurred prior to the adoption of the TRPA Regional Plan in 1987 (TRPA 1987). Existing structures in the shorezone include boat ramps, breakwaters or jetties, fences, marinas, piers, retaining walls, shoreline protective structures, and water intake lines. The footprints of structures in the beach represent permanent losses of TYC habitat. Some structures may also pose an indirect threat to TYC habitat by impeding natural sand transport along the shoreline, affecting patterns of erosion and deposition, and influencing TYC propagule transport via wind and/or water (Ferreira 1998). Although the shade from elevated structures may inhibit TYC growth (Ingolia 2008), TYC have been found adjacent to or under structures during the regular lake-wide surveys (Figure 3.2). Structures may protect TYC from trampling and beach raking, and may also provide a safe site for seed germination.

Figure 3.2. TYC growing around pier footings at Blackwood Beach in Placer County, California, in September 2014.

TRPA is currently operating a partial permitting program that excludes permitting of new boat launch facilities, but allows for limited permitting of other types of shorezone development. Since 1987, projects to maintain, expand, or modify existing structures in the shorezone have not been permitted by TRPA if they could adversely impact TYC (TRPA 1987). Scaling up to a full permitting program that would allow construction of new boat launch facilities is not expected until new Shorezone Ordinances are adopted by TRPA. When new Shorezone Ordinances are adopted, TYC protection will be at least equal to current regulation requirements (see section 7.2). Therefore, the threat to TYC from future development of additional boat launch facilities is expected to remain small.

The other types of development that may occur in the shorezone of Lake Tahoe are those associated with the Lake Tahoe Environmental Improvement Program (EIP), which started in 1997. EIP projects are implemented by partnerships of federal, state, or local agencies in Nevada and California, private property owners, and the Washoe Tribe of Nevada and California, and are focused on improving environmental thresholds such as water quality or forest health. A recent example is the Bijou Area Erosion Control Project implemented by the City of South Lake Tahoe in 2013 and 2014 to install a new storm drain system with an open rock-lined outfall to Lake Tahoe. Impacts to TYC were unavoidable during construction, and an incidental take permit (California Fish and Game Code Section 2081) was issued by California Department of Fish and Wildlife (CDFW). The incidental take permit required a 3 to 1 replanting mitigation ratio and habitat protections. Upon completion of the project, 30 robust TYC stems colonized the sand interstices among the rocks in the outfall, possibly indicating that TYC may be more resilient to disturbances in the shorezone than previously thought (Figure 3.3). The mitigation planting was installed in 2015 in an area located above the culvert. The mitigation planting is held to performance standards for 3 years post project implementation and includes site protections and monitoring in perpetuity.

Figure 3.3. TYC growing among the rocks in September 2014 in the outfall constructed for the Bijou Area Erosion Control Project in South Lake Tahoe, California.

3.4 Climate change

The effects of climate change on TYC depend on how it influences the level of Lake Tahoe. As described in Section 3.1, lake level is primarily controlled by environmental factors that increase water input (tributary stream discharge and precipitation) or cause water loss (evaporation and outflow to the Truckee River). While multiple modeling efforts have shown no definitive increase or decrease in projected precipitation in the Lake Tahoe basin as a result of climate change (Coats 2010, Sahoo *et al.* 2013, Tahoe Environmental Research Center (TERC) 2014), those same studies are in agreement that air temperatures are likely to increase. It is not known if warming air temperatures will change the total amount of precipitation that falls within the Lake Tahoe basin in the future, but higher temperatures lead to increased evaporation. One study estimated that annual net evaporation from Lake

Tahoe may increase 14% by 2080 from the baseline period 1950–1999 (Reclamation 2015).

A likely increase in evaporation in the Lake Tahoe basin is further supported by observed trends in air temperature. According to TERC's *State of the Lake Report,* the daily minimum air temperature at Tahoe City has already increased by 4.2°F (2.3°C) and the maximum temperature by 1.7°F (0.9°C) over the last 100 years (TERC 2014). Additional observations suggest that the entire Sierra Nevada region is warming (Stewart *et al.* 2005, Schneider *et al.* 2009, Sahoo *et al*. 2011), but that the Lake Tahoe basin is warming faster than the surrounding region (Coats 2010). In addition, the number of days per year with average temperatures at or below freezing has declined by 27 days since 1911 (TERC 2014). The long-term trend line for average minimum temperature is now greater than 32°F (0°C), indicating more rain, less snow, and earlier snowmelt. The amount of precipitation that falls as snow has already declined from 51 to 35%, and snowmelt now begins an average of 2 weeks earlier than it did in 1960 (May 15 instead of May 30). Potential effects to TYC from earlier snowmelt include an earlier release from dormancy and a longer growing season.

If the predictions of higher temperatures translate to greater evaporation, this would likely result in more years with lower lake levels. One modeling study predicts that the surface level of Lake Tahoe will remain below the natural rim (6,223 ft, 1,896.8 m LTD) after 2085 under the A2 (high) emissions scenario, but not the B1 (low) scenario (Sahoo *et al.* 2013). Low lake levels provide a benefit to TYC in the form of greater beach habitat availability. However, earlier snowmelt and increased temperatures could lead to lower water availability at the end of the growing season. Because less than 2% of the Lake Tahoe basin's total annual precipitation currently falls in the summer months (July–September) (Western Regional Climate Center 2014) when TYC is actively growing, it must rely almost exclusively on subsurface moisture from the water table of Lake Tahoe. For TYC to continue to utilize subsurface moisture under low lake level conditions, plants would need to follow the margin of the lake downward as it recedes.

During the TYC monitoring period since 1979, TYC has typically moved within a lake level elevational range from the natural rim to the upper limit of 6,229.1 ft (1,898.7 m). The ability of TYC to survive sustained low lake levels was documented when TYC thrived with greater than 90% occupancy (Appendix C) during a period when Lake Tahoe remained below the natural rim from September 1990 to May 1993 that included the lowest elevation ever recorded (since 1990) of 6,220.3 ft (1,895.9 m) in November 1992 (USGS gage 103370000). It is not known how TYC might respond to a more prolonged period of sustained low lake levels, but it is likely that increased competition with other beach vegetation, including weeds, would occur. In addition, sustained low water levels could lead to a reduction in access to subsurface water in the upper end of the species' elevation range. An exact threshold is not known, but TYC plants growing above 6,226 ft (1,897.7 m) would likely be most vulnerable to sustained periods of disconnection from subsurface water that could result in heavy mortality.

If the predictions of higher temperatures translate to more extended drought conditions, less precipitation could also reduce flows in the streams that feed Lake Tahoe if rainfall is absorbed by dry ground and not discharged as groundwater or surface runoff (Murphy *et al*. 2000). This could alter the quantity and quality of TYC habitat at stream mouths by affecting the stream channel-forming processes that create and maintain swales and berms where TYC thrives.

Alternatively, climate change that results in sustained high lake levels that reduce the amount of TYC habitat poses a substantial threat to TYC. From 1979 to 2014, at lake levels of 6,226.0 ft (1,897.7 m) or greater, more than half of the TYC survey sites (of 50 total) were inundated and site occupancy decreased to 22 or fewer (see Figure 2.8). During sustained high lake levels, recreation pressure increases on the remaining beaches and threatens existing TYC. However, TYC recovered after 6 years of sustained inundation in the late 1990s (see section 2.5), so the inundation duration threshold that poses the most serious risk to TYC is probably longer than 6 years. Increased recreation intensity in the future could reduce that threshold.

Regardless of the direction of change in precipitation, climate change is predicted to increase the intensity of precipitation events in North America (U.S. Global Change Research Program 2009). Large storm events with big waves can scour beaches and destroy plants, as was observed near the western-most breach of the barrier beach at the Upper Truckee Marsh in 2006 (Figure 3.4). Because precipitation is expected to shift toward rain, larger storm events could produce more runoff and flooding and may result in higher lake levels, though the duration and timing of potential runoff and the magnitude of its influence on lake level are uncertain. Since 1917, the maximum legal lake elevation of 6,229.1 ft (1,898.7 m) has only been exceeded once (January 1997) after a series of huge storms events that occurred under a strong El Niño pattern. The other relatively recent strong El Niño event that occurred in 1982 did not cause such an exceedance. The highest lake level ever recorded was 6,231.3 ft (1,899.3 m) in July 1907, prior to the reconfiguration of the dam at Tahoe City (CSLC 2000).

Figure 3.4. TYC being eroded out of the substrate by wave action in May 2006, near the west breach of the barrier beach at the Upper Truckee Marsh, California.

The climate-related scenario with the greatest threat to TYC would be a period of sustained low lake level followed by a rapid rise in lake level which inundates TYC plants across the entire elevation range of the species. If this occurred, species viability would depend entirely on recruitment from the seedbank and re-sprouting of submerged rootstocks after the lake receded. Managers would likely need to consider *ex-situ* propagation and conservation until the lake receded.

Adapting TYC management to a changing climate requires that managers protect those sites that have the greatest resistance to fluctuating lake levels. The 6 Core TYC survey sites (UTE, Taylor Creek, Nevada Beach, Blackwood South, Ward Creek, and Edgewood) have maintained an average persistence of 86% during the fluctuating lake levels from 1979 to 2014 (Table 2.2), while the 11 High sites have maintained an average persistence of 71%. Core sites are all located at the mouths of large creeks and are characterized by high levels of topographic diversity. Three of them are fenced (UTE, Taylor Creek, and Nevada Beach), and the other 3 have light recreation or a pattern of recreational use that allows TYC plants to persist without fencing. Many of the High sites include long stretches of beach that also have a high degree of topographic diversity and tend to have less impacts from recreation. The Imminent Extinction Contingency Plan focuses management on Core and High priority sites when the threat level changes from normal to moderate with an emphasis on protecting TYC from the impacts of recreation regardless of lake level (see Section 4.3).

4.0 Conservation History

4.1 Pre-2000

TYC was recognized as a distinct species in 1941 (Rollins 1941), but conservation concerns did not emerge until the 1970s. Since the late 1970s, various management efforts and field surveys for TYC have been conducted, offering important information regarding the historical distribution of the species. Each agency—as well as private landowners and non-profit organizations—involved in the effort contributed various amounts of in-kind services and/or funding. Known conservation actions are summarized below.

4.1.1 Educational institutions and non-profit and private entities

Increasing impacts from development and recreation along the shore of Lake Tahoe led the California Native Plant Society (CNPS) to place TYC on the 1B list in the first edition of its *Inventory of Rare and Endangered Vascular Plants of California* (Powell 1974). The 1B ranking is the highest priority and includes plants that are rare, threatened, or endangered in California and elsewhere. The same year, the Smithsonian Institution (1974) determined TYC was "threatened" in its comprehensive, pioneering list for the continental United States. Subsequent surveys by Michael Baad with Cal State Sacramento on USFS lands (Baad 1978, 1979) and Margaret Williams, Lyn Wise, and Arnold Tiehm from the Northern Nevada Native Plant Society on Nevada State Park lands (CSLC 1994) provided the initial field assessments of TYC occurrence, population size, construction impacts, and recreational pressures.

Jean Ferreira significantly added to the knowledge base for TYC with surveys and detailed autecological studies conducted during the 1980s for her Master's thesis (Ferreira 1987). She visited all historical and extant occurrences and provided site-specific narratives and small-scale maps that documented inundation, succession, and recreational impacts. She also marked plants, measured growth and phenology, germinated seeds, and grew plants *ex situ*.

Western Botanical Services conducted the first TYC re-introductions on USFS lands. With the help of Ferreira, Julie Etra collected a total of 4,000 seeds from the UTE population in 1986 and propagated TYC under greenhouse conditions. Historic localities were chosen on USFS land (Meeks Bay, Taylor Creek, Tallac Creek, and Baldwin Beach) and in spring of 1987 and 1988, container-grown TYC were planted at these sites (USFS 1987a, 1987b). In 1991, Etra also planted 119 TYC at the Kingsbury General Improvement District Nevada/Kahle site (Etra 1992, 1994). These were among the earliest scientific reintroductions of rare plants in North America (Guerrant and Pavlik 1997), and they provided valuable insights for the experimental plantings (re-introductions) of TYC conducted during 2003 through 2010 as part of the adaptive management program.

4.1.2 Regional and federal agencies

In 1980, the USFWS identified TYC as a category 1 candidate species under the ESA (45 FR 82480). Lake Tahoe filled to capacity after record snowfall through the winter of 1982, and in subsequent years of high lake levels, TYC occupied only 30% of the 37 surveyed sites. A prolonged regional drought from 1988 through 1994 resulted in sustained low lake levels that exposed large expanses of shorezone (CSLC 1998). In 1993, TYC was recorded from 35 of 46 surveyed sites (CSLC 1994). In 1995, the USFWS funded a study to determine the genetic characteristics of TYC and address questions related to the evolutionary and ecological consequences of periodic fluctuations in population size. In February 1996, USFWS published a Candidate Notice of Review (61 FR 7597) which removed TYC from the candidate list because the species was shown to be more abundant or widespread than previously believed. However, the drought ended in 1995 and Lake Tahoe filled and inundated most TYC occurrences and its shorezone habitat. During sustained high lake levels from 1995 to 2000 there were only 8–10 occupied sites (CS2002). In 1999, there was fear the species was on the brink of extinction and the USFWS returned TYC to the candidate list, citing the combined threat of sustained high lake elevation and increased human use of lakeshore habitats (64 FR 57533).

The USFS Lake Tahoe Basin Management Unit (LTBMU) responded to the CNPS listing and USFWS concerns by hiring its first botanist, Charles Knapp, to conduct the first lake-wide survey for TYC in 1979. He compiled the available information, designed survey methods, and conducted extensive field surveys, finding TYC in 1979 at 24 of 34 surveyed sites on both public and private lands around Lake Tahoe (Knapp 1979). He noted the transient nature of the populations, developed criteria for recognizing TYC habitat, stressed the importance of long-term monitoring and management, and developed a Species Management Guide for TYC that called for yearly monitoring and suggested actions to enhance and create populations (Knapp 1980a). His work laid the foundation for all subsequent efforts to conserve the species and its habitat.

In 1982, S.B. Reed followed up on Knapp's work with a Sensitive Plant Interim Management Prescription (Reed 1982). The management guide and the prescription were both drafted under mandate from Chapter 2670 of the Forest Service Manual to conserve and manage endangered species and their habitat on USFS lands and provide for their existence in perpetuity (USFS 2005). Management actions under these plans called for annual monitoring of TYC, active protection of existing occurrences and associated habitat, and the exploration of methods to introduce the species to new sites and reestablish the species at historic sites on National Forest System lands. Enclosures were subsequently constructed around existing TYC populations at USFS beaches; in 1981 at Meeks Bay and Taylor Creek, and in 1986 at Tallac Creek and Baldwin Beach (USFS 1981, 1986). Propagation of TYC was initiated in 1986, and in 1987 and 1988, 500 seedlings per site were introduced into the enclosures (USFS 1987a, 1987b). Two of the outplanting sites supported existing plants.

In 1987, TRPA adopted its Regional Plan, which included TYC in the threshold category for Sensitive Plant Species. Every 5 years TRPA is required to evaluate progress made on threshold attainment and assess threshold status. Beginning in 1993, TRPA implemented a short-term TYC monitoring program. During the period from 1993 to 1994, TRPA surveyed 100% of the ground surface on all littoral parcels using reconnaissance level and intensive transect methods.

4.1.2 State and local agencies

In 1982, TYC was listed as endangered by the State of California (California Fish and Game Code 2050 *et seq.*) and as critically endangered by the State of Nevada (NRS) 527.260 *et seq*. In 1989, the CSLC, in response to several permit applications for new pier construction and maintenance activities on existing piers, developed a *Rorippa* Enhancement Plan (REP) so that CSLC could consider relevant projects and meet its obligations under the law (CSLC 1989). To supplement the REP, an interim management program was developed that identified construction, access, and conservation guidelines. Additionally, fees were collected from applicants to be used to fund the preparation of a biological assessment. A draft biological assessment for TYC was prepared in 1994 and later revised two times (CSLC 1994, 1998, 2000). Beginning in September 1997, CSLC formed a multi-agency survey team to perform annual lake-wide surveys for the presence or absence of TYC and developed the first annual survey report (CSLC 1999).

In 1988, CTC funded the Lester Beach TYC reintroduction project on CSP land. Working with Western Botanical Services, 1,168 TYC seedlings were planted on Lester Beach at D.L. Bliss State Park, a historical site.

From 1994 to 2001, CTC worked in cooperation with the Tahoe Baikal Institute to lead cooperative TYC surveys, develop a GIS database of population locations and their extent, and present educational programs at the USFS's Taylor Creek visitor center on the biology and status of the species. In 2001, CTC purchased the Barton property at the Upper Truckee Marsh and constructed a permanent enclosure to protect the largest occurrence of TYC.

4.2 Adaptive management 2000–2014

In response to the potential federal listing of TYC, a multi-agency and private interest group task force was formed in 1999, comprised of an Executive Committee (Executives) and a Technical Advisory Group—later to be titled the Adaptive Management Working

Group (AMWG). Working with Dr. Bruce Pavlik and other experts on rare plant ecology and conservation biology, the task force produced the *Conservation Strategy for Tahoe yellow cress* (CS2002) that provided an adaptive management framework for conservation of the species with an emphasis on precluding the need to federally list TYC (Pavlik *et al.* 2002). CS2002 has guided TYC adaptive management and conservation over the last 12 years.

4.2.1. Memorandum of Understanding (MOU)

In January 2003, 13 stakeholders signed a MOU/CA, agreeing to cooperatively implement the adaptive management framework of CS2002 on a voluntary basis, consistent with their own governing authorities and decision-making processes. Each participating entity designates individuals to serve on the TYC AMWG and Executive Committee. The MOU does not contain any funding obligation and the sole consequence of failure to implement this MOU/CA is the consideration by the USFWS to list the TYC under the ESA. The purpose of the MOU is to:

- Ensure the implementation of conservation measures and management activities identified in this CS;
- Facilitate voluntary cooperation among the signatories;
- Ensure continued monitoring of TYC according to the adaptive survey strategy linked to lake level;
- Describe a process to be undertaken if any signatory is unable to perform a conservation measure or management activity set forth in the CS; and
- Set forth the miscellaneous provisions of the agreement.

The 2003 MOU/CA expired on January 29, 2013, 10 years after the date of the final signature. A new MOU/CA (Appendix A) was signed on June 1, 2013, by all 13 original entities:

- California Department of Fish and Wildlife (CDFW)[1],
- California State Lands Commission (CSLC),
- California State Parks (CSP),
- California Tahoe Conservancy (CTC),
- League to Save Lake Tahoe (LTSLT),
- Nevada Division of Forestry (NDF),
- Nevada Division of State Lands (NDSL),
- Nevada Division of State Parks (NSP),

[1] Known in 2003 as the California Department of Fish and Game.

- Nevada Natural Heritage Program (NNHP),
- Tahoe Lakefront Owners' Association (TLOA),
- Tahoe Regional Planning Agency (TRPA),
- U.S. Fish and Wildlife Service (USFWS), and
- U.S. Forest Service (USFS)

This MOU/CA is active for 10 years, with an expiration date of June 1, 2023. The new MOU/CA also allows CS2002 to be modified by consensus vote of the Executives. The Executives had already approved revision of CS2002 in 2012 with expectations that this revised *Conservation Strategy for Tahoe yellow cress* (CS2015) would specifically affect the USFWS's listing decision process and provide grounds to preclude the need to list TYC under the ESA. According to clause E1 of the MOU to implement CS2015 (Appendix A):

> **E1.** *"Successful implementation of the MOU/CA and CS should remove the threats to the species and ensure the long-term survival of TYC by maintaining and enhancing existing habitat in the Lake Tahoe basin and integrating new information on the biology of the species into future conservation and management activities. As a result, the need to list the species under the ESA should be avoided. The sole consequence of failure by the Parties to implement this MOU/CA shall be the consideration by the USFWS to list the TYC under the ESA."*

On October 8, 2015, the USFWS published a 12-month finding that listing TYC under the ESA was not warranted, largely based upon the lengthy track record of the MOU signatories in successful, ongoing implementation of conservation actions that are managing, avoiding, or mitigating identified impacts to TYC and its habitat (80 FR 60834). The 2013 MOU and implementation of CS2015 are intended to continue to ensure long-term conservation of TYC, such that USFWS will not have to re-evaluate the status of TYC under the ESA.

4.2.2 Adaptive management framework

Adaptive management is the best available mechanism for linking science and decision making, and most government agencies have to some extent adopted its basic conceptual framework and rhetoric (Holling 1978, Walters 1986, Stankey *et al.* 2005, Gregory *et al.* 2006). An adaptive management approach can bring the most updated scientific research directly into the decision-making process, resulting in an outcome that is more likely to improve the target resources (Pavlik and Stanton 2014). The "learn by doing approach" of adaptive management is usually portrayed as a cycle of forming a strategy, design, implementation, monitoring, evaluation, and adjusting management (Figure 4.1).

Figure 4.1. The adaptive management cycle (from Pavlik and Stanton 2014).

The current adaptive management structure for TYC has evolved from the framework outlined in CS2002 and centers on the AMWG as the body responsible for implementing management and research under guidance of the Executives (Figure 4.2).

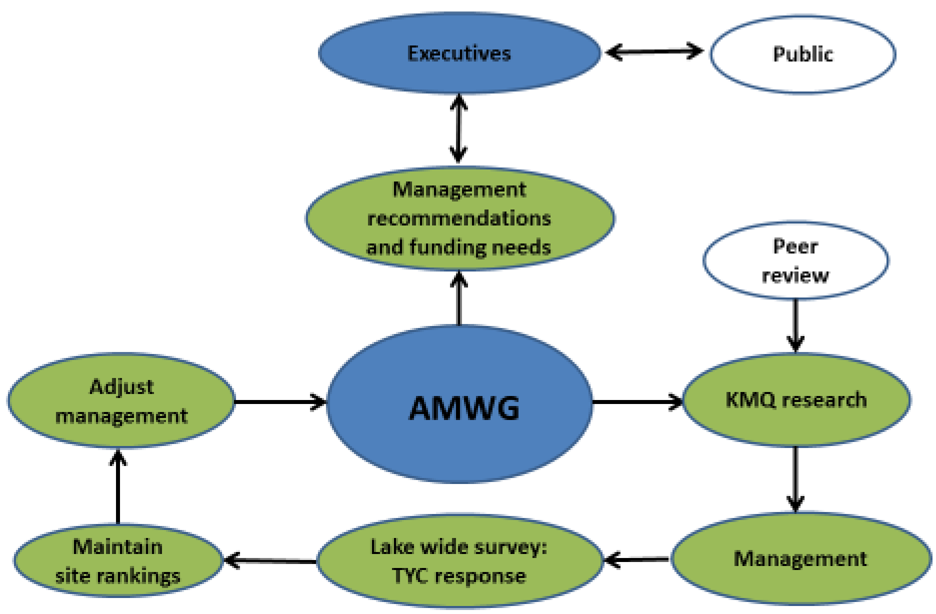

Figure 4.2. The structured flow of information in the adaptive management framework—the AMWG has the central role of coordinating monitoring, management, and research for TYC.

The AMWG is comprised of representatives from the 13 signatories on the MOU. The Nevada Tahoe Conservation District (NTCD) and Reclamation are also active participants in the AMWG, but they are not currently signatories on the MOU. The Executives include the Executive Directors of TRPA, CSLC, CTC, TLOA, LTSLT; the Field Supervisor of the Reno USFWS Field Office; the Forest Supervisor of the LTBMU; the Administrators of NDSL, NSP, and NNHP; the State Forester Firewarden of NDF; the Regional Manager of CDFW; and the District Superintendent of CSP. The Executives provide leadership and direction to guide TYC management within their jurisdiction. In general, Executives are publically accountable for their agency's actions, have authority to direct management, and have authority to allocate funding and resources to implement TYC conservation. However, a number of the agencies have governing boards that set policies and allocate funding, and the authority granted to each Executive by their agency varies. Executives rely heavily on the AMWG to provide technical recommendations in their decisions regarding TYC management actions.

The primary task of the AMWG is to implement the CS through an adaptive management framework. The AMWG has been meeting quarterly since 2002, and it coordinates and conducts lake-wide TYC monitoring and integrates results from monitoring and research to maintain the site rankings, adjust management, and develop new management recommendation and funding needs, which are submitted at least once a year to the Executives. From 2003 through 2010 the AMWG maintained a focus of implementing field research based on the Key Management Question framework (section 4.4). In 2008, the USFS solicited peer review of the CS and its implementation, including review of the technical reports on the experimental plantings from 2003 to 2006. The Center for Plant Conservation facilitated the peer review process and the outcomes of the review were summarized in the 2010 AMWG annual report (Stanton and Pavlik 2010). In 2009, the AMWG launched the Stewardship Program (Section 6) and began generating educational and outreach materials, including the development of a website (*www.tahoeyellowcress.org*). Since 2010, the AMWG has continued to implement the adaptive management framework of CS2002 with a focus on the lake-wide monitoring, and implementing management actions and the Stewardship Program.

4.2.3 Lake-wide monitoring

Lake-wide monitoring began with the survey of 36 sites in 1979 and has since expanded to 50 sites. The surveys are conducted in the first week of September by members of the AMWG along with volunteers. Typically, the surveyors are assigned to one of four teams that each covers sites located within one quartile of the lake. Each team has three to five members that walk the beach in transects parallel to the water looking for TYC. Stems are counted in total when possible, but when there are hundreds to thousands of stems, estimates are used. Several agencies often donate a boat with a driver to help a team access long stretches of shoreline as quickly as possible.

Prior to 2010, lake-wide monitoring was conducted on an annual basis. In 2010, the AMWG adopted an adaptive survey strategy that emphasizes high lake level monitoring. Surveys are now conducted every year when Lake Tahoe is at or above 6,226 ft (1,897.7 m) LTD, but only every other year at lower lake levels.

The lake-wide monitoring data has been useful in describing several aspects of TYC population dynamics, but changes to the methodology are needed. As described in section 2.7, the stem counts and site persistence are utilized in the SVI calculation for the site ranking process. Continuing lake-wide surveys in order to maintain and update site rankings is Objective 5.2 (see section 5.1). The survey data has also been important in understanding the strong effect of lake level on site occupancy. However, the survey methodology has not quantitatively assed the impact of recreation on occupied sites or improved understanding of how it effects TYC distribution. Improving surveys to assess impacts from recreation is Objective 5.4. Another shortcoming of the survey methodology is that surveys have focused on repeat visits to known occurrences and so have not helped to identify or define potentially suitable, but unoccupied habitat. The maintenance of unoccupied suitable habitat for TYC colonization was an important component of CS2002, but has been de-emphasized in CS2015 because of the continued lack of understanding in what defines suitable habitat. Objective 5.3 is to develop a monitoring strategy to evaluate geomorphic beach processes that create the kind of diverse habitat that favors TYC.

4.3 Imminent Extinction Contingency Plan

Pavlik *et al.* (2002) identified an Imminent Extinction Contingency Plan (IECP) as an integral component of the adaptive management framework in CS2002. The IECP specified four threat levels (1–4) based on the number of TYC occurrences or percent occupancy of surveyed sites. The lowest threat level was designated Level One: Normal Operations that occurred when 60% or more of TYC survey sites are occupied. At Level One, no management actions were identified, only the direction that “existing guidelines and policies will remain in effect for protection of existing occurrences and potentially suitable habitat”. Levels Two through Four corresponded to occupancy rates of less than 60%, 50%, and 40%, respectively. There were five actions specified for Level Two, nine for Level Three, and seven for Level Four.

These four threat levels have been revised and condensed to three levels to more concisely reflect the relationship between lake level and threat to TYC. The greatest threat occurs under sustained high lake levels that reduce the number of occurrences. The slope of the line in Figure 2.9 indicates that, on average, over 70% of surveyed sites will be occupied when the lake is at or below 6,225 ft (1,897.4 m) LTD in September, but less than 40% will be occupied when lake level is at or above 6,228 ft (1,898.3 m) LTD in September. These occupancy categories represent an increasing gradient of extinction threat to TYC and were used as the basis for the revised threat levels.

The revised IECP describes the actions that may be taken to protect the species and alert all stakeholders in advance of the level of effort and resource commitment that may be required. Any and all of the actions described below may be recommended by the AMWG and reviewed and approved by the Executives. The Executives will operate within the given authorities and procedures of their respective agencies.

Level 1: Normal Operations

When there is greater than 70% occupancy (currently 32 or more occupied sites), the AMWG will recommend a course of action to the Executives as part of the normal operation of the adaptive management framework. Existing guidelines and policies will remain in effect for protection of existing occurrences and potentially suitable habitat.

Normal TYC management actions include, but are not limited to:

1. Conduct quarterly AMWG meetings and/or participate in the EIP Working Groups;
2. Coordinate with the Executives;
3. Implement the adaptive survey strategy;
4. Maintain site viability rankings;
5. Maintain existing fences on public sites;
6. Maintain the TYC Stewardship Program;
7. Maintain a supply of seeds and container-grown TYC; and
8. Participate in requested reviews of shorezone projects within TYC habitat.

Level 2: Moderate Threat

When there is from 40% to 69% occupancy, all actions carried out under normal operation continue along with the following:

1. Encourage fencing of all Core and High rank sites;
2. Develop guidelines for expedited/emergency fencing projects (e.g., regulatory framework, design specifications, cost estimates) to protect TYC and its habitat;
3. Expand propagation efforts and plantings of container-grown TYC on public sites where possible;
4. Increase participation in the Stewardship Program and encourage additional planting of container-grown TYC on private sites;

5. Increase public awareness of TYC through *www.tahoeyellowcress.org*, local news outlets, social media, and the annual State of the Lake Report; and
6. Promote raking guidelines that minimize damage to TYC stems or habitat (Appendix G).

Level 3: High Threat

When there is less than 40% occupancy, all actions carried out under Levels 1 and 2 continue along with the following:

1. Fence all occupied sites on public lands;
2. Encourage participation in lake-wide fencing of all non-ephemeral sites;
3. Expand outplanting of container-grown TYC wherever possible; and
4. Investigate projects that could restore/modify beach substrates in a manner beneficial to TYC and Lake Tahoe.

4.4 Key Management Question framework

Before CS2002 was finalized, the AMWG began the process of developing a Key Management Question (KMQ) framework to focus the research phase of the TYC adaptive management program (Pavlik and O'Leary 2002). KMQs were shaped first by a written survey of AMWG members, who identified more than 60 variables potentially relevant to TYC conservation. Many of these variables and the questions they evoked were academic (*e.g.,* pollen flow, pollinator availability), lacking a direct connection to realistic management options, or they were components of larger questions that could be subsumed and thus simplified. During the selection process, the AMWG remained focused on generating information with immediate value to decision-making. The goal was to develop a concise set of well-constructed KMQs that narrow an otherwise broad base of scientific inquiry (represented by the lower triangle in Figure 4.3) and management vision (upper triangle in Figure 4.3) to a finely-resolved point directly pertinent to future management (Pavlik and Stanton 2014). A good KMQ directly links the management vision to the science, and all research is then designed to inform the specific goals and objectives of the CS. KMQs also have the effect of focusing agency effort and leadership.

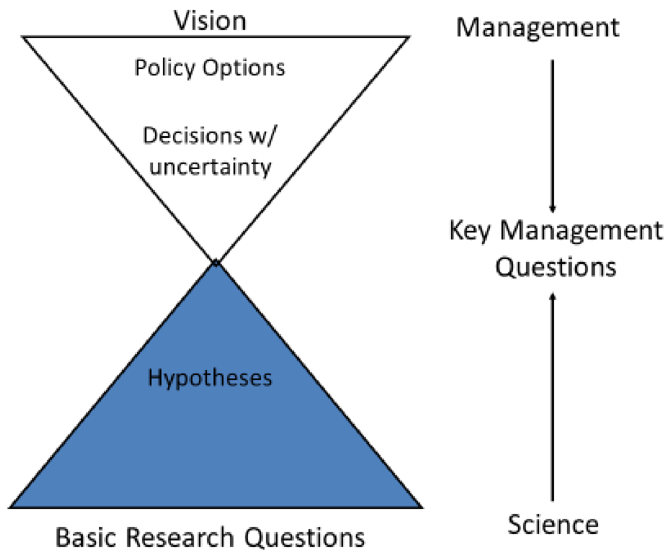

Figure 4.3. Key Management Questions narrow the broad base of research questions to those which directly inform management (from Pavlik and Stanton 2014).

With this guidance, the AMWG distilled the initial 60 variables of interest down into 5 KMQs that addressed knowledge gaps for TYC decision making (Pavlik and O'Leary 2002):

1. Can TYC populations occupy any site around the lake margin that has sandy beach habitat?
2. Are there ecosystem factors that affect TYC performance within an occupied site or microhabitat?
3. Can TYC populations be created or enlarged in order to restore the self-sustaining dynamics of the species?
4. Can any TYC genotype or gene pool perform equally well at any appropriate site?
5. Can TYC microhabitats/places be found or created that are less likely to be adversely disturbed despite high visitor use or intense shoreline activity?

These KMQs helped AMWG members fully envision the range of relevant research that was needed and see linkages between specific research projects and specific decisions they would be facing.

4.4.1 Field research 2003 to 2010

Upon completion of the KMQ framework in 2002, the AMWG initiated re-introduction experiments in the field at multiple sites around Lake Tahoe. At the time it was known that TYC could be successfully grown in the greenhouse and outplanted, based on early outplantings of TYC in the late 1980s and early 1990s (USFS 1987a, 1897b; Etra 1992, 1994). The limited successes of these early plantings indicated that it was possible to create or enlarge TYC populations (KMQ 3), but the plantings lacked experimental design and long-term monitoring and did not provide any information on site or habitat factors that might affect project success (KMQs 1 and 2) or whether it was necessary to utilize TYC seed from local or mixed sources (KMQ 4). Furthermore, the AMWG was concerned that the increase in visitor use over the previous decade might mean that outplantings would be more subject to vandalism (KMQ 5).

From 2003 to 2006, the AMWG oversaw the planting of over 9,300 container-grown TYC in experimental plots at 11 public sites around Lake Tahoe (Table 4.1). Appendix B contains the methods and results for the experimental re-introductions. All of the sites were fenced except for Avalanche Beach in Emerald Bay where the remote location and an accumulation of beach wrack with full size trees negated the need for fencing. The sites were located on all four shores of Lake Tahoe and varied by ownership and many other factors that were not directly measured including substrate and vegetation composition. During the period, lake level fluctuated from at or near the rim (6,223 ft, 1896.8 m) in 2003 and 2004 to the legal limit (6,229.1 ft, 1898.6 m) in early 2006.

Table 4.1. Site name, land ownership, CS2015 rank, year planted (2003–2006), lake level in September (feet LTD), and number of TYC installed at 11 locations.

Site Name	Ownership	2003 (6,224.2 ft LTD)	2004 (6,223.3 ft LTD)	2005 (6,225.1 ft LTD)	2006 (6,228.1 ft LTD)	CS2015 Rank
Avalanche	CSP	300				Medium
Zephyr Cove	USFS	286				Low
Taylor Creek	USFS	541	546		150	Core
Sand Harbor	NSP	172	281			Ephemeral
Upper Truckee East	CTC		1,425	650	250	Core
Nevada Beach	USFS		582	534	200	Core
Ebright	USFS			418	100	Unranked
Pope Beach	USFS			250	150	Low
Hidden Beach	NSP			180		Ephemeral
D.L. Bliss	CSP				100	Ephemeral
Tallac Creek	USFS				225	Core
Total		**3,302**	**2,814**	**2,032**	**1,175**	**9,323**

The first phase of experimental plantings focused on how different microhabitats (KMQ 2) and maternal seed source (KMQ 4) affected TYC survival, reproduction, and growth (Pavlik and Stanton 2004, 2005, 2006, 2007). Microhabitats were categorized according to elevation, based on the assumption that the groundwater table is at the level of Lake Tahoe and, therefore, the height of a plot above the lake is equivalent to the depth of the water. TYC propagated from seed collected at up to 11 different sites were incorporated into the elevation block designs. The initial hypotheses were that 1) TYC performance would be better when planted at lower elevations (closer to the lake) because the depth to the water table is shallower, and 2) maternal seed would not play a strong role in TYC performance because of the limited genetic variation observed (Saich and Hipkins 2000). Appendix B contains the methods for the plantings, including seed collection, greenhouse propagation, site selection, outplanting design, biological and physiological monitoring, and data analysis and key results.

The 2003–2006 plantings were almost all conducted in June during peak lake level; several small-scale plantings in July suggested that the delay in planting time reduced establishment and growth. Therefore, the second phase of experimental re-introductions in 2008 and 2009 (Table 4.2) tested the timing of planting from June through September (Stanton and Pavlik 2009, 2010, 2011). Sites on private property were utilized for the first time in phase two and were not fenced.

Table 4.2. Site name, land ownership, CS2015 rank, lake level in September (feet LTD), and number of container-grown TYC installed in 2008 and 2009 at seven locations.

Site Name	Ownership	2008 (6,224 ft LTD)	2009 (6,223.5 ft LTD)	CS2015 Rank
Blackwood Creek North	private	200		High
Edgewood Golf Course	private	200		Core
Ebright	USFS		200	Unranked
Pope Beach	USFS		200	Ephemeral
Sugar Pine SP	CSP	200		Ephemeral
Upper Truckee East	CTC	200	200	Core
Zephyr Cove	USFS		200	Low
Total		**800**	**800**	**1,600**

In the third phase of experiments, the AMWG tested translocation of TYC to assess whether this technique could be a viable mitigation option in projects with unavoidable impacts to TYC. Translocation involves moving established plants from one location to another. From 2005 through 2009, a total of 522 naturally-occurring or previously-outplanted TYC were moved within and among sites (Table 4.3; Pavlik and Stanton 2009a, Stanton and Pavlik 2010). Pilot-scale translocations in 2005 and 2006 demonstrated that TYC previously outplanted (in 2003 and 2004) survived being moved within and between sites (Pavlik and Stanton 2004, 2005). The AMWG subsequently initiated experiments that paired translocation of naturally-occurring TYC alongside container-grown TYC from 2007 through 2009 (Stanton and Pavlik 2008, 2009, 2010). Appendix F contains the methods, data analysis, key results, and discussion of these translocations.

Table 4.3. Translocation of TYC from 2005 to 2009 at eight locations, including the donor source and receptor site name, and number of translocated plants.

Year	Donor Source	Number of translocated plants	Receptor Site Name (CS Rank)
2005	2003 and 2004 Taylor outplanting	56	Taylor Creek (Core)
2006	2003 Zephyr Cove outplanting	36	Tallac Creek (Core)
2006	2005 Pope outplanting	30	Taylor Creek (Core)
2007	west end of beach near Upper Truckee River	50	Upper Truckee East (Core)
2007	south side of Blackwood Creek (public beach)	50	Blackwood Creek North (Core)
2008	west end of beach near Upper Truckee River	50	Upper Truckee East (Core)
2008	eroded pit 150 m of Edgewood Creek	50	Edgewood (Core)
2009	2006 Pope outplanting	50	Pope Beach (Low)
2009	eroded pit 150 m of Edgewood Creek	50	Nevada Beach (High)
2009	2006 Tallac outplanting	50	Ebright (Unranked)
2009	east end of beach outside of enclosure	50	Upper Truckee East (Core)
	Total	**522**	

4.4.2 Capacity for TYC outplanting and translocation

Taken together, the results from the field studies conducted from 2003 to 2009 have provided answers to the KMQs regarding the capacity for outplanting and translocating TYC. TYC was not able to establish at every site where it was planted, so managers cannot assume that TYC can occupy any sandy site (KMQ 1). Within a site, it appears that TYC must access subsurface water in order to establish and persist, and planting TYC within 3–5 ft (1–1.5 m) above the lake may result in better establishment and growth (KMQ 2). Other factors may influence the ability of TYC to establish and persist, including substrate texture, beach aspect, proximity to a creek, the presence of other TYC, and competing vegetation. Prodigious seed production in the experimental plantings suggests that these plantings may have enhanced existing occurrences and that it may be possible to create new TYC populations (KMQ 3). In addition, planting earlier in the growing season (June) can result in better establishment and growth than planting in August or September. As described in section 2.3, similar survival and reproduction in outplanted TYC sourced from different seed lots indicates that TYC from any genotype can perform equally well at any appropriate site (KMQ 4); however, outplanting efforts should utilize seed from multiple sites when possible, in order to preserve unique alleles and maintain the limited genetic variation across populations (DeWoody and Hipkins 2004, 2006; Peacock and Kirchoff 2010). Finally, while most sites were fenced, plants did establish on private sites that were unfenced, but installing fence on heavily used public sites is probably critically important in helping TYC survive intense disturbance (KMQ 5). In addition, TYC planted in meadow microhabitats under high lake level conditions did survive and produce moderate amounts of seed, but they did not persist into subsequent years with lower lake levels so meadow habitat is strictly a temporary high water refuge.

The experimental TYC reintroductions and translocations generated much new information about the importance of TYC clonal growth and logistical factors involved with implementation. Total survivorship and reproduction was similar between the methods of translocation and outplanting, but container-grown plants were able to grow much larger than translocated TYC at several of the sites. The implication for mitigation strategies in projects where TYC impact is unavoidable is that translocation of naturally-occurring TYC is a viable option, but using container-grown stock gives a greater pay-off of increased growth and seed output. This can be accomplished by translocating the TYC to the greenhouse and allowing the plants to establish in containers before planting. Horticultural practices that might further facilitate TYC establishment and growth of TYC were not evaluated, but control of competing vegetation may be necessary, and applying a regular watering regime beyond the first 3 days would likely improve project success. The best management practices that have been developed for outplanting and translocating TYC are discussed in further detail in sections 5.3.6–8.

4.4.3 Research gaps

Developing a KMQ framework was the first step in the implementation of CS2002. The process should be initiated again upon adoption of CS2015 so that the AMWG can develop KMQs to guide management and conservation over the next 10 years. The research gaps mentioned briefly below have been incorporated into the goals and objectives in section 5, but the AMWG will likely identify others.

One of the most important research gaps is that assessing the self-sustaining metapopulation dynamic of TYC is still hindered by a lack of understanding surrounding dispersal, recruitment, seedbank dynamics, rootstock longevity, and gene flow. Continuation of the microsatellite DNA study with leaf samples collected in 2009 could be used to estimate both an average rate of gene flow, the direction of gene flow across populations, and to test hypotheses about the underlying causal mechanisms of observed variation (Objective 5.2). Understanding patterns of gene flow and dispersal is important for knowing how to maintain connectivity among populations and preserving the limited genetic variation in TYC.

Another research gap is that the geomorphic beach processes that may affect TYC seedbanks and seedling recruitment are not well understood, especially those at creek mouths or outflows that form berms and swales. TYC can thrive on berms and can rapidly colonize scoured areas on the beach that provide a smaller distance to the subsurface water table, but there is a lack of understanding about what distinguishes substrates where TYC can establish from those where it cannot. Developing a monitoring strategy to assess geomorphic beach processes is Objective 5.3.

Recreation poses the greatest threat to TYC, and it will continue to increase as populations in northern California and Nevada increase. Developing a monitoring strategy to evaluate impacts from recreation is Objective 5.4. Likewise, assessing potential impacts to TYC stems and habitat from shorezone projects requires guidelines for analysis methods, significance thresholds, and uncertainties.

Finally, modeling the effects of climate change on Lake Tahoe is an active area of research. Assessing how predicted changes may affect the ability of TYC to survive in the future is an additional research need.

5.0 Management Goals and Action

5.1 Goals

Successful implementation of this CS may continue to preclude the need to list TYC under the ESA and may provide grounds for changing the legal status of the species in California and Nevada. The following goals and objectives provide measureable targets for the conservation and management of TYC within an adaptive management framework. These six goals were originally presented in CS2002, but have been modified to incorporate results from the KMQ-driven research program, information derived from a longer survey record, and the professional knowledge of independent researchers and the AMWG members that have been the day-to-day practitioners of TYC conservation for over 12 years. The revised goals and objectives are not intended to alter the current regulatory requirements of any agency or negatively affect the protection afforded this species through existing policies and guidelines. These goals and objectives are intended to provide additional direction to successfully conserve TYC.

Goal 1: Protect TYC plants and habitat on public lands

Goal 2: Promote stewardship, protection, and awareness of TYC on private lands

Goal 3: Manage TYC populations to promote persistence

Goal 4: Utilize key management questions (KMQs) to direct research that supports management and conservation

Goal 5: Continue long-term monitoring using an adaptive survey strategy

Goal 6: Utilize an adaptive management framework

In CS2002, goals and objectives were tied to the understanding of the TYC metapopulation dynamic and the associated need "to protect occupied habitat and potentially suitable habitat" (CS2002 Goal 1) that can be available for colonization as necessary in order "to promote conditions that favor a metapopulation dynamic" (CS2002 Goal 3). Both goals have been modified because field surveys and research studies from 2003 to 2009 have highlighted the difficulty in measuring metapopulation events or even confirming the hypothesis that TYC possesses a mainland-island dynamic (section 2.5). Furthermore, the survey strategy over the last 30 years has focused on repeated surveys of known occurrences and has never included a strategic assessment of unoccupied habitat, and has therefore failed to validate the supposition put forth in 1994 that TYC "potentially suitable habitat" is defined as "any parcel containing 30% sand" (CSLC 1994). To address these issues, the emphasis has shifted from a metapopulation approach to managing persistence (number of years TYC present/number of surveyed years*100).

Since protection of stems and habitat on public sites may be accomplished primarily through fencing and education, while a stewardship approach is required on private sites, goals have been modified to separate public and private lands in order to better evaluate success of the different approaches. CS2002 Goal 2—"improve TYC populations"—was linked to the MVP concept to manage sites for specified levels of persistence and stem counts. While Ephemeral sites did maintain lower stem counts than other sites over the survey period (Table 2.2 and section 2.7), stem counts do not necessarily indicate population size because of clonal growth, and they no longer appear to be a strong predictor of persistence. Instead, protecting existing TYC plants and habitat, especially at sites near creek mouths, appears to offer the most realistic way to ensure TYC persistence. Minor modifications were also made to CS2002 Goals 4–6 to improve relevancy.

5.2. Objectives

As in CS2002, each goal is tied to objectives, but these have been updated to be more specific, measurable, achievable, and realistic within a specified timeframe. For all objectives, the timeframe is the 10-year period of the MOU which expires on June 1, 2023 (Appendix A). Objectives were developed by working backwards from the range of available management actions, stewardship products and approaches, and restoration tools. For instance, success in promoting stewardship on private lands (Goal 2) may be measured by the level of enrollment in the Stewardship Program (Objective 2.1), but also by tracking unique hits on the TYC website (*www.tahoeyellowcress.org*) (Objective 2.2) or measuring media coverage in response to press releases (Objective 2.3). Success in managing TYC occurrences for persistence (Goal 3) may be measured through survey data analysis (Objective 3.1), and also by the number of sites maintained free of invasive weeds (Objective 3.3) or number of projects implemented at creek mouths (Objective 3.4). In cases where there is no existing tool, the objectives may provide direction on research needs (Objective 4.2 Conduct DNA analysis) or a data gap (Objective 5.4 Develop monitoring strategy on recreation impacts). For each objective, Table 5.1 specifies the monitoring variable, the measurement frequency, and the desired direction of change. These goals and objectives may be further refined within the adaptive management process.

Goal 1 Protect TYC plants and habitat on public lands

Objectives:

1.1 Maintain appropriate permanent or temporary enclosures or fencing

1.2 Utilize visitor, employee, and permittee education (signs, kiosks, brochures, and trainings) to raise awareness of TYC and minimize trampling of stems and habitat

1.3 Utilize on-site security measures (patrols, law enforcement, and violation reporting mechanisms) to reduce impacts from recreation

1.4 Explore options for establishing TYC Refuge Areas that protect TYC habitat, especially at stream mouths

Goal 2 Promote stewardship, protection, and awareness of TYC on private lands

Objectives:

2.1 Maintain or increase enrollment of private lakefront homeowners in the Stewardship Program

2.2 Increase visibility of the TYC website (*www.tahoeyellowcress.org*)

2.3 Promote coverage of TYC conservation activities and survey and research results via local news outlets, social media, and the annual TERC State of the Lake Report

2.4 Promote raking guidelines that avoid and minimize damage to TYC stems and habitat (Appendix G)

2.5 Develop a programmatic Safe Harbor Agreement in California with CDFW

Goal 3 Manage TYC occurrences to promote persistence

Objectives:

3.1 Maintain or increase the average persistence of Core and High sites (number of years TYC present/number of surveyed years*100)

3.2 Maintain a supply of viable TYC seed and container-grown TYC to conduct plantings as necessary for population enhancement/creation and Stewardship

3.3 Control the spread and prevent the introduction of invasive weeds that compete with TYC

3.4 Focus management on TYC occurrences at stream mouths

Goal 4 Utilize key management questions (KMQs) to direct research that supports management and conservation

Objectives:

4.1 Develop KMQs to guide management and conservation over the next 10 years

4.2 Conduct microsatellite DNA analysis of 2009 TYC leaf samples to increase understanding of TYC dispersal patterns and genetic architecture

Goal 5 Continue the adaptive survey strategy

Objectives:

5.1 Conduct lake-wide surveys of known and historical TYC sites in all years when lake level exceeds 6,226 ft (1,897.7 m) LTD; at lower lake levels, survey every other year

5.2 Utilize survey data to maintain site viability rankings

5.3 Develop monitoring strategy to evaluate geomorphic beach processes, especially those at creek mouths or outflows that form berms and swales

5.4 Develop monitoring strategy to evaluate impacts from recreation

Goal 6 Continue the adaptive management process

Objectives:

6.1 Continue AMWG internal coordination through regular meetings and email communications

6.2 Continue AMWG coordination with the Executives to secure funding to implement this CS

6.3. Develop guidelines for expedited/emergency fencing projects (*e.g.*, regulatory framework, design specifications, cost estimates)

6.4 Develop analysis methods, significance thresholds, and uncertainty guidelines for assessing potential impacts to TYC stems and habitat from shorezone projects

Table 5.1. Goals and objectives of the TYC CS including the variables that may be measured, measurement frequency, and desired direction of change.

Goal	Objective	Variable	Measurement frequency	Desired direction of change
Goal 1 Protection on public lands	1.1	Number of enclosures and condition	annual	stable
	1.2	Number of signs, kiosks, brochures, press releases, trainings	annual	stable or increase
	1.3	On-site security measures	quarterly	as needed
	1.4	Number and size of refuges established	annual	increase
Goal 2 Stewardship Program	2.1	Number of Stewardship Plans	annual	stable or increase
	2.2	Number of unique hits on website	quarterly	stable or increase
	2.2	Website content tracking	bi-annual	stable
	2.3	Number of press releases	annual	increase
	2.4	Number of stewards that adopt raking guidelines	annual	increase
	2.5	CDFW Safe Harbor Agreement	n/a	develop
Goal 3 Persistence of TYC sites	3.1	Number of years TYC present/Number of years surveyed*100	only when the survey record has equal years of low and high lake levels	stable or increase
	3.2	Number of seed and/or container-grown TYC	as needed	as needed
	3.3	Number of sites maintained free of invasive plants	as needed	stable or increase
	3.4	Number of management actions at creek mouths	annual	stable or increase
Goal 4 Key Management Questions	4.1	Report on KMQs through 2023	annual	develop
	4.2	Peer reviewed work on DNA	n/a	develop
Goal 5 Adaptive survey strategy	5.1	Survey when lake is >6,226 ft (1,897.7 m) LTD or every 2 years	annual (or every 2 years)	stable
	5.2	Recalculate site viability indices (SVI)	only when the survey record has equal years of low and high lake levels	stable
	5.3	Monitoring protocol for recreation impacts	annual (or every 2 years)	develop
	5.4	Monitoring protocol for geomorphic processes	annual (or every 2 years)l	develop
Goal 6 Adaptive management	6.1	Number of AMWG members and/or meetings	annual	maintain
	6.2	Executives meeting	annual	maintain
	6.3	Fencing guidelines	n/a	develop
	6.4	Shorezone project review guidelines	n/a	develop

5.3 Management Actions

The suite of management actions available for TYC has grown tremendously since the implementation of CS2002 and now includes both *in situ* (on-site) and *ex situ* (off-site) measures. *In situ* conservation measures protect TYC in its natural habitat and include the first four actions identified: fences and signs, establishment of Refuge Areas, education and outreach, and appropriate habitat management and restoration. New tools have emerged for *ex situ* conservation of TYC directly from field research conducted since 2002 that developed and/or refined methods for TYC seed collection, greenhouse propagation, outplanting, and translocation. To achieve the goals and objectives above, public land managers must prioritize *in situ* conservation that sustains TYC in its natural habitat. *Ex situ* actions on public lands should be considered when *in situ* conservation is insufficient to ensure species viability and when projects require mitigation. On private sites, *ex situ* conservation measures like outplanting of container-grown TYC may be used as part of a suite of approved conservation practices in the Stewardship Program to augment an existing population or to plant in an area where habitat is present, but TYC does not occur.

The strong influence of lake level on persistence and stem counts means that managers must first evaluate potential management actions with respect to predicted lake level. The biggest threats to TYC occur when lake levels are high, predicted occupancy is low, and there are likely few TYC stems at occupied sites. Under high water conditions, management actions that protect existing TYC, minimize recreation impacts, control competition with other vegetation, and increase stem counts may be applied. Core and High sites are the most persistent across all lake levels and should be a focus of management.

It will be the job of the AMWG and individual land managers to select from among the actions listed below as necessary to address specific objectives of CS2015. Participants in the Stewardship Program may also select from these actions for purposes of general conservation or for addressing TYC in their permitted projects in the shorezone. Regulatory agencies may also choose from among these tools in designing mitigation for public EIP or private projects in the shorezone.

5.3.1 Fences and enclosures

Permanent and temporary enclosures and fencing have remained one of the most important tools for protecting TYC at heavily used public sites. They protect important habitat for TYC across all lake levels, but particularly when the level of Lake Tahoe is high (>6,226 ft (1,897.7 m) LTD).

All fences in the shorezone on public (non-federal) and private lands must meet the TRPA design standard to have 90% open space and must be maintained to be free of debris (TRPA 2013; Code 84.12.2). Best management practices for fencing TYC include:

- Maintain fencing and signs in good condition;
- Regularly remove trash and weeds from inside fencing;
- Develop on-site security measures when necessary; and
- Where possible, utilize temporary fencing that can be moved as lake levels fluctuate to protect optimal TYC habitat close to the water.

The maintenance of fencing in good working condition is essential to fulfilling their intended purpose to protect TYC from trampling. While enclosures provide the highest level of protection, there are certain situations (*e.g.*, moving creek mouths, access corridors) where they may not be feasible; partial fences or other barriers are still recommended to provide some level of protection. Maintaining associated signs and kiosks with legible text and good quality photos is important to public perception and provides an opportunity to educate beach users about TYC and its unique place at Lake Tahoe (Figure 5.1).

Figure 5.1. Examples of TYC enclosure signs for Sugar Pine Point State Park (A) and USFS signs for research plantings with legible text and photos (B).

The enclosure on CTC lands at the Upper Truckee Marsh provides a good example of the benefits of utilizing retractable fencing and on-site security measures. Since it was installed in 2000, it has protected 40% of the lake-wide stem count on average (Appendix C). When Lake Tahoe is low, the beach becomes very wide and sediment carried by the Upper Truckee River creates an extensive network of sandy berms (Figure 5.2A). In contrast, when the lake is near capacity, the water line abuts the meadow and available habitat is confined to a narrow strip (Figure 5.2B).

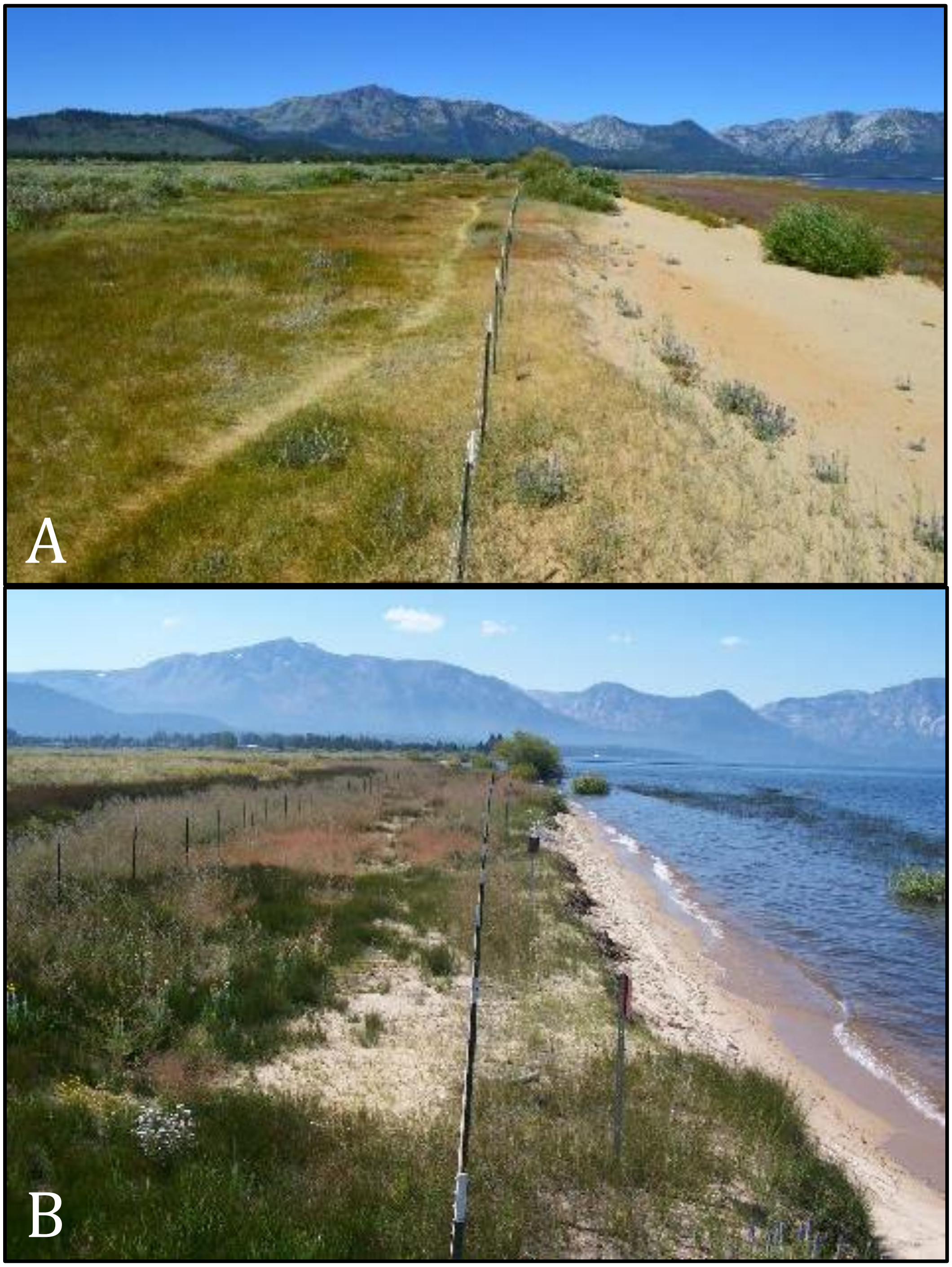

Figure 5.2. The CTC enclosure at the Upper Truckee Marsh looking west in June 2014 with a lake surface elevation of 6,223 ft (1896.8 m) LTD (A) and west in September 2006 with a lake surface elevation of 6,228 ft (1898.6 m) LTD (B).

The beach at UTE receives moderate recreation use and outside of the fence there is considerably less vegetation than in the enclosure, which supports a diverse plant community of TYC and other native and non-native species. The permanent part of the fence runs parallel to the water on the edge of the meadow. Under high lake levels foot traffic is confined to the meadow outside of the enclosure. At lower lake levels, temporary signs are used to demarcate the lakeward edge of the enclosure and allow for beach access between the enclosure and the water and also in the meadow outside of the enclosure (Figure 5.3). Moving the signs every year in response to lake level is labor intensive, but provides a flexible way to protect as much of the habitat as possible, while still allowing access. CTC maintains an informational kiosk on the values of the wetland and, since 2003, has utilized a site steward that patrols during the summer months, conducting user interviews, advising people to remain outside the enclosure, and providing education to the public about the natural resources at the marsh.

Figure 5.3. Temporary signs demarcate the lakeward edge of the CTC enclosure at the Upper Truckee Marsh. Note the permanent fencing in the background.

5.3.2 Refuge Areas

The idea of establishing special TYC Refuge Areas arose from the observation that in low lake level years, large numbers of TYC stems and quantities of seed were present in habitat near the water's edge and especially at creek mouths; but the permanent fences on public lands are generally located above the high water line and protect only a portion of TYC habitat and stems (Figure 5.4 A, from Stanton and Pavlik 2007). With a TYC Refuge Area, movable signs and natural barriers can be used to demarcate the important habitat that occurs around the stream environment zone (SEZ) near the lake that encompasses both the low lake "seed factory" and higher lake level habitat (Figure 5.4 B).

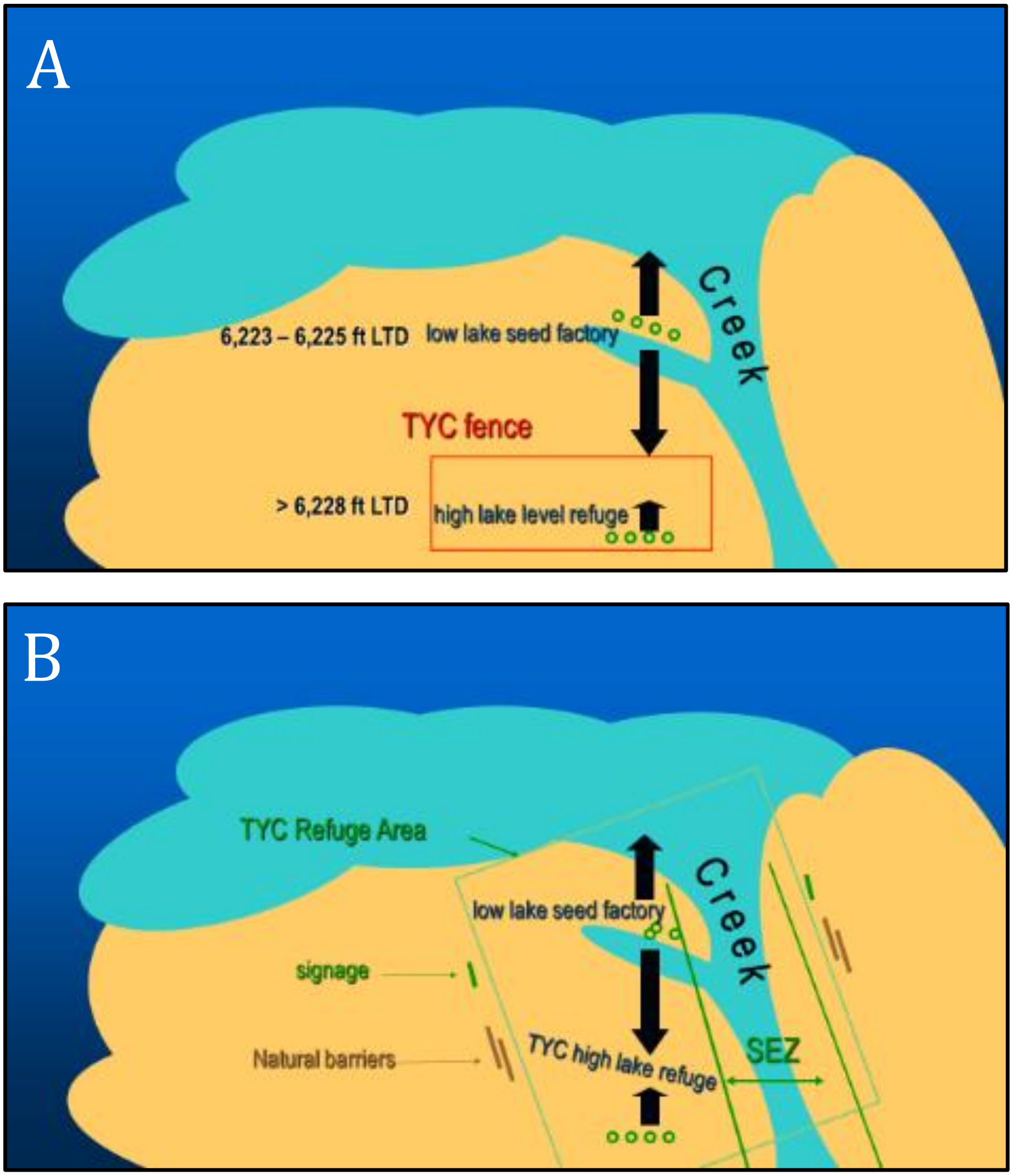

Figure 5.4. Schematics of a typical TYC enclosure fence that only protects a portion of available TYC habitat and stems (A) and of a TYC Refuge Area on a public beach at a creek mouth that protects all available TYC habitat and stems within the stream environment zone (B).

Best management practices for establishing a TYC Refuge Area (RA) include:

- Select sites at the mouth of a creek that support TYC;
- Position RA boundary to capture as many TYC as possible;
- Utilize temporary, interpretative signage to demarcate the boundary of the RA;
- Strategically place large natural barriers (rocks, logs) that are difficult to move on the RA boundary to deter use;
- Maintain signs in good condition;
- Regularly remove trash and weeds from inside RA; and
- Develop on-site security measures, when necessary.

5.3.3 Education and outreach

Improving public awareness about TYC and its unique place at Lake Tahoe is a critical part of the strategy to protect and conserve TYC on both public and private beaches. TLOA has played a large role in promoting TYC awareness among its members and has incorporated TYC education into annual meetings and workshops. In 2009, the AMWG worked with the Natural Resources Conservation Service (NRCS) to obtain grant funding to provide technical assistance to private property owners that allowed production of 10,000 tri-fold brochures called “A Unique Piece of Tahoe: Tahoe yellow cress”, with a second batch printed in 2010 (Figure 5.5). These brochures are still in use by the Stewardship Program and are made available at several public beaches and the offices of many AMWG member agencies.

Figure 5.5. Three panels of the tri-fold brochure "A Unique Piece of Tahoe: Tahoe yellow cress" created in 2009.

In 2009, the AMWG also developed a website to serve as a comprehensive source of information about TYC life history, research, conservation, and the AMWG partners with links to each organization's website. The website address, *www.tahoeyellowcress.org*, appears on the brochure. NTCD re-designed the website in 2012 to include a page dedicated to the Stewardship Program and a contact form for requesting information from NTCD.

Best management practices for education and outreach include:

- Utilize visitor education (signs, kiosks, and brochures) at public beaches to raise awareness and minimize trampling;
- Install kiosks at Core and High priority sites, where possible;
- Promote beach raking guidelines (Appendix G) that minimize damage to TYC stems or habitat;
- Increase visibility of *www.tahoeyellowcress.org*;
- Promote coverage of TYC conservation activities and survey and research results in local news outlets, social media, and in the annual State of the Lake Report issued by TERC (*http://terc.ucdavis.edu/stateofthelake/*);
- Incorporate TYC into other education programs (Lake Tahoe Water Trail, BMP programs, boat inspection, Master Gardener, TLOA member outreach, employee orientations); and
- Incorporate TYC education into beach operator permits (TRPA, USFS).

5.3.4 Beach raking guidelines

Beach raking is a common practice on many types of properties around the lake and is one of the most prevalent direct threats to TYC. Beach raking occurs on multiple scales from single residence parcels to long stretches of public or private beach. On larger beaches, mechanical equipment is used to clean off all vegetation, beach wrack, and debris and leave only sand. The following guidelines can help landowners identify TYC and take steps to avoid damage to TYC from raking. These guidelines are repeated in Appendix G in Spanish and English and include a photo of TYC.

1. Conduct a visual survey of your property for evidence of Tahoe yellow cress (TYC):

    a. TYC is a small, fleshy plant with small yellow flowers with four petals, growing close to the ground. TYC has been observed in flower from May to October.
    b. The size of a TYC colony can vary from a single stem to many stems that seem to form a mat.

   c. TYC is typically found on sandy beaches in full sun, especially near the water's edge, stream mouths, and depressions where soil is moist.

2. When removing beach litter:
   a. Remove litter and debris by hand or with a soft leaf rake.
   b. Avoid removing plants and minimize disturbance to the sand surface where TYC seeds may lie.

3. If TYC is thought to occur on your property and you would like a TYC survey conducted, or if you have any questions, please contact NTCD at 775-586-1610.

5.3.5 Habitat management and restoration

Management of TYC habitat may include any of the actions listed in Section 5.3. Actions that raise awareness of TYC, minimize recreation impacts, discourage raking, and increase stem counts may be applied according to the best management practices listed. In addition, TYC is subject to competition with other vegetation as described in section 2.8.3, and hand removal of competing vegetation may be a necessary habitat management tool under high lake levels when the amount of TYC habitat is low.

While occupied TYC habitat can be managed in various ways, what it means to restore TYC habitat is not known. At the landscape scale, the habitat of TYC will continue to be altered without the restoration of a natural water fluctuating regime at Lake Tahoe. Restoration of that regime would necessitate removal of the dam at Tahoe City, which is infeasible due to legally-binding agreements that grant use of the stored water to downstream stakeholders. Therefore, potential restoration actions can only address other aspects of TYC habitat that are generally not well understood, including substrate and geomorphic beach processes that increase access to subsurface water and create berms and swales.

It is not clear if it is feasible to restore/modify the substrates in the shorezone in a manner that would be beneficial to both TYC and Lake Tahoe. Actions that scour the beach and lower its elevation would make it easier for potentially colonizing TYC to access the groundwater table and become established. For instance, TYC was observed to rapidly colonize an area of beach adjacent to Edgewood Golf Course that collapsed after intense storms in January 2006 (Figure 5.6). Likewise, TYC rapidly colonized the rock-lined outfall of a storm drain that was built for a large erosion control project (see Figure 3.3).

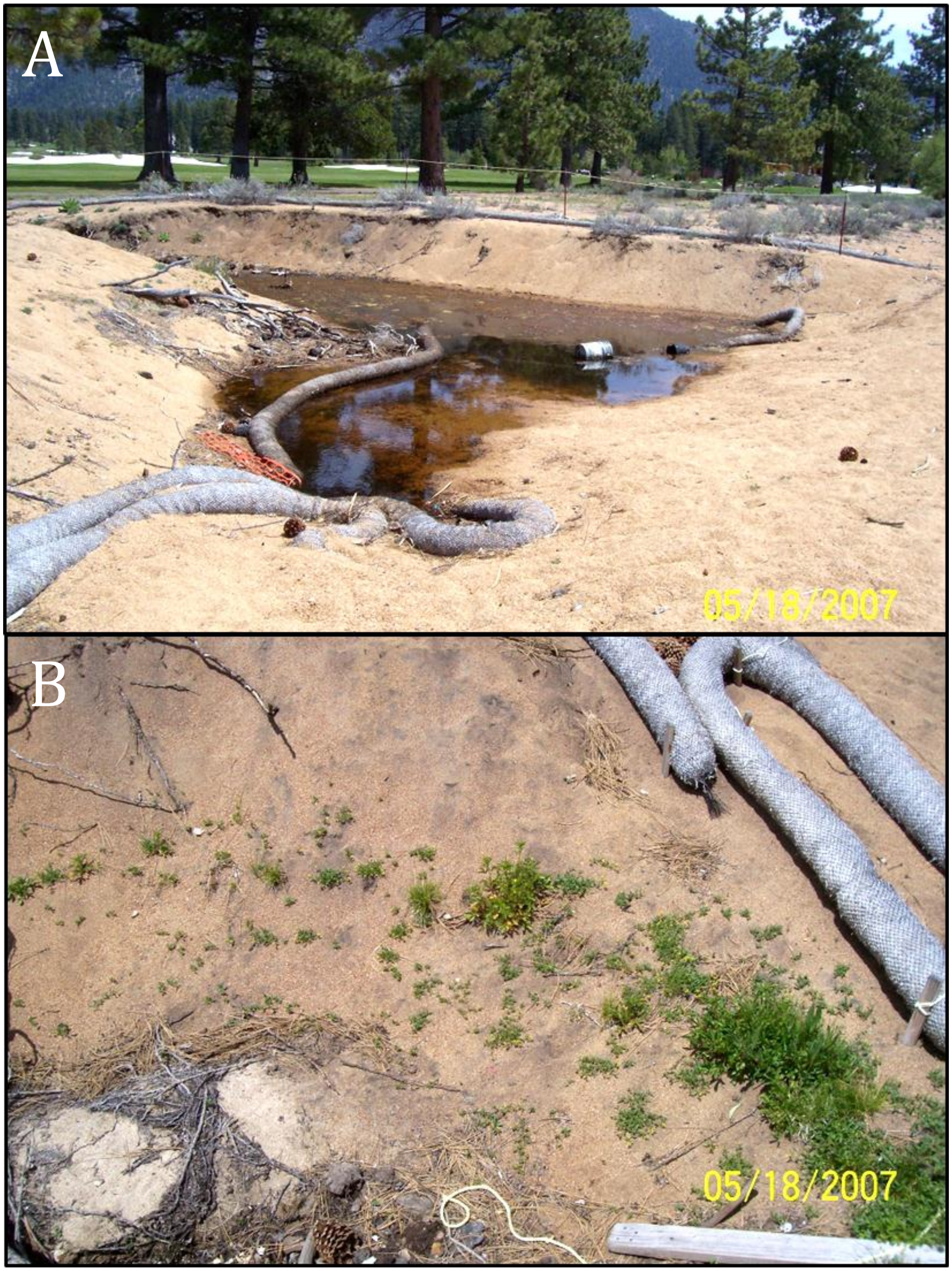

Figure 5.6. A beach collapse that occurred in January 2006 at Edgewood Golf Course brought the water table to the surface (A) and allowed TYC plants to colonize (B).

For the Core and High sites that occur around creeks, processes occurring in upstream reaches of the creeks probably have the ability to alter flows and sediment delivery, but the potential impact on TYC has not been evaluated. Flood events might foster the creation of swales in the forebeach, but would also destroy existing TYC. Developing a monitoring strategy to evaluate geomorphic beach processes, especially those at creek mouths or outflows that form berms and swales is Objective 5.3 under Goal 5 to continue the adaptive survey strategy.

One restoration action that might clearly benefit TYC is stopping beach raking. Once raking stopped, it is not known if TYC would colonize a parcel that has been continuously raked for years or decades. If raking represents a temporary habitat modification that does not modify the substrate in any substantial way, then TYC should be able to colonize after raking stops if the recreation impacts were not too great. If raking does in fact change the substrate in some way, then restoration would require returning the substrate to its original condition.

Best management practices for TYC habitat management include:

- Control competition with TYC by hand removing invasive weeds and plants;
- Evaluate beach maintenance actions and discourage raking and other practices that remove TYC;
- Evaluate recreation patterns to identify opportunities to protect TYC from trampling and minimize impacts; and
- Evaluate geomorphic beach processes to identify potential actions that might scour areas of the beach to increase TYC access to subsurface water.

5.3.6 Seed collection and banking

Restoration efforts are not limited by seed availability because TYC stems produce thousands, if not millions, of seeds in a single season, and these are readily gathered, sorted, and stored (Pavlik *et al.* 2002a). As discussed in section 2.3, seed source likely does not play a biologically-significant role in determining the success of container–grown plantings of TYC, and multiple or geographically-stratified seed sources or seed transfer guidelines are not likely required for TYC restoration efforts. Nonetheless, there appears to be limited genetic variation among TYC populations, and seed collection should utilize seed from multiple sites when possible in order to preserve unique alleles.

TYC seed or plant collection activities occurring on the California side of Lake Tahoe for the function of scientific, educational, or management purposes require a permit or other authorization from CDFW pursuant to the California Endangered Species Act (CESA) or California State Safe Harbor Agreement Program Act (Fish and Game Code Sections 2080 and 2089.2). Such activities may be subject to specific requirements associated with the individual permit or authorization from CDFW.

General TYC seed collection best management practices include:

- Obtain appropriate collecting permit(s);
- Collect seed from no more than 10% of the total available seed at any site, or according to specific permit conditions;
- Collect from stems in a wide range of sizes and from as many different microhabitats as possible (*e.g.,* close to the lake, berms, swales, any unusual features);
- Collect fruits that are as dark and dry as possible, including dehiscing fruits;
- Individual fruits may be harvested by hand, but shaking the leaf stems inside of a manila envelope also works to dislodge mature and dehiscing fruits;
- Store fruit and seed samples in dry manila envelopes (never in plastic) labeled with collection site and date at room temperature;
- Clean sample using tweezers and soft brushes to separate seeds from chaff; and
- Clean dry seed may be stored in small plastic tubs or petri dishes.

TYC seed have been banked at the Rae Selling Berry Seed Bank and Plant Conservation Program maintained at Portland State University. The Rancho Santa Ana Botanic Garden in Claremont, California, also stores TYC seed (Figure 5.7).

Figure 5.7. TYC seed under magnification and fruits photographed at the Rancho Santa Ana Botanic Garden. Photo by John McDonald.

5.3.7 Greenhouse propagation

Compared to many other rare plants, TYC are easy to grow and maintain. The key to producing vigorous container-grown TYC is applying regular water during the growth season and giving the containers enough space to develop good root structure (Figure 5.8). Once plants are established they can be used in the same year or held over the winter in the greenhouse or outdoors. When they are held over the winter in the greenhouse plants will continue a reproductive cycle and readily produce seed.

Figure 5.8. Root structure of a container-grown TYC plant.

Best management practices for propagation of TYC are as follows:

- Sow seeds at least 5–6 months in advance of outplanting (*i.e.*, by January for a June planting);
- Sow a small number (±10) of TYC seed in plastic supercell containers (10 cu in volume; 1.5 inches (3.8 cm) diameter, 8.5 in (21.5 cm length) filled with standard greenhouse soil-less potting mix;

- Top dress with light layer of vermiculite to hold seeds in place;
- Keep cells in greenhouse and mist daily to saturation with water (enrichment with standard nutrient solutions is fine);
- Once germination has occurred and plants are leafy and beginning to flower, plants may be moved to a lathe house;
- Use hand watering or standard drip irrigation on established plants to maintain moist soil;
- Thin plants from each container, as needed, to keep TYC plants from getting elongated and spindly;
- When using a 98-cell rack to hold containers (Figure 5.9), increase space between vigorous TYC to every other cell; and
- Allow 5–6 months for good root development (Figure 5.8) before outplanting.

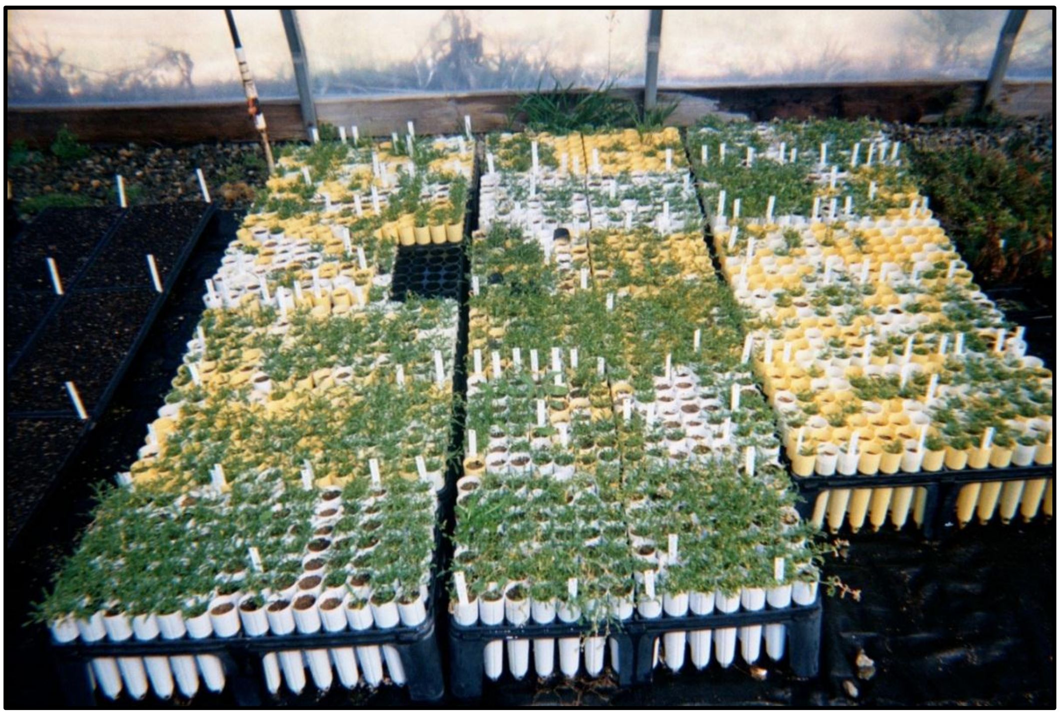

Figure 5.9. Container-grown TYC in the greenhouse at the NDF Washoe Nursery.

5.3.8 Outplanting container-grown plants

Outplanting container-grown TYC may be used to enhance an existing TYC occurrence, create a new occurrence, or to fulfill a component of mitigation. TYC outplanting activities occurring on the California side of Lake Tahoe for the function of scientific, educational, or management purposes require a permit or other authorization from CDFW pursuant to CESA or the California State Safe Harbor Agreement Program Act (Fish and Game Code Sections 2080 and 2089.2). Such activities may be subject to specific requirements associated with the individual permit or authorization from CDFW.

When considering outplanting to increase stem counts, managers must consider predicted lake level in the coming growing season in planning as one of the most important factors. Many sites that provide habitat in low lake elevation years have no habitat in transitional or high lake level years. Decreasing impacts from recreation by protecting existing or outplanted TYC from trampling is probably the next most important factor that increases the chance of project success. The effect of other factors like amount of shade, proximity to a creek mouth, and presence of naturally-occurring TYC or competing vegetation have less clear effects on the performance of out-planted TYC, but should be considered in project planning.

To maximize the probability that outplanted (or translocated) TYC can access subsurface water, the elevation profile of the beach should be assessed and plants should be established within 4.9 ft (1.5 m) of the water level. Planting elevation was a top predictor variable in the multivariate analysis of survival and reproduction of the 2003, 2004, and 2006 cohorts, such that plants generally had better establishment and growth at lower elevations (Appendix B). However, planting too close to the water increases the risk of inundation and having plants washed away.

The most accurate way to assess elevation is to use a laser level and site it from different locations on the beach on a measurement pole that is placed just within the water. Handheld GPS will not have sufficient accuracy, but a Trimble™-type GPS would probably work. Increments of less than 1.6 ft (0.5 m) are not necessary to get a useful elevation profile. The calculations are made by adding the height measured on the pole to the lake level that day. The best time to do this is when the lake is at low elevation near the end of the growing season in the fall (September or October) before the project. However, it can be done at any time because the calculations are relative to the water level and can easily be adjusted to the water level during project implementation. When setting project goals, it is important to reference elevations relative to the lake level (*i.e.*, plus or minus) to build in flexibility that can accommodate lake fluctuations.

Next, it is necessary to evaluate substrate by digging several pits at site. Outplanting and translocation projects should site plantings away from existing vegetation and consider including weed management actions (*e.g.*, manual pull within 5 ft (1.5 m)) during TYC establishment.

As with any planting project, managers should strive to produce high vigor container-grown TYC. The quality of the container-grown plants was a top predictor variable in the multivariate analysis of survival and reproduction of the 2003, 2004, and 2006 cohorts, such that plants with higher vigor generally had better establishment and growth (AppendixB). Vigor is primarily assessed by the quality and amount of root development. Shoot health can look poor in container-grown TYC that have already completed a reproductive cycle, but if there is good root development the plants will have a better chance at establishment.

Timing of plantings may influence survival and reproduction. The regulatory window for TYC surveys and activities extends from June 15 to September 30. Monthly experimental plantings in 2008 and 2009 suggest that planting in June or July results in better plant survival and reproduction than August or September (Appendix B). The level of Lake Tahoe usually peaks in June (or July in very wet years) and presumably the greater water availability during that time facilitates establishment of container-grown plants. Likewise, water availability presumably declines as the season progresses and lake level drops. At a site with sandy substrate and a shallow depth to the water table (*e.g.*, UTE), a plant outplanted in June may grow about five times larger than a plant put in the ground in August or September. However, some sites appear to provide suboptimal habitat where reproduction fails regardless of planting time.

Best management practices for outplanting container-grown TYC at Lake Tahoe:

1. Use high quality container-grown TYC with good root development. Poor root development appears to decrease the chances of TYC survival, but phenology (vegetative, flowering, fruiting, senescent) does not appear to influence performance.
2. Prime the planting area with water until thoroughly wet. This watering makes it possible to dig a hole in sand without it collapsing.
3. Use a planting dibble or a long-nosed shovel (sharp shooter) to make an opening in the sand, at least as deep as the tube. If a larger pot is used, the hole will need to accommodate the entire root mass.
4. To remove the TYC from the tube, use a box knife to slice open the tube, taking care to not go any deeper than necessary and avoid cutting through roots. Extract the root mass, doing your best to keep protruding roots and the soil-less potting mix intact (Figure 5.10).
5. Loosen the bottom of the roots gently with fingers, if plants are root bound. Less vigorous root systems require less manipulating and the soil tube may fall apart (using this type of plant is not advised).

6. Orient roots vertically in the opening in the sand, leaving the plant at or slightly below sand surface level.
7. Fill in the hole around the plant with sand and make sure no roots are exposed and the plant is not elevated above the soil surface.
8. Apply water all around plant to saturation using water from Lake Tahoe. Plant should not sink into a deep bowl and all foliage should be exposed (Figure 5.11).
9. Watering for 3 days after planting has been shown to allow for good survival. Longer water periods were not tested, but would likely support increased survival, especially during periods of hot, dry weather.

Figure 5.10. Planting a container-grown TYC with an intact soil tube.

Figure 5.11. Watering a container-grown TYC.

Best management practices for site selection to increase establishment of container-grown TYC:

- Choose a location where the sandy substrate is constantly damp at a minimum 9-in (22 cm) depth, which is just slightly deeper than the length of the container.
- Plant in full sun in open environments with no competing vegetation.
- Sandy substrates appear to provide the best habitat, but the surface appearance can be deceiving. Dig in multiple places to determine if the subsurface has cobbles and select spots with finer subsurface material.
- Establishment may improve in locations in close proximity to a creek or source of sub-surface water.

Other planning best management practices for planting container-grown TYC:

- Planting earlier in the growing season near peak lake level increases the length of time a plant has to establish and increases potential for reproduction. In drier years, Lake Tahoe reaches a peak in early June, in wet years it may peak in July. Check the level at: *http://www.waterdata.usgs.gov/ca/nwis/uv?site_no=10337000*.
- Protect plants with fencing and/or use the approved sign from the Stewardship Program for private property.

- Sites on the east and north shore are drier, and it may be beneficial to extend the watering period beyond 3 days if resources are available.

5.3.9 Translocation of naturally-occurring TYC in mitigation

Translocation involves moving established plants in the field from one location to another. It has been used as a salvage measure to preserve individuals when habitat is disturbed or destroyed. The potential use and effectiveness of translocation as a mitigation tool is a critical management concern due to the many EIP projects—current and future—that could impact the shorezone environment, particularly at creek mouths that support core TYC populations. In particular, SEZ restoration is under consideration for the Upper Truckee River, Blackwood Creek, Ward Creek, and Tallac Creek.

TYC translocation activities occurring on the California side of Lake Tahoe on non-USFS lands for the function of scientific, educational, or management purposes require a permit or other authorization from CDFW pursuant to CESA or the California State Safe Harbor Agreement Program Act (Fish and Game Code Sections 2080 and 2089.2). Such activities may be subject to specific requirements associated with the individual permit or authorization from CDFW.

Many translocation projects with other rare plants have lacked a rigorous experimental component and adequate monitoring, and are often undertaken with little or no knowledge of the horticultural requirements or genetic architecture of the species (CNPS 1998). However, TYC was a good candidate for translocation research for three reasons. First, the horticultural requirements of TYC have been determined through nursery propagation (Pavlik *et al.* 2002a). Second, genetic studies using allozymes concluded that TYC has very little genetic variation and that the experimental plantings in 2003 and 2004 had adequately captured the limited genetic variation (Saich and Hipkins 2000; DeWoody and Hipkins 2004, 2006). Therefore, genetic contamination through outplanting efforts is not likely a concern. Third, a great deal has been learned about the optimal techniques, plant characteristics, habitat conditions, and logistical factors that optimize the chances for successful outplantings of container-grown plants.

Pilot-scale translocations of 56 TYC in 2005 and 68 TYC in 2006 demonstrated that previously outplanted TYC would survive being moved within and between sites (Pavlik and Stanton 2009a). Experimental translocations conducted from 2007 through 2009 compared the methods of translocation and outplanting of container-grown plants to determine if translocation of naturally-occurring TYC and outplanting of container-grown TYC result in the same rates of survival and reproduction. The results suggest that survival rates may not vary, but container-grown plants have better growth and reproduction (Appendix F). In optimal habitats where there is a shallow depth to the water table, no competing vegetation, and a sandy substrate, a container-grown plant may grow 3 times larger. The implication for mitigation and restoration seem to be that translocation is a viable option, but using container-grown stock gives a greater pay-off of increased growth and seed output. Container-grown plants can also be used in greater numbers and therefore can ensure a higher probability of success.

The better performance of container-grown TYC likely results when the soil from the potting tube stays intact as the plant is placed in the ground because the roots are holding it together in a conical shape (the soil tube will fall apart if there is poor root development). An intact soil tube probably helps buffer the container-grown plant from transplant shock by providing a "sponge" that holds more water than the surrounding sand substrate (see Figure 5.8). In contrast, the process of uprooting a naturally-occurring TYC is an excavation that gradually exposes a bare root structure (Figure 5.12). Bare roots are more likely to desiccate if there is insufficient moisture in the substrate. Translocating TYC to a greenhouse first, and allowing the plants to establish a root system in soil-less potting mix before outplanting, would likely increase plant performance to comparable levels as container-grown plants started by seed, but this method has not been tested experimentally.

An additional factor in translocation of TYC, is that its clonal growth form makes it virtually impossible to manually remove the entire root from the ground. The roots may be composed of one to many root stems and some degree of fine root network (Figure 5.13). Eventually the main root stem breaks, sometimes after only 4 in (10.2 cm) of root have been exposed, other times after more than 20 in (50 cm) is visible. At Pope Beach, over half (35) of the 50 TYC that were translocated in May 2009 were observed to re-sprout later in the growing season, but the plants were no longer protected in fencing, so their performance was not quantitatively assessed (Stanton and Pavlik 2010).

Figure 5.12. Extracting a TYC at Tallac Creek in June 2009.

Figure 5.13. The exposed root system of one TYC plant translocated at Upper Truckee East in June 2009.

Through the multiple experiments from 2004 to 2009, the following best management practices were developed.

Best management practices for extraction at donor location:

- Insert a sharp-shooter shovel into the sand several centimeters away from the above-ground canopy of the TYC of interest. Take care to cut outside of the zone of the perceived rootmass.
- Grasp the above ground cluster of stems, plant canopy, and the rootmass and slowly extract with a rocking motion of the shovel to capture as much root structure as possible and minimize damage. Very little soil may cling to the roots once exposed because of the sandy nature of the substrate (Figure 5.12).
- Place plants in a moist plastic bag and kept in the shade until all plants are extracted.
- Transport immediately to the receptor site or to greenhouse for planting in containers.
- Place TYC in pots large enough to accommodate the root mass if plants are transferred to a greenhouse after translocation. A 1 gallon (3.8 liter) pot may be sufficient.

Best management practices for planting at a receptor site:

- Pre-water the planting area to allow digging of a hole approximately 1 ft (0.3 m) deep to accommodate the extended rootmass.
- Secure in the ground with sand, taking care not to coil the roots.
- Hand water for 3 days following the translocation; use buckets of lake water and apply slowly to the planting area.

6.0 TYC Stewardship Program

Forty four percent of the 50 TYC survey sites occur on private lands (see Table 7.1); therefore, TYC cannot be fully protected without stewardship by private landowners. In many cases, the primary barrier to conservation of TYC on private lands is a lack of awareness. Many lakefront property owners do not know what TYC is, what it looks like, or that raking their beach may destroy habitat and kill a plant considered rare and endangered by the States of California and Nevada. Others may be concerned that having a state-listed endangered plant on their property will hinder or prevent their development projects in the shorezone.

A great deal of progress has been made with private property stewardship since the implementation of CS2002, but TYC conservation on private lands will continue to be a central challenge. The Stewardship Program was implemented to address the concerns of private lakefront owners and provide a formal way for them to participate in the conservation of the unique plant that grows on their beaches.

In 2009, the TYC Stewardship Program was developed through a cooperative effort of NRCS, NTCD, TLOA, and the AMWG. The Stewardship Program provides lakefront landowners an opportunity to choose from a range of TYC conservation measures and create a completely customized plan for TYC on their property. Elements of a Stewardship Plan include a site assessment, approved conservation practices, habitat restoration measures, and monitoring. Approved conservation measures are based on the NRCS National Conservation Practice Standards (Code 643 Restoration of Rare or Declining Habitats; NRCS 2010). The AMWG customized the general practices specified in the NRCS code to address the unique conditions and regulatory constraints in the shorezone at Lake Tahoe and to meet the specific conservation needs of TYC.

The NTCD has been the primary entity to work with private property owners. Any lakefront landowner may request a TYC site assessment from NTCD to develop a Stewardship Plan. Stewardship Plans are voluntary and information is confidential. TRPA will consider Stewardship Plans in the permitting process for private landowners with a project that occurs in the shorezone.

It is still relatively early for evaluating the impacts of the Stewardship Plans and plantings of container-grown TYC. In 2011, NTCD completed 37 Stewardship Plans and conducted outplantings of TYC at 8 properties. NTCD also expanded its Backyard Conservation Program to include TYC education and outreach. In 2013, NTCD completed 10 Stewardship Plans, conducted plantings at 4 of the properties, conducted volunteer group plantings at an additional 4 locations; and conducted volunteer group seed collections at the Upper Truckee Marsh enclosure and Baldwin Beach. Survival of the plantings in 2013 varied from 0 to over 60%. Monitoring is ongoing to determine the long-term sustainability of outplanting and stewardship efforts.

6.1 Site assessment

The first step in enrolling a property owner in the Stewardship Program is a site visit by NTCD staff to determine if habitat or TYC exists on the property. NTCD staff use maps and/or photos to illustrate areas where TYC and/or potential TYC habitat was found (Figure 6.1). If no habitat or TYC are present, then the property will not be enrolled.

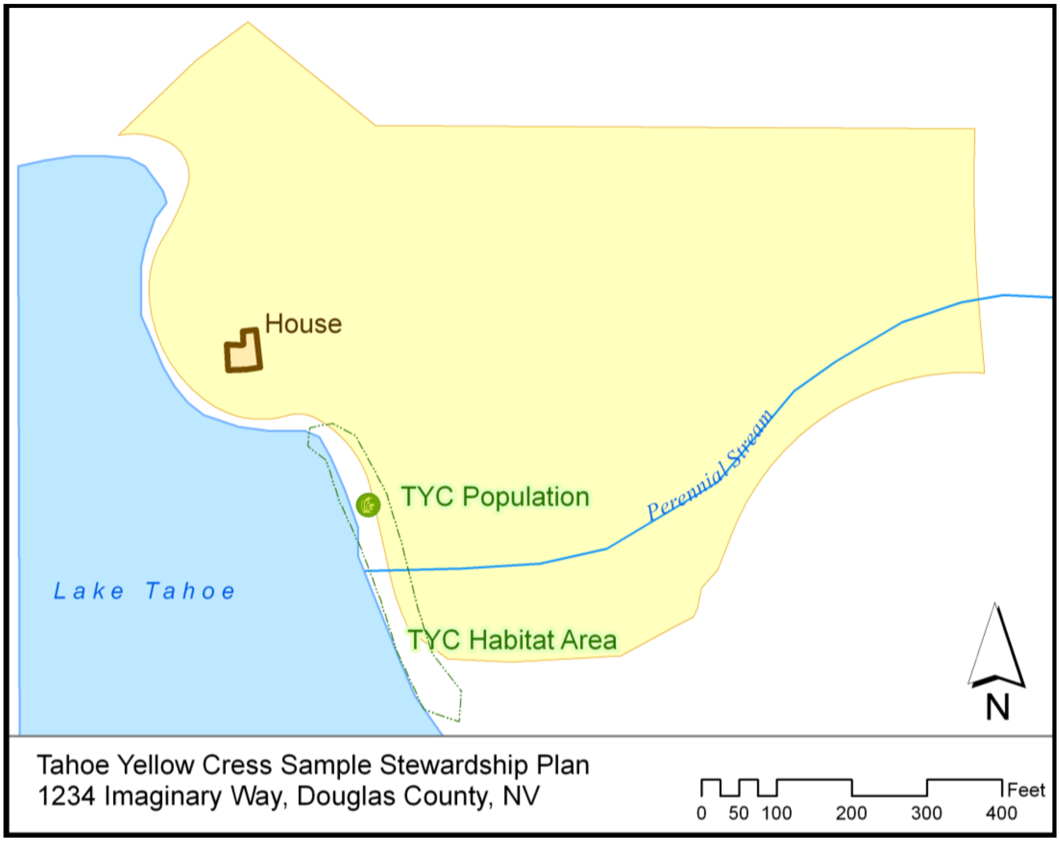

Figure 6.1. Stewardship Program site assessment map for a hypothetical property.

6.2 Approved conservation practices

TYC occurrence can vary significantly with lake levels, such that population numbers decline during years with high lake levels and increase during years with low levels. For this reason the implementation of conservation practices for TYC may vary from year to year depending on lake levels. Conservation measures include habitat protection, habitat restoration and management, and monitoring. Enrolled stewards may choose to implement any of the approved practices, discussed in more detail below, and create a completely customized plan for their property.

6.2.1 Habitat protection

These methods are intended to protect TYC plants or suitable habitat from disturbance by people and pets. Habitat protection measures include physical barriers, signs, and verbal education.

Barriers can be used to impede access to TYC plants or habitat and may include fences or natural boundary markers. Fences are best suited in high traffic areas and should be installed in accordance with local and state law. Rope fences are commonly used in landscaping areas to passively deter foot traffic (Figure 5.2). They can be of any height up to 4 ft (1.2 m) tall and may have from one to four rope strands.

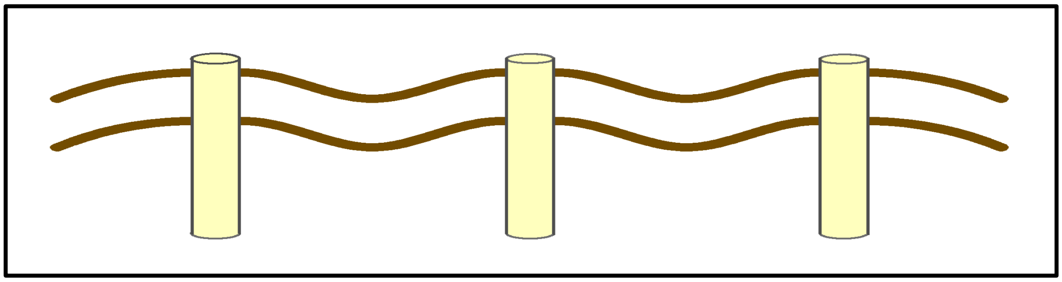

Figure 6.2. An illustration of the rope fence used in the Stewardship Program for demarcating and protecting TYC plants or habitat.

There are also many varieties of retractable fencing available. These fences are typically designed with a self-winding roll for storage when not in use. Designs range from retractable tape that can be stretched between posts to 40 in (102 cm) high retractable banners. Fences crossing public access areas will be limited to the minimum areal extent and installation time necessary to protect the TYC, usually June through September, and should be installed in accordance with local and state law.

Hand placement of boundary markers near TYC plants to discourage trampling or other disturbance is best suited to locations with minimal use. Preference should be given to using natural materials such as driftwood, timber, and rock. Natural boundary markers must be composed of small material that can be hand placed (Figure 6.3). Natural boundary markers should be installed in accordance with local and state law. Manipulation of large rocks and boulders in the shorezone is not allowed by TRPA without a permit.

Small driftwood (less than 4 in (10.2 cm) diameter)

Small rocks (less than 8 in (20.3 cm) diameter)

Figure 6.3. Natural boundary markers used in the Stewardship Program for demarcating and protecting TYC.

Stewards may choose to install the TYC Informational Sign (Figure 6.4) to educate and deter beach visitors from trampling TYC. The sign may be placed in the shorezone of Lake Tahoe provided the sign is within 3 ft (1 m) of TYC stems. All other signs require a permit. NTCD provides signs to stewards as available.

Figure 6.4. The TYC informational sign for use in the Stewardship Program on private property.

Stewards may choose to verbally educate others about conservation practices for TYC preservation and the need to avoid trampling or harming TYC plants on their property. The following public information resources are available to assist:

- Website: *www.tahoeyellowcress.org*
- Brochure: "A Unique Piece of Tahoe: Tahoe yellow cress" available through NTCD
- Informational signs available through NTCD

6.2.2 Habitat restoration and management

Stewards may choose to implement habitat management measures including weed removal, restricting beach raking, and outplanting of container-grown plants.

Invasive species may be removed from the beach in order to reduce competition with TYC and allow for existing population expansion. During the site assessment, NTCD will provide a list of invasive plants that should be removed and native plants that should not be removed. The steward receives the "Invasive Weeds of the Lake Tahoe Basin" brochure and works with NTCD staff on plant identification and removal techniques.

To improve habitat and limit damage to TYC, the steward may choose to restrict beach raking and not rake in areas where there are TYC plants or habitat. Reducing or stopping beach raking will improve the potential for plant survival within TYC habitat.

The steward may choose to plant container-grown TYC to augment an existing population or to plant in an area where habitat is present, but TYC does not occur. NTCD coordinates the planting of TYC, if plants are available.

6.2.3 Monitoring

Current and historical monitoring data for TYC are housed at NNHP in Carson City, Nevada. Stewards may choose to contribute to this program and give consent to furnish monitoring data to NNHP. In contrast, stewards may choose to keep all monitoring information confidential and only allow NTCD data access to further develop conservation practices for the property. Monitoring activities may include an annual site survey or participation in the lake-wide AMWG survey.

The steward may choose to assess the status of TYC plants and habitat on their property every year and either have NTCD conduct the survey or do it themselves. NTCD provides training on TYC identification and proper data collection protocols. Data collection could include a count of the number of TYC stems, a description of actual or potential threats to plants or habitat, and/or annual photo monitoring. Photo monitoring requires that the TYC plants or habitat are photographed at the same time every year.

Stewards may also volunteer to receive training to assist the AMWG in periodic lake-wide surveys, which include all sites being monitored around Lake Tahoe. The surveys are conducted the first week of September in years when peak lake level is greater than 6,226 ft (1,897.7 m) LTD or every other year. In high lake level years, boats are needed that can navigate shallow areas to spot TYC underwater. Stewards with a suitable boat may offer it for use in the lake-wide survey.

7.0 Regulatory framework

7.1. Land ownership of TYC sites

The Lake Tahoe Region comprises about 500 square miles (1295 square kilometers), with approximately two thirds occurring in California and one third in Nevada. Lake Tahoe is the dominant feature of the Region, measuring 191 square miles (495 square kilometers), and is the focus of environmental regulations to protect and restore its exceptional water clarity.

Since TYC is found only on the shoreline of Lake Tahoe, the land ownership of the entire geographic range of the species is known. Nearly half of the 50 TYC survey sites are on private land (Table 7.1). As such, the survival of the species relies heavily on its persistence on private lands. Management Goal 2 emphasizes the need to raise awareness of TYC and the importance of conservation and stewardship by private landowners. On public lands, TYC occurrences generally experience much denser recreational use. Management Goal 1 and the Imminent Extinction Contingency Plan specifically address TYC management on public lands.

Table 7.1. Number of TYC survey sites under different ownership categories.

Owner	Number of survey sites	% of total
Public	**26**	**52**
CA Public	**9**	**18**
CSP	6	12
CTC	2	4
Public	1	2
NV Public	**5**	**10**
IVGID	1	2
NSP	3	6
UNR/City SLT	1	2
USFS	**12**	**24**
Private	**22**	**44**
Mixed Ownership	**2**	**4**
Private/City SLT	1	2
Private/USFS	1	2
Grand Total	**50**	**100**

A number of federal and state regulations apply to the land and water of the Lake Tahoe basin across the different ownership categories. Collectively, these regulations are meant to protect the water quality of Lake Tahoe and the biological resources of the Region and provide for orderly growth and development that is consistent with environmental goals. The most comprehensive regulations are administered by TRPA, a Compact Agency created by an Act of Congress in 1969. Other federal regulations are applied on USFS lands. On non-federal lands, state regulations of either Nevada or California apply in addition to TRPA regulations under many circumstances. The Lahontan Regional Water Quality Control Board (Lahontan) and CSLC have jurisdiction over the California portion of the Lake Tahoe shorezone. CDFW and NDF have jurisdiction over TYC as an endangered species in California and Nevada, respectively. Multiple additional agencies, including the U.S. Army Corps of Engineers and NDSL, also have authority over their respective jurisdictions of the shorezone.

The policies, regulations, and laws that ensure that TYC is not adversely affected by development or other projects in the various jurisdictions of the Lake Tahoe Basin are summarized below. Project review guidelines are included in Appendix H.

7.2 Tahoe Regional Planning Agency

7.2.1 The Compact

The Tahoe Regional Planning Compact (Compact) was created by identical statutes in the States of California and Nevada, ratified by Congress, and signed into federal law first in 1969 (Public Law 91–148) and then as a revision in 1980 (Public Law 96–551). The Compact is the authorizing legislation for TRPA and charges TRPA with attaining and maintaining environmental threshold carrying capacities (thresholds) to protect the unique values of the Lake Tahoe basin. The Compact requires development of a Lake Tahoe Regional Plan, mentioned below, along with ordinances, rules, regulations, and policies to achieve or maintain many of the thresholds. The TRPA is a bi-state regional planning agency that has authority within the Lake Tahoe Region to implement the Lake Tahoe Regional Plan, which includes the Environmental Threshold Carrying Capacities for the Lake Tahoe Region, Goals and Policies, and the Code of Ordinances (TRPA 2012).

7.2.2. Lake Tahoe Regional Plan

The Lake Tahoe Regional Plan is a regulatory framework that includes several initiatives and documents. The Lake Tahoe Regional Plan is meant to be updated every 4 years, in conjunction with an environmental evaluation report, so that it can adapt to changing needs, circumstances and emerging threats. The Lake Tahoe Regional Plan consists of many components, including: Environmental Threshold Carrying Capacities, Goals and Policies, and a Code of Ordinances. The first Lake Tahoe Regional Plan was adopted in 1987 (TRPA 1987). On December 12, 2012, the TRPA Governing Board approved amendments to the Lake Tahoe Regional Plan, effective February 9, 2013 (TRPA 2012).

7.2.3. Goals and Policies

The 2013 Lake Tahoe Regional Plan includes a new set of Goals and Policies. The relevant goal for TYC is Goal 3: "Conserve threatened, endangered, and sensitive plants and uncommon plant communities of the Lake Tahoe region". One policy applies specifically to TYC:

Vegetation Policy-3.3: The CS for Tahoe yellow cress in the Lake Tahoe Region shall foster stewardship for this species by:

- Providing education to landowners;
- Providing technical and planning assistance to landowners with Tahoe yellow cress to develop stewardship plans;
- Streamlining the TYC project review process, while protecting the species and its habitat; and
- Supporting propagation efforts.

7.2.4. Code of Ordinances

Section 61.3.6: Sensitive and Uncommon Plant Protection and Wildfire Reduction

TRPA regulates projects and activities in the vicinity of sensitive plants or their associated habitat to preserve sensitive plants and their habitat. All projects or activities that are likely to harm, destroy, or otherwise jeopardize sensitive plants or their habitat are required to fully mitigate their significant adverse effects. Projects and activities that cannot fully mitigate their significant adverse effects are prohibited. Measures to protect sensitive plants and their habitat include, but are not limited to:

- Fencing to enclose individual populations or habitat;
- Restrictions on access or intensity of use;
- Modifications to project design as necessary to avoid adverse impacts;
- Dedication of open space to include entire areas of suitable habitat; or
- Restoration of disturbed habitat.

Additional mitigation and restoration measures that are not specified in Chapter 61 may be included as additional conditions to permits and can include: seed collection, greenhouse propagation of TYC, planting container-grown TYC, and salvage or translocation of natural TYC stems. These measures are described in Section 5.0. To ensure that projects or activities in the shorezone do not adversely affect TYC, TRPA requires a survey of the project area for the presence of TYC prior to permit issuance, and if necessary, a protection plan with the above measures imposed during construction activities (see Appendix H). The survey must be completed within the TYC growing season of June 15 through September 30 to be valid. If impacts to TYC cannot be avoided through a protection plan, then TRPA must further analyze the impacts of the project or activity through preparation of an Environmental Assessment or Environmental Impact Statement (EIS) to determine if more stringent mitigation measures or alternatives can be developed to avoid significant impacts to TYC. Again, projects that cannot fully mitigate their significant impacts to TYC are prohibited by the Regional Plan.

The other relevant protections for TYC in the 2013 Code of Ordinances include chapters that are focused on the shorezone and lake zone that are collectively referred to as the Shorezone Ordinances (Chapters 80–86). The Shorezone Ordinances set forth the findings that must be made by TRPA prior to approving a project in the shorezone or lake zone. The shorezone is comprised of three zones (nearshore, foreshore, and backshore), while the lake zone includes the bed of Lake Tahoe below an elevation of 6,193 ft (1,887.6 m) LTD (Figure 7.1).

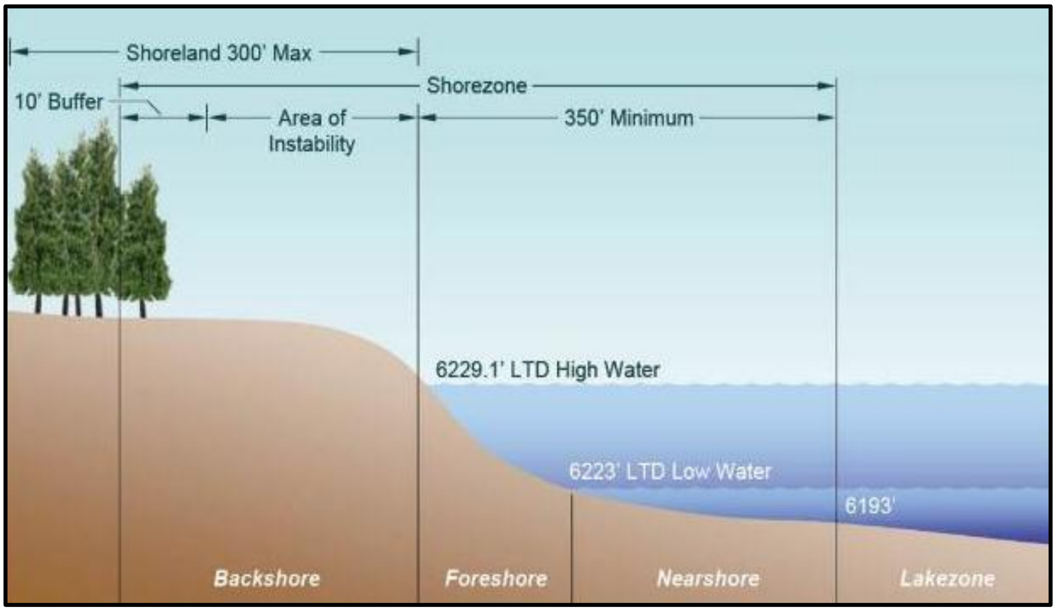

Figure 7.1. Nearshore extends from 6,223 ft (1,896.8 m) down to 6,193 ft (1,887.6 m) or a lateral distance of 350 ft (107 m) from high water line at 6,229.1 ft (1,898.6 m); foreshore is the zone of lake level fluctuation between 6,223 ft (1,896.8 m) and 6,229.1 ft (1,898.6 m); and backshore is the zone of instability above 6,229.1 ft (1,898.6 m) plus a 10 ft (3 m) buffer (TRPA 2012).

The Shorezone Ordinances specify Permissible Uses and Structures (Chapter 81), standards for the maintenance and repair of Existing Structures (Chapter 82), and identifies management strategies and development standards with respect to three zones—Shorezone Tolerance Districts (Chapter 83), Lakeward of High Water (Chapter 84), and Backshore (Chapter 85). In addition, Chapter 86 specifies Mitigation Fee Requirements.

TYC habitat is primarily limited to the foreshore between the water's edge and the high water line of Lake Tahoe. Habitat may extend further lakeward when the lake level is below the rim (6,223 ft (1,896.8 m) LTD), but TYC has rarely been observed above the high water level (CSLC 1994, Pavlik *et al.* 2002,). Projects which occur in the shorezone require consideration of impacts to TYC if plants or suitable habitat are present, but projects which occur only in the lake zone typically do not, depending on disturbance activities required in the shorezone to access the lake zone. Shorezone projects must comply with the standards for development lakeward of high water found in Chapter 84.

In 2014, the TRPA reinitiated the process of adopting amendments to the Shorezone Ordinances and corresponding amendments to the Water Quality Control Plan for the Lahontan Region (Lahontan 2005). As part of this process, a joint EIS/substitute environmental document is required by TRPA and Lahontan. In conjunction with CSLC, these agencies are working closely to develop a coordinated set of shorezone regulations and programs.

New Shorezone Ordinances are currently under development; topics to be addressed include, but are not limited to:

- Development and design standards for shorezone structures;
- Total number and the allocation of piers, mooring buoys, boatlifts, boat ramps, and boat slips;
- Permissible, special, and prohibited uses in the shorezone;
- Boating access and regulations;
- Mitigation programs; and
- Monitoring, enforcement, and environmental improvement programs.

7.3 Federal Protections

7.3.1 National Environmental Policy Act

The National Environmental Policy Act (NEPA)(42 United States Code 4371 *et seq*.) requires all federal agencies to formally document and publicly disclose the environmental impacts of all actions and management decisions. NEPA documentation is provided in an EIS, environmental assessment, or categorical exclusion and may be subject to administrative appeal or litigation. For a full description of NEPA, refer to: *http://www.fs.fed.us/emc/nepa/*.

7.3.2 U.S. Forest Service

7.3.2.1. Forest Service Manual (FSM) Direction:

FSM Section 2670 provides policy for the protection of sensitive species and calls for the development and implementation of management practices to ensure that species do not become threatened or endangered because of Forest Service actions. It requires a review of all activities or programs that are planned, funded, executed, or permitted for possible effects on federally-listed or Forest Service sensitive species (FSM 2672.4, USFS 2005).

A Biological Evaluation (BE) provides the means to conduct this review, analyze the significance of potential adverse effects, and determine how negative impacts will be minimized or avoided for those species whose viability has been identified as a concern. The objectives of a BE are to: ensure that USFS actions do not contribute to loss of viability of any native or desired nonnative plant or animal species; ensure that USFS actions do not jeopardize or adversely modify critical habitat of federally-listed species; and provide a process and standard through which rare plant species receive full consideration throughout the planning process, reducing negative impacts on species and enhancing opportunities for mitigation.

7.3.2.2. Lake Tahoe Basin Management Unit Land Resource Management Plan (LRMP), 1988:

The 1988 LRMP guides management of approximately 154,000 acres of National Forest System lands in the Lake Tahoe basin in California and Nevada under administration of the LTBMU by describing desired conditions, objectives, suitable uses, standards and guidelines and monitoring requirements (USFS 1988). It directs the LTBMU to manage the viability of sensitive species and to ensure that these species do not become threatened or endangered because of USFS activities. The primary purpose of the direction is to ensure that existing habitat of these plants is adequately protected and that additional habitat is provided to perpetuate the species.

7.3.2.3. Sierra Nevada Forest Plan Amendment (SNFPA), 2004:

The SNFPA amends LRMPs for all of the Sierra Nevada national forests, including LTBMU. It establishes standards and guidelines pertaining to the protection and consideration of sensitive plants, including conducting field surveys, minimizing or eliminating direct and indirect impacts from management activities, and adhering to the Regional Native Plant Policy (USFS 1994).

7.3.2.4. LTBMU LRMP Revision, ongoing:

The LRMP is being revised to update management direction for the entire LTBMU. Public notification of the availability of the Final EIS was published in July 2015 (80 FR 42491). The Final Record of Decision (ROD) has not yet been signed, so the revised LRMP has yet to be adopted and may still undergo changes. The revised plan would take effect 30 days after the ROD is signed.

The revised LRMP (USFS 2015a, 2015b) addresses four key themes (forest health and fuels reduction, watershed restoration, recreation, and access) and specifies desired conditions (DC), objectives, suitable uses, standards and guidelines (SG), and monitoring requirements. The following DCs and SGs are relevant to TYC conservation:

- DC59: Ecological conditions throughout the planning area contribute to the recovery of federal Threatened (T) and Endangered (E) species, and prevent listing of federal Candidate species (C), Proposed species (P), and Forest Service Sensitive (S) species.
- DC77: TYC persists in sandy beach habitat around Lake Tahoe, despite periodic high water levels and human-related impacts. Viable populations are maintained at Core sites that occur on USFS lands. At other sites, occurrences may decrease or

disappear, but losses are counterbalanced by establishment of new sites, as determined by the species' metapopulation dynamics.

- SG41: During project development, evaluate the project area, including any designated critical habitat, for the habitat suitability and/or occurrence of TEPCS species.
- SG93: Management actions are consistent with habitat and population recovery objectives outlined in conservation strategies and recovery plans.
- SG96: Projects proposed on the shorezone, barrier beach, and backshore of Lake Tahoe that have the potential to affect TYC plants or their suitable habitat, must be assessed for TYC prior to, but in the same year as, project implementation.

Management strategies included in the revised LRMP (USFS 2015a, 2015b) that are relevant to TYC include, but are not limited to:

- Work collaboratively with partners to implement a public-private TYC adaptive framework;
- Continue monitoring of TYC occurrences;
- Encourage TYC stewardship on private lands;
- Continue TYC public outreach and education efforts;
- Balance conservation of known TYC occurrences and high quality habitat with development and use of recreational facilities and access; and
- Revise site-specific TYC management plans to allow for adaptive management of known occurrences and high quality habitat that addresses both the annual shifts in habitat and threat level associated with lake level changes, and the provision of adequate beach access for recreational users.

7.4 California State Protections

7.4.1 California Environmental Quality Act (CEQA)

CEQA (California Public Resources Code § 21000 *et seq.*) requires state, local, and other California agencies to evaluate and disclose the potential environmental implications of their proposed actions, and requires that significant environmental impacts are reduced to a less-than-significant level through adoption of feasible avoidance, minimization, or mitigation measures unless overriding considerations are identified and documented that make the mitigation measures or alternatives infeasible. CEQA applies to certain discretionary activities in California undertaken by either a public agency or a private entity that must receive some approval from a California government agency. CEQA contains a substantive mandate that public agencies refrain from approving projects with significant environmental effects, if there are feasible alternatives or mitigation measures that can substantially lessen or avoid those effects. The state and local agencies approving projects are required to impose mitigation measures where appropriate. An

Environmental Impact Report (EIR) is generally required when a project or activity includes significant and unavoidable impacts that cannot be mitigated to a less than significant level, or if required by CEQA Guidelines for specific activities. When alternatives or mitigation measures cannot be feasibly attained, and significant unavoidable impacts are outweighed by other benefits to the environment and the state, public agencies have the discretion to prepare a statement of overriding considerations based on substantial evidence in the EIR record.

CEQA Lead Agency Role: Lead agency means the public agency which has the principal responsibility for carrying out or approving a project which may have a significant effect upon the environment (CEQA Guidelines, Section 21067).

CEQA Responsible Agency Role: A responsible agency is an agency other than the lead agency that has a legal responsibility for carrying out or approving a project. A responsible agency must actively participate in the lead agency's CEQA process, review the lead agency's CEQA document, and use that document when making a decision on the project. The responsible agency must rely on the lead agency's environmental document to prepare and issue its own findings regarding the project (CEQA Guidelines, Sections 15096 and 15381).

CEQA Trustee Agency Role: Trustee agency means a state agency that has jurisdiction by law over natural resources affected by a project, that are held in trust for the people of the State of California (CEQA Guidelines, Section 21070).

7.4.2 California Endangered Species Act (CESA)

CESA (California Fish and Game Code Section 2050 *et seq.*) prohibits take of wildlife and plants listed as threatened or endangered by the California Fish and Game Commission. Take is defined as any action or attempt to “hunt, pursue, catch, capture, or kill.” Therefore, projects that occur in the shorezone on the California side of Lake Tahoe with TYC plants or suitable habitat present must comply with CESA because TYC is listed as an endangered species under CESA.

CESA allows for incidental take that occurs during otherwise lawful activities (California Fish and Game Code Section 2081). The CDFW may authorize incidental take of state-listed species if an applicant submits an approved plan that minimizes and “fully mitigates” the impacts of this take. Adequate funding must be provided to implement the required minimization and mitigation measures and to monitor effectiveness and compliance.

7.4.3 Native Plant Protection Act (NPPA)

The NPPA (California Fish and Game Code Section 1900 *et seq.*) directs CDFW to carry out the Legislature's intent to "preserve, protect and enhance rare and endangered plants in this State." The NPPA gives the California Fish and Game Commission the authority to designate native plants as "endangered" or "rare" and prohibits take of these species. Exceptions for emergencies and some agricultural and nursery operations may apply. Vegetation removal from canals, roads, and other sites that entail take may also be allowed after properly notifying CDFW in advance.

7.4.4 California Department of Fish and Wildlife (CDFW)

CDFW has jurisdiction over the conservation, protection, and management of wildlife, native plants, and habitat necessary to maintain biologically-sustainable populations. CDFW assumes different roles and responsibilities in the CEQA process. CDFW is always a trustee agency when projects may affect fish, wildlife, or their habitats (CEQA Guidelines 15386(a)). As a trustee for these resources, CDFW provides the requisite biological expertise to review and comment upon environmental documents and impacts arising from project activities, as those terms are used in CEQA (Fish and Game Code Section 1802). CDFW is one of four trustee agencies. The others include the CSLC, Department of Parks and Recreation, and University of California. As the trustee agency for fish and wildlife resources, CDFW must be notified when a CEQA project involves fish and wildlife of the state, rare and endangered native plants, wildlife areas, and ecological reserves.

CDFW may also assume the role of lead agency if CDFW is proposing its own project or issuing a permit for a project with no other agency approvals (CEQA Guidelines 15050). CDFW takes on the role of a responsible agency when a lead agency's decision will result in a project that is issued a permit by CDFW. CDFW staff must rely on the environmental document prepared by the lead agency to make a finding.

Lake and Streambed Alteration (LSA) Program: The LSA Program (California Fish and Game Code Section 1602) requires an entity to notify CDFW prior to commencing any activity that may do one or more of the following:

- Substantially divert or obstruct the natural flow of any river, stream or lake;
- Substantially change or use any material from the bed, channel or bank of any river, stream, or lake; or
- Deposit debris, waste or other materials that could pass into any river, stream or lake.

In addition to perennial waters (flow year round), ephemeral streams (dry for periods of time) and watercourses with subsurface flow are covered by the LSA Program; and it may also apply to activities within the floodplain of a body of water. CDFW requires an LSA Agreement when it determines that an activity, as described in a complete LSA Notification, may substantially adversely affect existing fish or wildlife resources. An LSA Agreement includes measures necessary to protect existing fish and wildlife resources. CDFW may suggest ways to modify projects that would eliminate or reduce harmful impacts to fish and wildlife resources. Before issuing an LSA Agreement, CDFW must comply with CEQA.

Safe Harbor Agreement Program Act (SHAPA): SHAPA is a program initiated in 2009 to encourage landowners to manage their lands voluntarily to benefit endangered, threatened, or candidate species (Fish and Game Code Sections 2089.2–2089.26). Under SHAPA, landowners work with CDFW to develop the safe harbor agreement and voluntarily agree to implement CDFW's recommendations for management activities and other recommendations that will contribute to the recovery of a CESA threatened, endangered, or candidate species. In return, the landowner receives regulatory assurances that the owner can alter or modify property enrolled in the safe harbor agreement and return it to the originally agreed upon "baseline" conditions at the end of the agreement, even if this means incidentally "taking" the covered species.

7.4.5 California State Lands Commission (CSLC)

On the California side of Lake Tahoe, the CSLC administers the state's fee ownership below the low water line (6,223 ft (1,898.7 m) of Lake Tahoe and administers a Public Trust easement between the low water line and a landward boundary of (6,228.75 ft (1,898.5 m). Public and private entities must apply to CSLC for surface leases to construct structures and other development activities on state lands at or below elevation 6,223 ft (1,896.8 m). Although the CSLC does not have leasing authority within the Public Trust easement, the CSLC does have authority to ensure that land uses within the easement are consistent with Public Trust uses pursuant to the Commission's statutory authorities and responsibilities set forth in Public Resources Code Sections 6301 and 6216, *et seq*. Public Trust lands are to be used to promote the public's interest in water-dependent or water-oriented activities including, but not limited to, water-related commerce, navigation, fisheries, recreation, ecological preservation, and scientific research. Basic to enjoyment of these rights is the ability by the public to access the waters of these submerged lands. Within the Public Trust easement of Lake Tahoe, public trust uses must be balanced to not exclude one use over another. For example, protection and conservation of TYC must be managed in a manner that does not exclude lateral public access along the California shoreline of Lake Tahoe.

Pursuant to CEQA and the Public Trust, the CSLC is required to consider impacts to TYC from development and restoration activities on State land, and to impose mitigation measures or alternatives to avoid or minimize impacts. To ensure that projects or activities do not adversely affect TYC, the CSLC requires a survey of the project area for the presence of TYC prior to approval of a lease, and if necessary, a protection plan with protection measures imposed during construction activities, similar to TRPA's project review process (see Appendix H). The survey must be completed within the TYC growing season of June 15 and September 30 to be valid. If impacts to TYC cannot be avoided through a protection plan, then as a requirement of CEQA, the CSLC must further analyze the impacts of the project or activity through preparation of an initial study to determine if a mitigated negative declaration or EIR is required for development of more stringent mitigation measures or alternatives to avoid or minimize impacts to TYC.

7.4.6 California Department of Parks and Recreation (CDPR)

It is a misdemeanor to pick, dig up, mutilate, destroy, injure, disturb, move, molest, burn, or carry away any tree or plant, or any portion of a tree or plant within CSP boundaries (California Public Resources Code Section 4306). In addition, CDPR is required under CEQA and CESA to manage TYC populations on CSP lands so as to ensure that their actions do not jeopardize the species. TYC occur at Emerald Bay, D.L. Bliss, and Sugar Pine Point State Parks.

Department of Parks and Recreation Operations Manual, Natural Resources
0310.5.1 Protection of Rare, Threatened, and Endangered Plants and Their Habitats Policy:
It is the policy of CDPR to protect rare plants and their habitats in fulfillment of its mission to help preserve the State's extraordinary biological diversity, and in accordance with the CESA and the California NPPA. These taxa and habitats will be protected in the context of the native environmental complexes in which they evolved, when feasible.

0310.5.2 Knowledge of Rare, Threatened, Endangered and Other Sensitive Plant Localities:
CDPR will strive to maintain a working knowledge of the occurrence of listed and other sensitive plants occurring within park units. Ideally, this information will be incorporated into the Unit Data File in both paper copy and digital form. The location of these plants should be noted on maps and be fully available to appropriate staff. Preferably, locations will be defined through use of GPS and depicted as layers of CDPR's GIS. However this information is stored, it will be used for General Planning efforts, resource management, wildfire and other emergency response planning, and facility siting.

0310.5.3 Park Projects and Plant Species of Concern Policy: Prior to conducting projects such as facility development or exotic plant eradication, CDPR will determine whether any plant species of concern are in the proposed project area. If plant species of concern are found, CDPR will attempt to modify the project to avoid impacts to populations of these plants. Permits, such as an Incidental Take Permit from CDFW (California Fish and Game

Code § 2081), are required if the proposed project cannot be relocated or redesigned to avoid impacts to plants listed as Threatened or Endangered under CESA. Project proponents will contact CDFW to obtain necessary permits.

0310.5.3.1 Use of Plant Species of Concern Policy: Rare, threatened, or endangered plant taxa, and other plant species of concern, will not be used for revegetation unless the revegetation is being done as part of a restoration plan for that taxon.

0310.5.4 Restoration of Listed Plant Populations: CDPR will strive to restore extirpated native plant species to parks whenever all of the following criteria are met:

- Adequate habitat to support the species either exists or can reasonably be restored in the park, and if necessary also on adjacent public lands and waters, and, once a natural population level is achieved, the population can be self-perpetuating.
- The genetic type used in restoration most nearly approximates the extirpated genetic type.
- The species disappeared, or was substantially diminished, as a direct or indirect result of human-induced change to the species' population.

7.5 Nevada State Protections

7.5.1 Nevada Division of Forestry

Nevada Revised Statute (NRS) 527.260–.300 establishes a program for the conservation, protection, restoration, and propagation of selected species of flora and for the perpetuation of the habitats of such species. A species or subspecies of native flora shall be regarded as threatened with extinction when the State Forester Firewarden, after consultation with competent authorities, determines that its existence is endangered and its survival requires assistance because of overexploitation, disease or other factors or because its habitat is threatened with destruction, drastic modification, or severe curtailment. Any species declared to be threatened with extinction shall be placed on the list of fully protected species, and no member of its kind may be removed or destroyed at any time by any means except under special permit issued by the State Forester Firewarden. The State Forester Firewarden has discretion in issuing or withholding permits, and in placing protective conditions on permits that are issued. Nevada law does not mandate the continued survival of any plant species which it declares to be in danger of extinction. NRS 527.050 makes the unauthorized cutting, destruction, mutilation, picking, or removal of any plant on the list of fully protected species at least a misdemeanor offense. This statute applies to all lands within the State. The only exemption from the law is for collection of plants by Native Americans for food, medicinal, or ceremonial use.

In carrying out the program authorized by NRS 527.260-.300, inclusive, the State Forester Firewarden, subject to the approval of the Director of the Nevada Department of

Conservation and Natural Resources, shall cooperate, to the maximum extent practicable, with other states and with the counties in the State of Nevada, and may enter into agreements with such other states and counties and with other legal entities for the administration and management of any area established pursuant to NRS 527.260–.300, inclusive, for the conservation, protection, restoration, and propagation of species of native flora which are threatened with extinction.

7.5.2 Nevada Division of State Lands

NDSL maintains permitting authority for the Nevada shorezone at Lake Tahoe with respect to issues related to navigation. If an entity wanted to protect TYC and their proposed management plan involved installing a hindrance to navigation then NDSL could be involved at that level by requiring/reviewing applications and issuing temporary authorizations.

7.6 Private Lands

To date, the presence of TYC has not stopped a single development or restoration project on private lands. As explained above, public agencies are required to consider impacts to naturally occurring TYC populations from development proposals on private lands prior to approving such development, and to require mitigation measures or modifications to project design to avoid significant TYC impacts. Due to the regulatory complexity of the Lake Tahoe basin, the specific policies that pertain to each project may vary, based on the proposed location and activities. As the overarching regulatory agency, TRPA assists private landowners seeking permits and coordinates with other agencies having jurisdiction.

It bears repeating that site persistence on private land is reliant on the cooperation and conservation efforts of private landowners. Recognition of this need has led to the development of several education and stewardship programs for private landowners. The TLOA and NTCD, have been instrumental in working with private landowners to conserve TYC. Efforts must be made to ensure that the education and stewardship assistance remains available to private landowners. In addition, regulatory agencies must remain mindful of the need to encourage TYC conservation on private lands. Development of a systematic Safe Harbor Agreement framework would greatly improve the likelihood of private cooperation and, therefore, site persistence.

7.7 Summary

On both public and private lands, TRPA is the overarching regulatory agency, except on USFS lands. On USFS lands, TYC management is governed by federal law and USFS regulations (see section 7.2). There are 12 sites managed by USFS—more than any other single landowner (Table 7.1). TYC management on USFS lands relies on a combination of measures including project survey requirements, permanent and temporary protection, and user and staff education. Since USFS listed TYC as a Forest Service Sensitive species in 1989, there have been few projects with significant impacts to TYC (C. Rowe, personal communication, 2014). However, visitor use of USFS beach facilities continues to increase and is expected to continue to impact TYC sites (USFS 2015), so it remains important to implement management actions at sites on USFS lands to ensure their persistence.

For all private lands and non-USFS public lands, TYC occurrences and habitat are regulated under prior and recently revised shorezone ordinances in the new Regional Plan promulgated by TRPA. In general, TRPA requires full mitigation of any significant adverse effects to TYC occurrences. Both the States of California and Nevada also provide regulatory protection to TYC through their endangered species statutes. Various state and local agencies also have management programs for TYC and its habitat on lands under their management; in general, these require consideration of any impact to naturally-occurring TYC occurrences and mitigation measure or modifications to avoid significant TYC impacts. On private lands, development proposals must be reviewed by those public agencies with jurisdiction, and are therefore subject to many of the same restrictions as projects on public lands. To date, the presence of TYC on private lands has not stopped a single development or restoration project on private lands or an environmental improvement project on public lands. Furthermore, based upon the long-term monitoring record, the trend of TYC appears to be relatively stable. In general, the existing TYC conservation programs and regulatory protections appear to be effective to ensure the long-term conservation of TYC on both public and private lands.

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