Implementation of the Conservation Strategy for Tahoe Yellow Cress (*Rorippa subumbellata*) 2009 Annual Report

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Adaptive Management Working Group,
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TABLE OF CONTENTS

EXECUTIVE SUMMARY 5

1.0 INTRODUCTION 7

2.0 2009 ANNUAL SURVEY 7

2.1 METHODS 7
2.1.1 SITE CONSERVATION AND RANKING 7
2.1.2 SITE OCCUPANCY AND ABUNDANCE 8
2.1.3 GENETIC MATERIAL COLLECTION 9
2.1.4 DETECTION PROBABILITY 9
2.2 RESULTS 10
2.3 DISCUSSION 26

3.0 2009 RESEARCH ACTIVITIES 26

3.1 EXPERIMENTAL REINTRODUCTIONS 26
3.1.1 METHODS 27
3.1.2 RESULTS 29
3.1.3 DISCUSSION 34
3.2 TRANSLOCATION 36
3.2.1 METHODS 36
3.2.2 RESULTS 38
3.2.3 DISCUSSION 41
3.3 GENETIC RESEARCH 42

4.0 PRIVATE LANDS CONSERVATION 42

4.1 STEWARDSHIP PROGRAM 42
4.2 PRIVATE LANDS CONSERVATION 43

5.0 2009 AMWG CONSERVATION ACTIVITIES 44

5.1 AMWG MEMBERSHIP 44
5.2 AGENCY ACTIVITY REPORTS 44
5.3 SITE-SPECIFIC INFORMATION SHEETS 45
5.4 FUNDING 45
5.5 PUBLIC LANDS MANAGEMENT 48

5.6 REGULATION 48

6.0 PHOTOS 48

7.0 REFERENCES 53

8.0 APPENDICES 56

APPENDIX A: GENERIC ANNUAL FIELD SURVEY FORM (REVISED)…………………………...57

APPENDIX B: SURVEY PROTOCOLS FOR TAHOE YELLOW CRESS ANNUAL SURVEYS…...58

APPENDIX C: PRESENCE OF TAHOE YELLOW CRESS (1978-2009)………………………………60

APPENDIX D: GENETIC ANALYSIS 2009 PROGRESS REPORT AND 2010 PROPASAL………...62

List of Figures

Figure 1. Elevation of Lake Tahoe in 2009 (USGS Tahoe City Station).

Figure 2. Lake level and number of Tahoe yellow cress sites occupied by survey year.

Figure 3. Map of Tahoe yellow cress occurrences in 2009.

Figure 4. The number of occupied Tahoe yellow cress sites in 5 stem count abundance categories in a low (2006) and a high (2009) lake level year.

Figure 5. Total survivorship of the 2008 founding cohort in A) year one, October 2008 and B) year two, October 2009.

Figure 6. Second year mean plant canopy size (cm^2) of the 2008 founding cohort in October, 2009.

Figure 7. First year A) survivorship and B) reproduction of the 2009 founding cohort in October, 2009.

Figure 8. First year A) survivorship and B) reproduction of the 2009 cohort of translocants and container-grown TYC in October, 2009.

Figure 9. The mean A) canopy area (cm^2) and B) seed production of translocants and container-grown TYC at four sites in October, 2009.

Figure 10. Mean canopy of container-grown and translocants from the 2008 cohort in October, 2009.

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List of Tables

Table 1. Stem counts and survey effort for 61 Tahoe yellow cress sites in September 2009.

Table 2. The number of occupied sites and estimated stem counts by site ownership in 2009.

Table 3. Stem count and survey effort in the 2009 annual survey by site ranking category.

Table 4. Second year survival and reproductive output of the 2008 experimental cohort in October, 2009.

Table 5. First year growth and reproductive output of the 2009 experimental cohort in October 2009.

Table 6. Mean canopy area and seed output per plant of 2009 translocants and container-grown TYC in October, 2009.

Table 7. Membership of the Tahoe yellow cress Adaptive Management Working Group (AMWG) in 2009.

Table 8. Summary of agency hours spent on Tahoe yellow cress related activities during the 2005-2009 period.

Table 9. Contracted funding sources for the TYC Conservation Strategy for 2008 to 2012.

List of Photos

Photo 1 2009 annual survey team in a CA Dept of Fish and Game boat.

Photo 2. Temporary fence at Pope Beach with remaining founders from the 2006 cohort visible in the foreground outside the fence.

Photo 3. Temporary fence for outplanting to test timing at Zephyr Cove, June 2009.

Photo 4. 2009 planting at Upper Truckee East on the margin of the fore beach lagoon.

Photo 5. Paired design of the 2009 translocation with a A) translocated and a B) container-grown TYC.

Photo 6. Translocation experiment in the Nevada Beach enclosure in September, 2009.

Photo 7. Extracting a donor plant from Tallac Creek for translocation to Ebright Beach, June 2009.

Photo 8. Soil-less potting mix still attached to the rootmass of a three year-old donor plant at Tallac Creek, June 2009.

EXECUTIVE SUMMARY

This is the ninth Tahoe yellow cress (TYC) annual report completed since 2001. The annual reports provide a record of all conservation activities related to Tahoe yellow cress and are utilized at quarterly meetings of the Adaptive Management Working Group (AMWG). This year, hard copies will not be produced unless requested but the draft, including all AMWG revisions, will be made available on the Nevada Natural Heritage website at http://heritage.nv.gov/vlibtyc.htm.
NOTE*The draft version was approved without changes at the Executive Committee Meeting on May 4, 2010.

Annual survey results
Annual field surveys to determine the number of occupied sites with TYC date back to 1979. Records from the survey period indicate there are more occupied sites when the lake is low and fewer when it is high. In 2009, the level of the lake during the survey in the first week of September (6223.5 ft Lake Tahoe Datum (LTD)] is considered very low. TYC was found at 47 sites, which is the greatest number of occupied sites recorded in a single year (also recorded in 2004 and 2005).This number of occupied sites means that the AMWG can operate under Level 1 (normal conditions) of the Imminent Extinction Contingency Plan defined in the Conservation Strategy (CS). At Level 1, no changes to the normal policies and guidelines for protection of existing occurrences and potentially suitable habitat are required.

Key research findings
Recent field experiments have focused on two main questions: 1) When is the optimal time to plant container-grown TYC during the regulatory survey window (June 15 to September 30)? and 2) Does translocation of naturally-occurring TYC and outplanting of container-grown TYC result in the same rates of survival and reproduction? Two years of data from 2008 and 2009 suggest the following key findings:

- At sites with moderate to optimal habitat conditions, planting in June or July results in better plant performance than August or September.
- Some sites appear to provide suboptimal habitat where reproduction fails regardless of planting time.
- Container-grown plants perform significantly better than translocated plants if habitat conditions are good to optimal.
- Translocated individuals will survive, but container-grown stock are capable of greater growth and seed output.

Tri-fold brochure- "TYC a unique piece of Tahoe"
BMP Ecosciences and NRCS collaborated on the production of a tri-fold brochure designed to educate the public about TYC conservation. The brochure was available in June, 2009 and the USFS distributed brochures at visitor kiosks at Baldwin and Pope Beach. The CTC Land Steward handed them out at the Upper Truckee Marsh and other agencies made them available in their offices.

Website

BMP Ecosciences also developed a website: www.tahoeyellowcress.org. The home page lists four "Simple things you can do" to help TYC and there are three subpages focused on research, conservation, and management. The "Natural history mystery of TYC" tells the story of how TYC may have evolved over time in response to the particular environmental forces at work in the Lake Tahoe basin and there are links to the home pages of all signatories on the CS.

Funding

Round 6 SNPLMA $350,000 USFS

LTBMU- $159,950

Dr. Bruce Pavlik, BMP Ecosciences- $190,950 contracted for research and additional AMWG –specified tasks from 2007 into mid 2010.

Round 7 SNPLMA $150,000 USFS

LTBMU - $100,000

Dr. Mary Peacock, University Nevada Reno (UNR)-$50,000 contracted to conduct microsatellite DNA analysis in 2008-2009.

R8 SNPLMA $45,000 NRCS

R9 SNPLMA $45,000 NRCS

To provide technical support to private property owners and help to develop site-specific plans for Tahoe yellow cress conservation.

R9 SNPLMA $120,000 USFS

The AMWG will need to identify contracting needs and specific tasks for these funds in 2010.

California Department of Fish and Game (CDFG) Section 6 funds $48,000

Dr. Bruce Pavlik, BMP Ecosciences- contracted for restoration mitigation research, completed contract on March 31, 2009.

AMWG staff time and costs

The number of staff hours spent on TYC conservation amounted to at least 1,600 hours, of which 336 hours were for the annual survey. Total in-kind cost contributed by each agency for all staff time and materials amounted to a minimum of $66,220 (some agencies did not report expenditures), not including any contracted funding (see above).

Regulation

At the Executive Meeting on August 5, 2009, the Committee directed the AMWG to conduct the 5 year review of the CS as specified in Clause F.1 and proposed to change the language in Section G.6 of the MOU as follows:

Change: The MOU/CA and CS may only be modified by mutual written consent of the Parties.

To: The MOU/CA may only be modified by mutual written consent of the Parties. The CS may be modified by mutual verbal consent of the Executives present at the annual Executive Committee Meeting, if a majority of the Executives are present.

The USFWS is taking the lead in obtaining the signatures for the needed change in time for an Executive Meeting to be held in May of 2010.

1.0 INTRODUCTION

This is the ninth Tahoe yellow cress (TYC) annual report completed since 2001. The annual reports provide a record of all conservation activities related to Tahoe yellow cress and are utilized at quarterly meetings of the Adaptive Management Working Group (AMWG). BMP Ecosciences has produced the reports since 2004 and has generally distributed hard copies of the report in April or May of each year to AMWG members after their comments have been incorporated. However, the report is not finalized until the TYC Executive Committee grants approval at their annual meeting. This year, hard copies will not be produced unless requested but the draft, including all AMWG revisions, will be made available on the Nevada Natural Heritage website at http://heritage.nv.gov/vlibtyc.htm. NOTE*The draft version was approved without changes at the Executive Committee Meeting on May 4, 2010.

The 2009 report is formatted into eight main sections. Section 2 presents results from the annual TYC lake-wide survey including two new sections on the material collection for genetic analysis and an evaluation of different survey methods to determine probability of detecting TYC in the field. Section 3 streamlines the research on experimental reintroduction and translocation by methods, results, and discussion sections rather than by experimental year. A separate report on the genetic analysis is presented in its entirety in its own Appendix. Section 4 discusses outreach efforts through the Stewardship Program including the publication of a new tri-fold brochure and a website www.tahoeyellowcress.org as well as conservation activities on private lands. Section 5 details all AMWG conservation activities for 2009 including current AMWG membership, agency activity report summary, funding, public lands management, and regulation. Section 6 contains a selection of photos from the 2009 research and the annual survey. The Appendices contain the revised annual survey form, the survey protocols, the comprehensive occurrence/ absence data for TYC at 61 sites around the lake from 1979 to 2009, and the complete report on ongoing genetic research at the University of Nevada, Reno. The Appendix table containing the status of Site Specific Information Sheets was omitted because it did not change in 2009 and all of the submitted Agency Activity Report Forms will be available on request, rather than included in an Appendix.

2.0 2009 ANNUAL SURVEY

2.1 METHODS

2.1.1 SITE CONSERVATION AND RANKING

Field data on stem counts and occupancy of known TYC sites around Lake Tahoe has been tracked in a comprehensive spreadsheet that has been called Appendix C since the adoption of the CS in 2003. The 2009 version of Appendix C (found in this report) has entries for 61 sites (same number as 2008). Sites with a sufficient data record are ranked for conservation priority based on a composite index that includes scores for relative abundance, persistence, and variability. Currently, a total of 38 of the 61 named sites are ranked: 10 Core, 6 High, 13 Medium, and 9 Low (see Table 1).

In 2003, the AMWG updated the rankings found in the CS and decided to maintain those rankings into the future and rank additional sites as minimum data analysis requirements are met. No new sites met the criteria in 2009. Although three sites (Tahoe Pines, Skunk Harbor, and Chimney Rock) met minimum ranking criteria in 2008, these were not ranked in 2009. The AMWG should consider ranking these sites in 2010 when several other sites will meet the minimum ranking criteria. Sugar Pine Point State Park, Bijou, the enclosure at Meeks Bay and the area outside the enclosure at Taylor Creek will all have 10 consecutive years of record from the annual survey. A ranking for the latter may help to identify how patterns of abundance fluctuate both within and outside of an enclosure at the same site.

2.1.2 Site Occupancy and Abundance

The annual, lake-wide survey for Tahoe yellow cress was conducted on September 8-10, 2009. Participants included; Stu Osbrack, Rory Nichols, Kathryn Heard, Elizabeth Hermsen, and Sean Glantz (U.S. Forest Service [USFS]); Steve Caicco (US Fish and Wildlife Service [USFWS]); Daniel Burmester, Tim Nosal, and Jay Rowan (California Department of Fish and Game [CDFG]); Dan Shaw, Lawani Colley, Curtis Gray, Lisa Fields, Nathan and Ashlie Lewis (California State Parks [CSP]); Eric Gillies (California State Lands Commission [CSLC]); Don Guy (California Department of Water Resources [DWR]); Peter Maholland (Nevada Division of State Parks [NDSP]); Roland Shaw [NDF]; Eileen Carey (Tahoe Regional Planning Agency [TRPA]); Meri McEneny (private); Mark Bibbo (EDAW); Nick Meyer and Melissa Faigeles (California Tahoe Conservancy [CTC]); and Alison Stanton and Kareela Collins [BMP Ecosciences].

The 25 participants were divided into 5 teams, allocated a portion of the 61 sites, and given a set of annual field survey forms developed by NNHP. Boats, provided by CDFG, NDSP, and DWR, were available for 3 of the 5 teams (Photo 1). At a site, team members covered the entire width of exposed beach, from waters edge to the backshore stabilized vegetation, generally keeping below the high water line. Disturbance and search effort were recorded at both occupied and unoccupied sites. Search effort is defined as the amount of person-minutes spent actively searching for and/or collecting data on Tahoe yellow cress.

The AMWG set a goal to be as comprehensive as possible in covering the entire shoreline in 2009 in order to take advantage of the expected low lake level. Teams were assigned contiguous stretches of shoreline and asked to extend the survey boundaries for existing sites whenever possible and to treat previously un-surveyed locations as new sites, including shoreline without any apparently suitable habitat. In the past, several large stretches of beach were essentially ignored as unsuitable but the AMWG wanted these areas to be searched and delineated as unsuitable on the occupancy map instead of being left blank. Most of those stretches occur on public lands so access was not an issue. Surveyors used the comments section of the annual survey form to describe why sites were unsuitable (i.e. topography, substrate, etc). Any modifications to existing site boundaries were delineated with GPS and surveyors were also asked to attempt to take GPS points on every parcel where TYC occurred on private land.

In 2008, the annual field survey forms were revised to be generic to eliminate the burden of getting data packets to every team and enable team leaders to print as many as necessary. In

2009, the forms were further revised to include location information on leaf tissue collected for the proposed genetic analysis at the University of Nevada Reno (Appendix A). All annual survey forms, including GPS data, are provided to the Nevada Natural Heritage Program (NNHP) for addition to the national BIOTICS database and are available upon request.

2.1.3 Genetic Material Collection

In 2009, the annual survey data collection protocols were revised to include a detailed protocol for TYC tissue sampling (Appendix B). The Lab for Ecological and Evolutionary Genetics at the University of Nevada, Reno (UNR) is conducting a genetic analysis on TYC population structure using microsatellite DNA that is extracted from a small amount of leaf tissue. It is possible to obtain a "genetic" tag of an individual plant with this technology so the sample unit was a single leaf from an "apparent TYC plant" or stem. To obtain a genetically representative sample from a population, the Center for Plant Conservation guidelines suggest sampling from 30 plants. Because TYC growth is clonal it is virtually impossible to identify an individual plant in the field, as apparently separate plants may be connected underground through extensive root networks. Likewise, many different stems will coalesce into a single large "plant". Therefore the target sample size was doubled to 60 leaves per site. A sample could come from a small vegetative ramet of 2cm or from a large "plant" that is 40 cm in diameter.

At sites with ≥ 60 stems, a single leaf was collected from 60 different stems located throughout the entire site to get a representative sample. At sites with <60 stems, surveyors were asked to collect leaves from as many stems as possible. Each leaf sample was placed in its own coin-sized envelope and labeled with a site code and consecutive numbers from 1-60 i.e. WRD 1, WRD 2. Information about sample locations were recorded in an effort to track the relative position of each sample or group of samples at a site and if the sample came from any sort of unique habitat feature. If plants were rather continuously distributed, surveyors took the GPS position of small groups of samples (<10 samples). At sites where plants were strongly clustered, the groups of samples were larger (20 samples or more). Samples were stored at room temperature in dry envelopes.

2.1.4 Detection Probability

Current survey methodology for TYC dates to the first surveys conducted by Knapp in 1979. According to the standard protocol, a minimum of two surveyors walk along the beach covering the littoral zone from the high water line, which is only rarely submerged, to the shoreline. The surveyors count stems and have been using GPS since the technology became available. However, no one has determined whether there is any significant probability of error in a surveyor's ability to detect TYC. While some rare plants are very cryptic and easy to overlook, TYC occurs in very open habitat, largely devoid of competing vegetation and it has generally been assumed that if TYC is present it is easy to detect.

To test this assumption, three of the five survey teams in the 2009 annual survey used a modified survey protocol at select private sites. Sites were selected that encompassed a minimum of ten private parcels (designated by Assessor Parcel Number (APN)]. Teams of two surveyors started the survey at opposite ends of the site and each team recorded a cumulative stem count for the site and took a GPS point on every parcel occupied by TYC. When the teams met in the middle of the site, they continued the survey in the same manner, duplicating the effort across the site.

The analysis was conducted in GIS using the TYC point file for each team and the APN layer. Each APN was counted as a unique site and the detection rate for each team was calculated as the number of parcels where TYC was found divided by the total number of parcels. The error rate was calculated as the difference between the detection rates of both teams. For example, the detection probability of Team 1 would be 80% if they found TYC on 8 out of 10 parcels. If Team 2 only found it on 7 parcels there would be a 10% error rate at that site.

A water-based survey method was also tested where surveyors did not access the parcel and instead walked in the water or used kayaks to detect presence of TYC. Such a method may be necessary or desirable in any effort to complete a comprehensive survey around the perimeter of Lake Tahoe. Since 1935, when the Truckee River Operating Agreement (TROA) went into effect, the upper limit of Lake Tahoe has been defined at 6229.1 feet Lake Tahoe Datum (LTD). The natural rim is at 6,223 feet LTD. On the California side of the lake, there is a public easement that exists below high water where the public may technically utilize the beach if they access it via the lake and are not accessing it by crossing private property above the high water. However, many property owners erect no trespassing signs on their lakefront parcel and may actively restrict access to the beach with various forms of fencing. On the Nevada side of the lake, private property lines extend to 6,223 ft, but it is legal for surveyors to walk on exposed beach below the natural rim of 6223ft. However, this zone is inundated in the vast majority of years. Since the enactment of TROA, the lake has dropped below the rim in only six years: 1962, 1978, 1989, 1991, 1992 and 1993 (USGS). The historic low of 6220.3 ft was recorded in November of 1992 (USGS).

The level of the lake during the survey period was 6223.5 ft Lake Tahoe Datum (LTD). The following week, two surveyors visited sites that they had not visited the previous week. One surveyor walked in ankle deep water, which was presumably at or near the level of the natural rim, while the second surveyor used a kayak to look for TYC presence on each parcel. Both surveyors used binoculars as needed to detect TYC. The water methods were employed at four different named survey sites; Lighthouse Shores, Tahoe Keys, Blackwood South, and McKinney Creek.

2.2 RESULTS

Lake level on September 8 was 6223.5 ft (LTD), about one half foot lower than it was for the survey the previous year. A peak lake elevation of 6224.6 ft was recorded on June 6 that was sustained for the entire month before beginning a steady decline in July (Fig 1). Lake elevations of 6,220 to 6,224 ft are considered low water, while elevations between 6,225 and 6,226 ft are transitional between low and high water (6,227 to 6,229.1 ft).

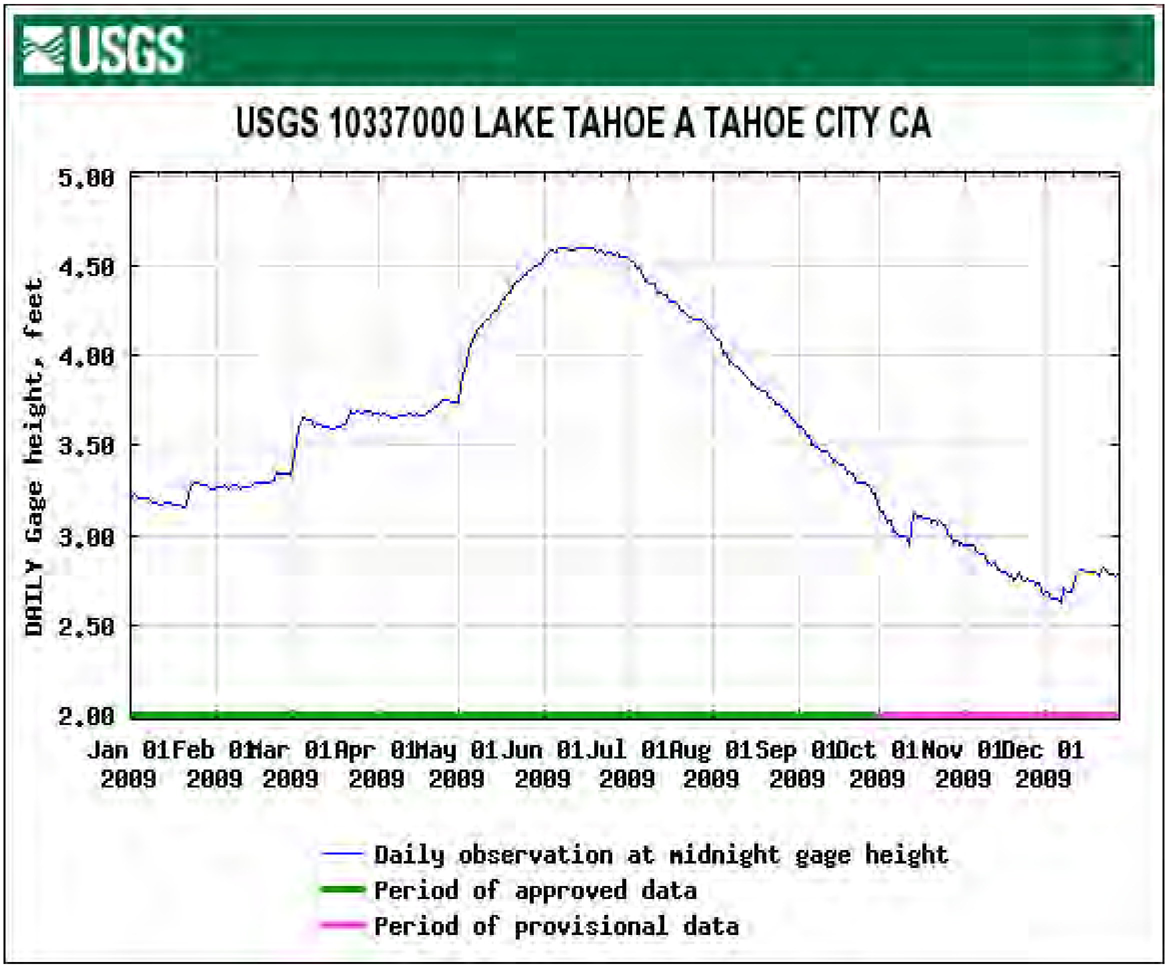


Figure 1. Elevation of Lake Tahoe in 2009 at the USGS Tahoe City Station (add 6,220.0 ft to gage height on the y axis).

During the survey period, Lake Tahoe was at a low elevation, only one half foot above the natural rim of 6,223 ft. With the further decline in lake elevation the number of TYC-occupied sites increased from 43 in 2008 to 47 (Figure 2), the same level as the last low lake level period in 2004-2005 and the highest number ever recorded. The locations of the 47 occupied sites are shown in the map compiled annually by NNHP (Figure 3). The fewest number of occupied sites occurred in 1995 and 1996, when only 9 sites were occupied.

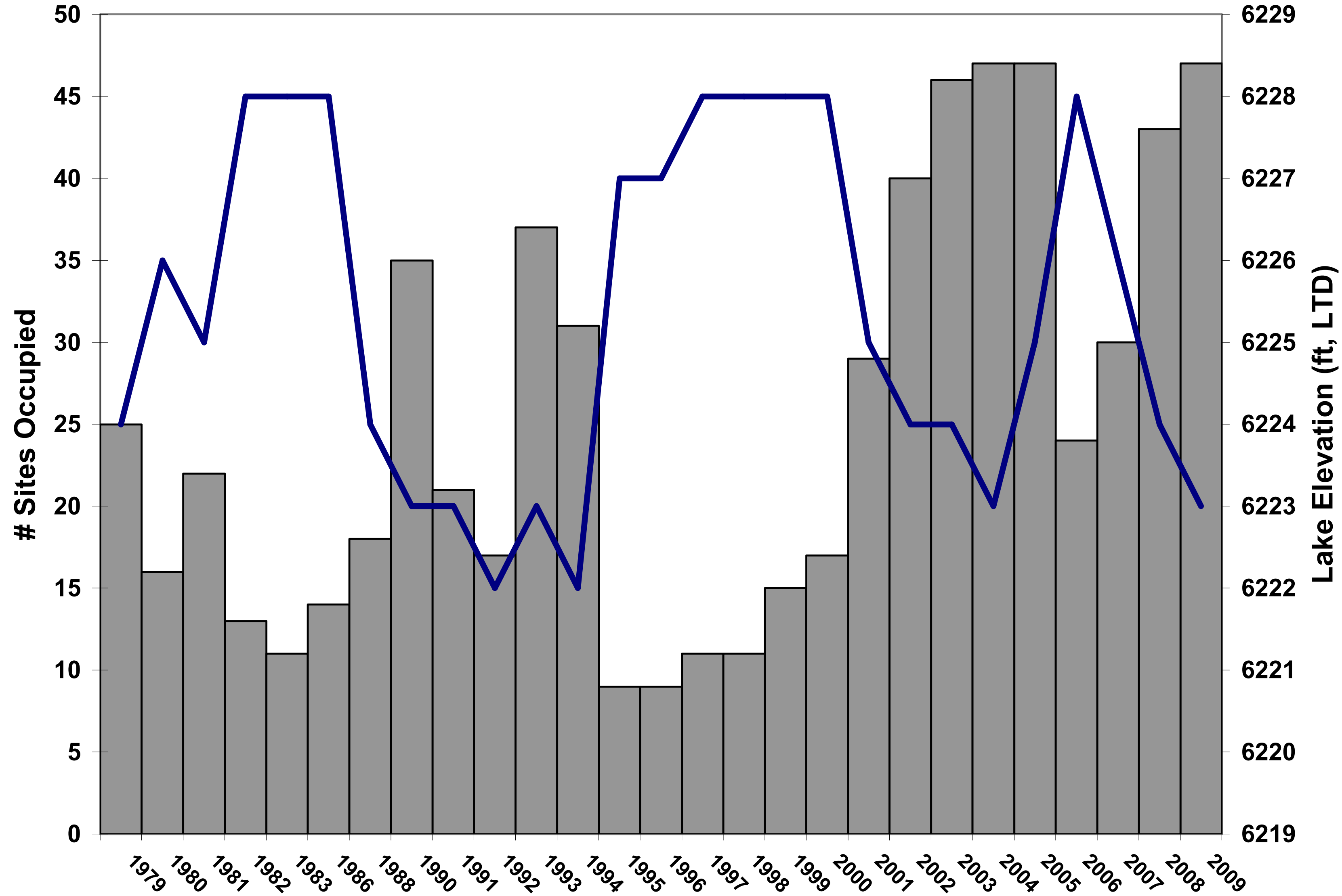
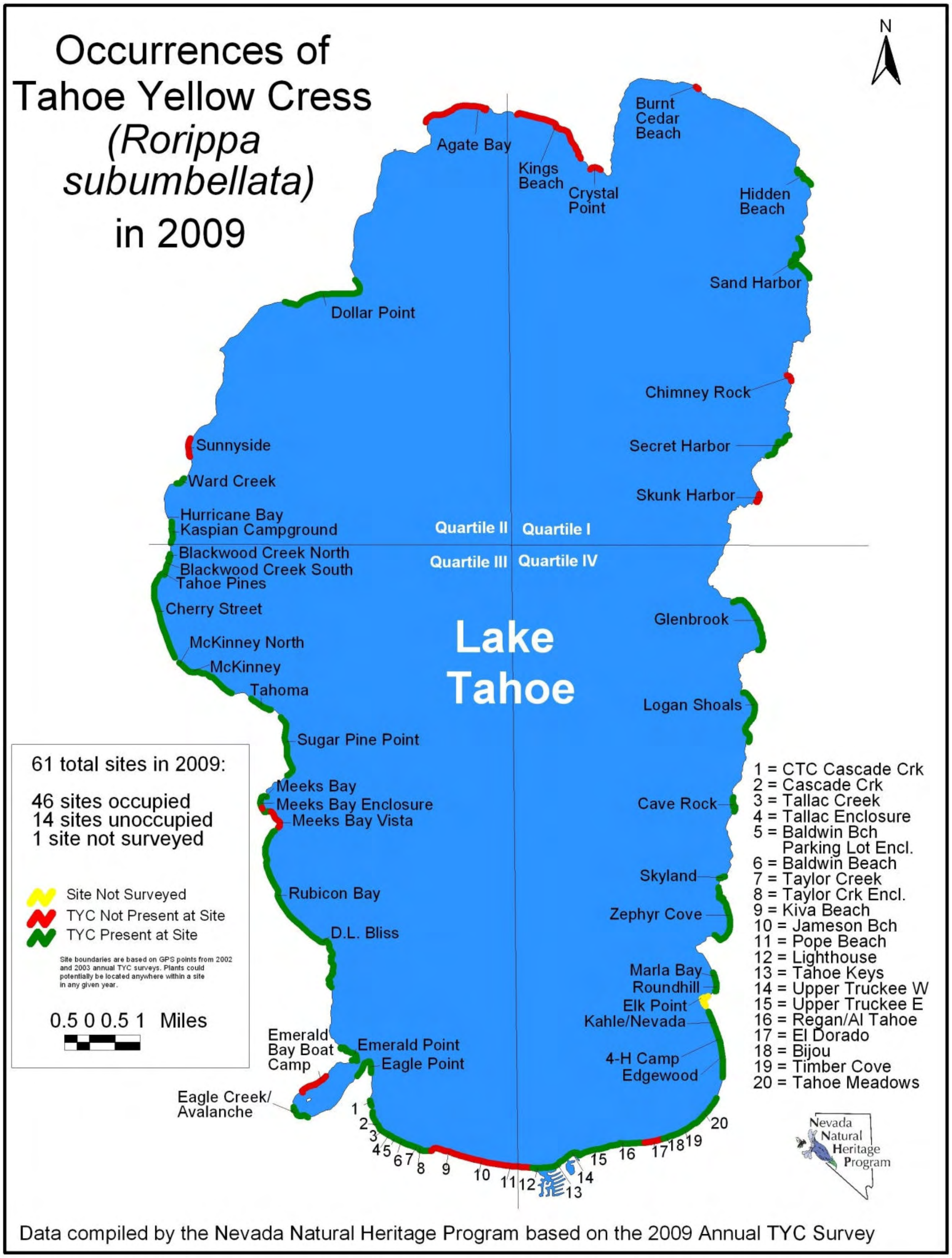


Figure 2. Lake level and number of Tahoe yellow cress sites occupied by survey year (solid blue line = lake level LTD)



Occurrences of
Tahoe Yellow Cress
(Rorippa
subumbellata)
in 2009
N
Lake
Tahoe
Quartile I
Quartile II
Quartile III
Quartile IV
Burnt
Cedar
Beach
Agate Bay
Kings
Beach
Crystal
Point
Hidden
Beach
Sand Harbor
Dollar Point
Chimney Rock
Sunnyside
Secret Harbor
Ward Creek
Skunk Harbor
Hurricane Bay
Kaspian Campground
Blackwood Creek North
Blackwood Creek South
Tahoe Pines
Cherry Street
Glenbrook
McKinney North
McKinney
Tahoma
Logan Shoals
Sugar Pine Point
Meeks Bay
Meeks Bay Enclosure
Meeks Bay Vista
Cave Rock
Skyland
Rubicon Bay
Zephyr Cove
D.L. Bliss
Marla Bay
Roundhill
Elk Point
Kahle/Nevada
Emerald
Bay Boat
Camp
Emerald Point
Eagle Point
4-H Camp
Edgewood
Eagle Creek/
Avalanche
61 total sites in 2009:
46 sites occupied
14 sites unoccupied
1 site not surveyed
Site Not Surveyed
TYC Not Present at Site
TYC Present at Site
Site boundaries are based on GPS points from 2002 and 2003 annual TYC surveys. Plants could potentially be located anywhere within a site in any given year.
0.5 0 0.5 1 Miles
1 = CTC Cascade Crk
2 = Cascade Crk
3 = Tallac Creek
4 = Tallac Enclosure
5 = Baldwin Bch Parking Lot Encl.
6 = Baldwin Beach
7 = Taylor Creek
8 = Taylor Crk Encl.
9 = Kiva Beach
10 = Jameson Bch
11 = Pope Beach
12 = Lighthouse
13 = Tahoe Keys
14 = Upper Truckee W
15 = Upper Truckee E
16 = Regan/Al Tahoe
17 = El Dorado
18 = Bijou
19 = Timber Cove
20 = Tahoe Meadows
Nevada
Natural
Heritage
Program
Data compiled by the Nevada Natural Heritage Program based on the 2009 Annual TYC Survey

All of the 61 known sites were surveyed except Elk Point and a total of 14 new sites were added to the survey list (Table 1). The total estimated stem count increased by more than 10,000 stems from the 2008 estimate (17,125 stems) to 27,522 stems. The number of stems counted at any one site ranged from 1 to over 10,000, while survey effort, in terms of recorded person minutes, ranged from 12 to 400. A total of 24 people participated, representing 10 agencies and 3 private firms. The total amount of time spent searching for TYC increased by about 36% in 2009 from 5,674 minutes (94 hours) to 8,828 minutes (147 hours). This increase is a function of the greater amount of beach exposed by the lower lake elevation and the increased survey effort. However, this figure does not include any travel time between sites or other time. When these are taken into consideration the total number of hours reported by all staff for the annual survey was approximately 336 hours.

Table 1. Stem counts and survey effort for 61 Tahoe yellow cress sites in September 2009 (NS = not surveyed, X= incomplete survey;plants known to be present).

Site ID	SITE NAME	Ownership	Rank	# Stems	Survey minutes
1	Sunnyside	Private/Placer Co	UNRANKED	0	110
2	Ward Creek	Private	HIGH	290	340
3	Kaspian Campground	USFS	UNRANKED	6	120
4	Blackwood North	Private	CORE	16	60
5	Blackwood South	Placer County	CORE	275	75
6	Tahoe Pines (Fleur Du Lac)	Private	UNRANKED	65	120
7	Cherry Street/Tahoe Swiss Village	Private	LOW	70	195
8	McKinney North/Shores	Private	LOW	70	50
9	McKinney Creek	Private	UNRANKED	32	60
10	Tahoma	Private	LOW	339	220
11	Sugar Pine Point State Park	CA State Parks	UNRANKED	56	60
12	Meeks Bay	USFS	HIGH	97	120
13	Meeks Bay Enclosure (+ 1 new encl)	USFS	UNRANKED	0	
14	Meeks Bay Vista	Private	UNRANKED	0	12
15	Rubicon Bay	Private	MEDIUM	1086	400
16	DL Bliss State Park	CA State Parks	UNRANKED*	70	50
17	Emerald Point	CA State Parks	MEDIUM	58	120
18	Emerald Bay Boat Camp	CA State Parks	MEDIUM	0	50
19	Eagle Creek/Avalanche	CA State Parks	HIGH	373	160
20	Eagle Point	CA State Parks	MEDIUM	6	112
21	CTC Cascade Creek	CTC	UNRANKED	71	180
22	Cascade Creek	Private	HIGH	545	304
23	Tallac Enclosure	USFS	CORE	348	240
24	Tallac Creek (outside Enclosure)	USFS	CORE	304	240
25	Baldwin Beach	USFS	MEDIUM	34	120
26	Baldwin Bch Parking Lot Encl (+ 1 new encl)	USFS	UNRANKED	314	140
27	Taylor Creek Enclosure	USFS	CORE	1557	240
28	Taylor Creek	USFS	UNRANKED	3030	270
29	Kiva Beach/Valhalla	USFS	LOW	0	60
30	Jameson	Private	UNRANKED	0	60
31	Pope Beach	USFS	LOW	0	240
32	Lighthouse	Private	CORE	350	70
33	Tahoe Keys	Private	MEDIUM	2014	150

Site ID	SITE NAME	Ownership	Rank	# Stems	Survey minutes
34	Upper Truckee West	CTC	CORE	428	125
35	Upper Truckee East	CTC	CORE	10400	340
36	Regan/Al Tahoe	Private/City SLT	LOW	807	140
37	El Dorado Beach	City SLT	LOW	0	20
38	Bijou (Timber Cove Lodge)	Public	UNRANKED	63	50
39	Timber Cove	Private	MEDIUM	72	80
40	Tahoe Meadows	Private	CORE	133	100
41	Edgewood	Private	CORE	855	90
42	4-H Camp/City Pump House	UNR/City	MEDIUM	237	40
43	Kahle/Nevada	USFS	HIGH	703	360
44	Elk Point	Private	UNRANKED	NS	NS
45	Roundhill	USFS	UNRANKED	6	90
46	Marla Bay	Private	UNRANKED	13	40
47	Zephyr Cove	Private/USFS	HIGH	265	270
48	Skyland	Private	UNRANKED	90	120
49	Cave Rock	NV State Parks	MEDIUM	38	30
50	Logan Shoals/Vista	Private	MEDIUM	1603	150
51	Glenbrook	Private	MEDIUM	90	240
52	Skunk Harbor	USFS	UNRANKED	0	90
53	Secret Harbor	USFS	MEDIUM	30	360
54	Chimney Rock	USFS	UNRANKED	0	90
55	Sand Harbor	NV State Parks	LOW	15	70
56	Hidden Beach	NV State Parks	UNRANKED	1	20
57	Burnt Cedar Beach	IVGID	UNRANKED	0	20
58	Crystal Point	Private/Placer Co	UNRANKED	0	20
59	Kings Beach	Private/Public	UNRANKED	0	60
60	Agate Bay	Private	UNRANKED	0	45
61	Dollar Point	Private	LOW	152	360
	Total Named Sites			27477	8168
	NEW SITES				
	Truckee River Outlet	Private		0	80
	Hurricane Bay	Private		0	30
	N of Meeks Bay	Private		incomplete	20
	Emerald Bay North Shore	CSP		0	130
	Emerald Bay South Shore	CSP		0	120
	South of Edgewood	Private		45	15
	Edwin Z'Berg Natural Preserve	CSP		0	100
	Vikingsholm	CSP		0	60
	Ponderosa			0	10
	Skinny Dipper Point			0	10
	Sand Harbor South	NV State Parks		0	20
	Thunderbird			0	30
	Skunk Harbor South			0	15
	Dead Man's Point			0	20
	Total New Sites			45	660
	GRAND TOTAL			27522	8828

Survey boundaries for named sites were extended in some instances. Of the 14 new sites that were identified, TYC was newly discovered in a previously un-surveyed location on the beach just south of Edgewood Golf Course in Nevada. The site consists of about 14 parcels with several piers and a cluster of 45 stems was found higher on the beach in an area protected by a single willow. In addition, newly exposed small patches of beach on the west shore that were occupied were included in tallies for Emerald Bay and D.L. Bliss State Parks. The survey was incomplete at Meeks Bay Vista because surveyors were asked to leave by a property owner just after disembarking from the boat.

Almost half (47%) of the occupied Tahoe yellow cress sites occurred on private lands or those under mixed public and private ownership, while 53% were on lands managed by public agencies (Table 2). Because of the site at the mouth of the Upper Truckee River (UTE), almost 40% of the estimated total stem count in 2009 was on land managed by CTC. Nearly a quarter of the stems were on USFS lands (23%) and about one third of the stems were on private/ mixed lands (33%).

Table 2. The number of occupied sites and estimated stem counts by site ownership in 2009.

Ownership	# Occupied Sites	# Stems	% total stems
CA State Parks	5	563	2.0
City SLT/UNR	2	300	1.1
CTC	3	10,899	39.6
IVGID	0	0	0.0
NV State Parks	3	54	0.2
Placer County	1	275	1.0
Private	20	7,930	28.8
Private/Mixed	2	1,072	3.9
USFS	11	6,429	23.4
Total	47	27,522	

Ranked sites supported the majority of stems (85%) and required the majority of the search effort (72%) (Table 3). Core sites supported 53% of all stems, about a 10% decline from the previous year. High, Medium, and Low priority sites supported 8, 19, and 5% of all stems, respectively, which was nearly exactly the same proportions as last year. The proportion of stems supported by unranked sites increased from 6% to 14 % of the total stem count.

Table 3. Stem count and survey effort in the 2009 annual survey by site ranking category.

Rank	N	# Stems (% total)	# survey minutes (% total)
CORE	10	14,666 (53)	1,580 (18)
HIGH	6	2,273 (8)	1,554 (18)
LOW	9	1,453 (5)	1,355 (15)
MEDIUM	12	5,268 (19)	1,852 (21)
UNRANKED	38	3,862 (14)	2,487 (28)
Total	75	27,522	8,828

The number of stems counted at each site was classified into abundance categories that match the minimum viable population (MVP) stem count estimates found in the CS. The MVPs were derived from the relationship between mean stem count at a site and that sites' persistence during the period from 1979 to 2000. Each MVP corresponds to a different probability of persistence after 20 years. The goal for Core sites is to manage and restore them to a minimum of 1,200 stems in order to insure a 90% probability of persistence for the next 20 years. Likewise, the goal for High priority sites is to obtain a minimum of 300 stems to ensure a 75% persistence probability and for Medium priority sites a minimum of 30 stems to ensure a 50% chance of persistence for 20 years.

Figure 4 provides a comparison of the proportion of sites that fall into each MVP abundance class between a high lake level survey year (6229 ft in 2006) and a low lake level year (6223 ft in 2009). When the lake was full, there were 36 unoccupied sites, compared to only 14 when the lake is near the natural rim. At the other end of the abundance spectrum, 5 sites had stems counts over 1,200 in a low lake level year compared to only one in a low level year.

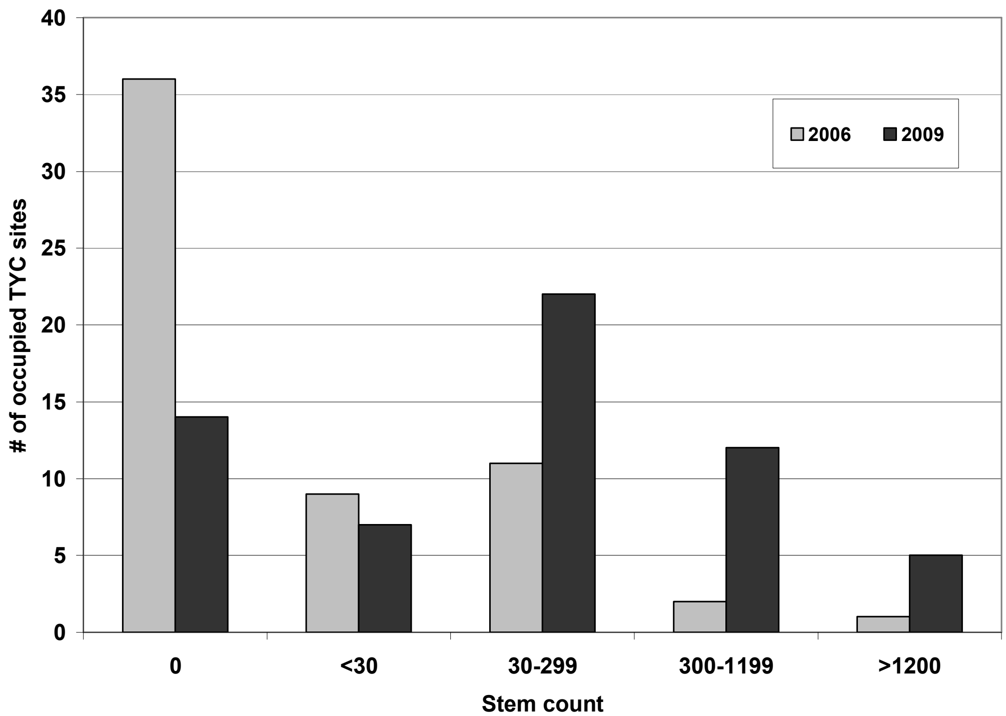


Figure 4. The number of occupied Tahoe yellow cress sites in 5 stem count abundance categories in a low (2006) and a high (2009) lake level year.

For the tissue sampling effort for the genetic analysis, leaves were collected from a total of 51 locations. At least one leaf was collected at all 47 occupied named "sites", two of which were split into two locations and two new sites called South of Edgewood and Emerald Bay Kayak beach. A grand total of 2,064 leaf samples were collected and have been stored for future analysis at UNR. Because some the stems included in the annual survey estimates were very small, the target of 60 leaf samples was only achieved at 20 sites. From 11 to 51 samples were collected from 21 sites and this may be a sufficient sample size for inclusion in the analysis. Less than 10 samples were obtain from the other 11 sites and hopefully those small samples sizes will be useful in some way.

Finally, the detection probability survey yielded some useful preliminary results. Using the standard protocol (a pair of surveyors walking on the beach) detection probability on the 14 parcels at Lighthouse was 100%. On the 17 parcels at Tahoe Keys, surveyors missed TYC on 3 parcels for a detection probability of 82.4%. These limited results lend support to the assumption that TYC is not a cryptic species, is easy to find when it is present, and therefore detection probability in most circumstances is very high.

In contrast, the water-based methods did not yield acceptable levels of detection. Detection probability at Lighthouse and Tahoe Keys via kayak or walking in the water was only 3%. That beach had a fairly steep profile in September and TYC was only detected on the large parcel in front of the Tahoe Keys Property Owner's Association offices. Likewise, detection probability at Blackwood South via kayak or walking in the water was only 7.6%. The majority of the plants occurred in a back beach depression that was not at all visible from the lake and the surveyors only detected 1 cluster of plants that was 5 meters from the waterline. In addition, the false detection rate at Blackwood South was 15.4% (other species were identified as TYC on 2 parcels).

2.3 DISCUSSION

The detection of TYC at all 10 Core sites and 37 other priority and unranked sites during the 2009 annual survey means that there were a sufficient number of occupied sites that the AMWG can operate under Level 1 (normal conditions) of the Imminent Extinction Contingency Plan defined in the Conservation Strategy. At Level 1, no changes to the normal policies and guidelines for protection of existing occurrences and potentially suitable habitat are required.

Protection measures for TYC remain focused on enclosures on public lands. Nearly half (49%) of the 2009 stem count was protected in the 8 public enclosures (13,453 stems).The enclosure at UTE alone protects 10,400 stems, or 38% of the 09 count, while an additional 3,053 stems are in enclosures other than UTE. Formal conservation measures on private property have yet to be implemented.

3.0 2009 RESEARCH ACTIVITIES

The 2009 research activities are divided into three sections. Section 3.1 presents two years of data from the 2008 and 2009 experimental reintroductions designed to test the timing of outplanting and a brief summary on the status of the 2006 experimental cohort. Section 3.2 presents data for translocations conducted in 2008 and 2009. Section 3.3 briefly summarizes genetic research using microsatellite DNA analysis.

3.1 EXPERIMENTAL REINTRODUCTIONS

The first phase of experimental plantings of container-grown plants from 2003 to 2006 addressed Key Management Questions focused on optimal planting techniques, plant characteristics, habitat conditions, and logistical factors for restoration efforts. High lake level in 2006 completely inundated all surviving founders from the 2003 to 2005 cohorts and so the 2006 cohort is the only remaining cohort subject to monitoring. A brief synopsis on the status of the 2006 experimental cohort is presented.

A second phase of experimental plantings was initiated in 2008. The purpose of the study was to determine the best time to conduct restoration outplantings of container-grown TYC. The regulatory window for TYC surveys and activities extends from June 15 to September 30, but past plantings have primarily been tested around the time of maximum lake elevation in June. In 2009, the experimental design was repeated and a second year of demographic data was collected for the 2008 experimental cohort. The research has been supported by Round 6 Sierra Nevada Public Lands Management Act (SNPLMA) funds administered by the LTBMU.

3.1.1 METHODS

2006 cohort monitoring
The final year of the first phase of experimental reintroductions was conducted in 2006 when 1,175 container-grown TYC were outplanted at seven enclosures: Lester Beach at D.L. Bliss State Park (CSP), at Taylor and Tallac Creek at Baldwin Beach (USFS), Ebright Beach (USFS), Pope Beach (USFS), Upper Truckee East (CTC) and Nevada Beach (USFS). For detailed experimental methods please see Pavlik and Stanton, 2007. The plantings at D.L. Bliss and Ebright essentially failed and were not monitored after 2007. Monitoring at the other 5 sites continued into 2008. In 2008, none of the founders in the meadow habitat at UTE emerged and the stakes were removed at the end of the growing season. Limited monitoring of the remaining 4 sites was conducted in 2009.

Plant propagation
The greenhouse propagation of Tahoe yellow cress was conducted at the Nevada Division of Forestry (NDF) nursery in Washoe, Nevada. Seed was sown in supercell containers with greenhouse potting mix and covered with a thin layer of vermiculite to hold the seed in place. Seedlings were watered regularly with a light fertilizer solution. The planting racks held 98 containers each and were periodically thinned to space plants and give them more light and opportunity for root growth. For the 2008 cohort, seed was collected in September 2007 at five sites: McKinney Creek, Blackwood Creek, Taylor Creek, Upper Truckee East, and Nevada Beach. Approximately 400 cells of each seed lot were sown on January 17, 2008 for a total of 2,000 cells. For the 2009 cohort, seed was collected in September 2004 from the Core population at Upper Truckee East. Approximately 10 TYC seed per pot was sown in 2,000 supercell containers on January 15, 2009. In both years the first batch of plants was removed from the greenhouse for planting in May (2009) or June (2008) and thereafter at four week intervals into September for each planting event.

Site selection and planting design
In 2008, four sites were approved for the experimental reintroductions; private property on the north side of Blackwood Creek, California Tahoe Conservancy (CTC) land at Upper Truckee

East (UTE), private property at Edgewood Golf Course, and California State Parks land just north of General Creek at Sugar Pine Point SP. Site descriptions may be found in the 2008 annual report (Stanton and Pavlik 2009).

Rather than use un-tested sites, sites that had supported successful reintroductions in the past were selected to repeat the experimental design in 2009. Plantings from 2003 to 2005 on USFS beaches at Zephyr Cove and Pope Beach and the planting at UTE were all very successful, although nearly all of the experimental plants at these sites were completely inundated in 2006 when the lake reached its legal capacity. Ebright Beach was also selected despite very poor performance of the 2004 and 2005 cohorts. Those plantings were conducted in the stabilized portion of the beach that supported scrub vegetation and it was expected that a lower placement of the fence at Ebright in 2009 in sandy open habitat would provide better growing conditions.

A standard planting protocol was utilized in both years. Container-grown plants were spaced one half meter apart in a regular grid design and marked with wooden stakes color-coded by month. The planting treatments were randomly distributed throughout the grid. The June cohort was installed beginning on June 17th when the lake was at an elevation of 6224.6 ft LTD. Lake level was 6224.3ft during the July 14-15th planting, 6223.9 ft on August 10-11th, and 6223.5ft on September 10-11th (see Figure 1). After each planting, newly planted individuals were hand-watered for 3 days. Plant status and phenology was monitored at every planting time, concluding in October. The canopy of surviving plants was also measured in October. Each site is briefly described.

Pope Beach
The first planting was conducted in May at Pope Beach because it was necessary to install a temporary fence to protect existing plants prior to the Memorial Day weekend. At the end of the 2008 season there had been 72 TYC from the 2006 cohort remaining on site plus 20 plants from the 2005 cohort that had re-sprouted after they were translocated to Taylor Creek in 2006 prior to inundation. On May 19, 2009, a temporary fence of 15 x 20 m and a grid of 300 wooden stakes were installed directly west of the location of this cohort of older plants (Photo 2). The translocation was conducted (see section 3.2) along with the planting of 50 container-grown TYC. Subsequent cohorts of container-grown plants were installed on the same schedule as the other sites, every four weeks, beginning on June 17th. The beach topography was mostly flat, the substrate was sandy, and only a few Penstemmon plants were present within the enclosure.

Ebright Beach
A temporary fence was installed at the west end of Baldwin Beach directly adjacent to the private property boundary on June 1, 2009. This is the same location that temporary fencing was previously installed in 2005, but the placement was much closer to the waterline of Lake Tahoe. However, 7 plants from the 2006 cohort still persisted and these were included within the upper portion of the fence. Those were the only TYC in the area. On June 15th, a grid of 250 wooden stakes was installed and 50 container-grown TYC were installed at the same time that the translocation was conducted. The beach topography was mostly flat, the substrate was sandy, and only a few Phacelia plants were present within the enclosure.

Zephyr Cove
On June 1, 2009, a temporary fence was installed in a similar location as the 2003 experimental planting, as close to the water as possible (but avoiding inundation) (Photo 3). On June 16, a grid of 200 wooden stakes was installed and 50 container-grown TYC were planted. A significantly smaller amount of habitat was available in 2009 than there was at the time of the 2003 planting. The previous outplanting took place on May 22, 2003 when the lake was 6224.4 ft, only 0.2ft lower than the level in 2009. At that time there was sufficient habitat to install two fences, one permanent and one temporary, separated by a 5m wide walkway through the center. In 2009, the same location on the beach only accommodated one fence. It may be that the high lake level in 2006 steepened the profile of the beach and reduced the amount of area that became exposed.

UTE
No new fencing was required at Upper Truckee East and the existing enclosure was used. A grid of 250 wooden stakes was installed toward the eastern end of the enclosure just to the west of the 2008 experimental plots (Photo 4). The beach topography was gently sloped and narrow and the substrate was sandy and mostly free of naturally occurring TYC at planting time. The planting grid was located on the margin of the front beach depression, which had standing water at the beginning of the growing season. A dense swath of vegetation including grass and TYC formed at the margin as the season progressed and it encroached in the first row of the outplanting.

Data analysis
The survivorship and reproductive data is presented simply as a proportion of the total cohort, not a mean of a replicated treatment, so no statistics were performed for this report. Means were calculated for canopy area and ANOVA was performed using the JMP statistical software (SAS). The Tukey HSD (Honestly Significant Difference) was used for multiple comparisons, a test that protects against the Type I error rate, particularly when sample sizes are different.

3.1.2 Results

In 2009, limited monitoring was conducted of the remaining sites of the 2006 cohort. For the 2009 cohort, first year survivorship of each planting cohort at a site was evaluated across all monitoring months, while the second year survivorship of the 2008 cohort was monitored in June and again in October. Plant canopy was only measured in October. For both cohorts only data from October is presented.

2006 cohort
Limited monitoring was conducted in 2009 of the 4 remaining sites of the 2006 cohort: Taylor and Tallac Creek at Baldwin Beach, Pope Beach, and Nevada Beach. At the Tallac enclosure there were about 99 TYC present in June, but vigorous clonal growth made it difficult to distinguish re-sprouted stems of the 2006 cohort from new recruitment. However, it was possible to identify at least 50 plants that were clearly from the 2006 planting (they were still next to a stake) and these were used for the translocation to Ebright. No further demographic data was collected and the stakes were removed. Consequently, plants from the 2006 cohort were included in the annual survey stem count in September even though they are generally excluded at outplanted sites. At Pope Beach approximately 110 TYC stems remained from the 2005-2006 founding cohorts. A total of 50 of these were used in the translocation, but 69 TYC stems were

left outside the temporary fence. No demographic data was collected on the unprotected stems but they were monitored for presence/absence on a monthly basis (see translocation section for results).

At Taylor Creek, only 19 plants from the 2006 cohort survived through September 2008 (19% of the original cohort). Of these, 13 were present in 2009 but no demographic data was collected and there was no additional recruitment within the plot. At Nevada Beach, a total of 140 plants from the 2006 cohort survived through September 2008 (71% of the original cohort). Survivorship dropped off dramatically in 2009 and only 48 plants (24% of the cohort) were identifiable as originating in the 2006 planting. However, it was not possible to identify the 24 plants in one of the moist shoreline plots that survived into 2008 because of heavy additional recruitment, so true survivorship may have been as high as 37% (74 plants). Surviving plants were not measured because of the lack of comparable data available from other sites or from past years.

2008 cohort

At the outset of the experiment in 2008, it was expected that the total first year survivorship of earlier planting cohorts in June and July would be greater then the later cohorts of August and September. Such a linear pattern was not particularly pronounced at any site in October 2008 (Figure 5A). The total survivorship of late planting cohorts was lower at UTE but the opposite pattern was present at Sugar Pine, where survivorship was at its highest levels in the August and September cohorts. Survivorship of the September cohort at Blackwood was almost 90% and planting time seemed to have little effect under the drier conditions at Edgewood on the east shore. In the second year, the pattern of survivorship of the 2008 cohort did not change much among the sites except that the September cohort did not survive well into the second year (Figure 5B). The higher than expected survival of the September cohort in 2008 was thought to be an artifact of only having one month of monitoring data available, so the reduced second year survivorship was expected. However, the performance of the August cohort remained greater than expected at UTE and Sugar Pine. Total survivorship at Blackwood declined by one half because one of the two planting blocks of 100 plants collapsed into Ward Creek in an early season run-off event in 2009.

A) B)

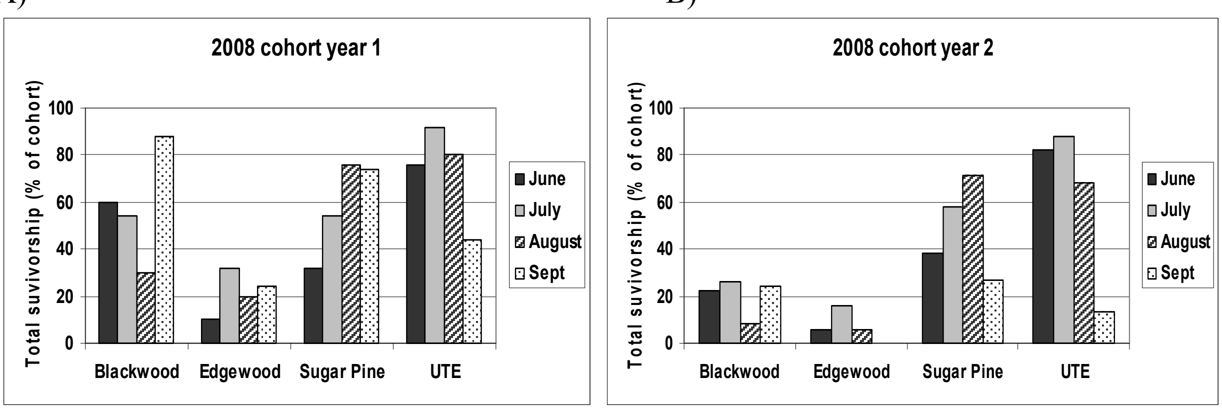


Figure 5. Total survivorship of the 2008 founding cohort in A) year one, October 2008 and B) year two, October 2009.

While the apparent pattern of both first and second year survivorship in the 2008 cohort was variable among the sites (survivorship increased with later planting time, decreased with later planting time, and had no effect), the canopy size of surviving plants in the second year was significantly greater in earlier planting cohorts than in later planting cohorts. Founders in the June and July cohorts at Blackwood and Sugar Pine were three to four times larger than founders in the August or September cohorts (Figure 6). At UTE, the difference was even greater. The mean canopy area of the June cohort was 906 cm^2, while the canopy of September founders was only 33 cm^2. Plant performance was optimal at UTE where the canopy of the June cohort was over four times larger than the early season cohorts at the other sites.

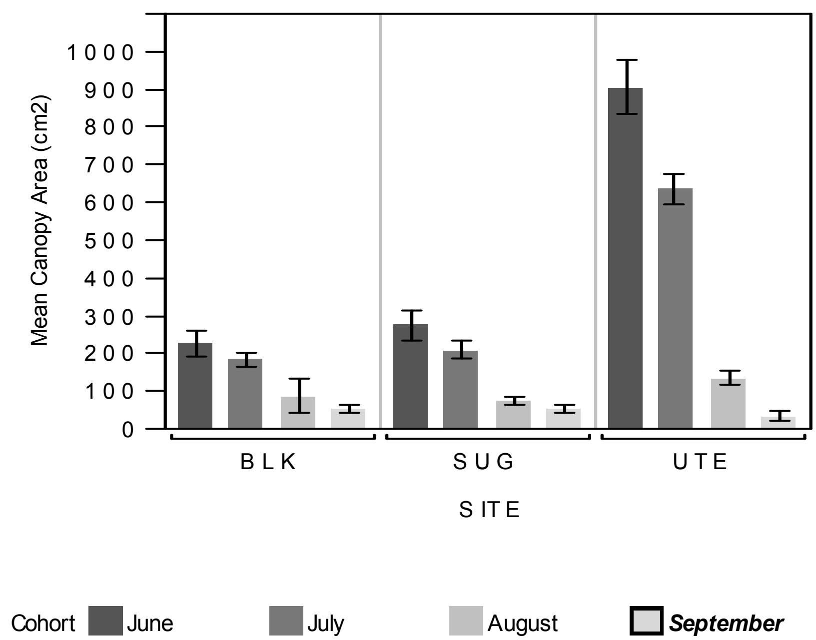


Figure 6. Second year mean plant canopy size (cm2) of the 2008 founding cohort in October 2009. Error bars are ± 1 standard error.

Within each site that had reproductive growth, estimated mean seed production per plant in the second year (a function of plant canopy area) was also significantly greater in the June and July cohorts than in the August and September cohorts (Table 4). When seed production for all three sites was combined, the total number of seeds produced per month was 155,158 seeds, 122,164 seeds, 19,356 seeds, and 2,449 seeds for June, July, August, and September, respectively. Seed production in June and July was significantly greater than August, which was significantly greater than September. The 247 surviving founders of the 2008 cohort produced a combined 299,129 seeds. None of the founders at Ebright survived to reproduce.

Table 4. Second year survival and reproductive output of the 2008 experimental cohort in October, 2009. Values followed by different letters within a column are significantly different Tukey Kramer HSD (p<.05). N=the number of estimates in the mean seeds per plant calculation.

SITE	**Cohort**	**Survivorship (% of cohort)**	**Reproduction (% of cohort)**	**Mean no. seeds per plant**	N
Blackwood	June	22.0	22.0	785.9**a**	10
	July	26.0	26.0	552.6**a**	13
	August	8.0	8.0	NA	2
	September	24.0	24.0	188.8**b**	6
Sugar Pine	June	38.5	36.5	933.7**a**	19
	July	58.0	54.0	672.2**a**	28
	August	71.4	63.3	245.6**b**	25
	September	26.7	22.2	219.4**b**	6
UTE	June	82.0	82.0	3,160.0**a**	41
	July	88.0	88.0	2,185.5**b**	44
	August	68.0	60.0	472.1**c**	28
	September	13.3	11.1	NA	2

2009 cohort

Like the 2008 cohort, the pattern of first year survivorship in the 2009 cohort was variable among the sites (Figure 7A). Survivorship apparently increased with later planting time or had no effect, but no site in 2009 exhibited the expected pattern where survivorship decreased with later planting time. Survivorship apparently increased with later planting time at Pope, while planting date appeared to have little effect at UTE or Zephyr. It was not clear why the June and September cohorts at Ebright had reasonably good survivorship while the July and August cohorts did not, but overall performance at this site was very poor.

Similar to the first year results of the 2008 cohort, the September cohort again survived much better than expected. As previously mentioned, this is possibly an artifact of having only one month of data available from a month when cooler temperature might act to preserve the container-grown plants from desiccation. However, another possibility is that the September cohort developed better root structure in the greenhouse during a more prolonged growing period. Or it may be the combination of the two factors that enabled plants to persist into October. Whatever the cause of the apparent persistence, reproduction failed completely in the September cohort at every site (Figure 7B).

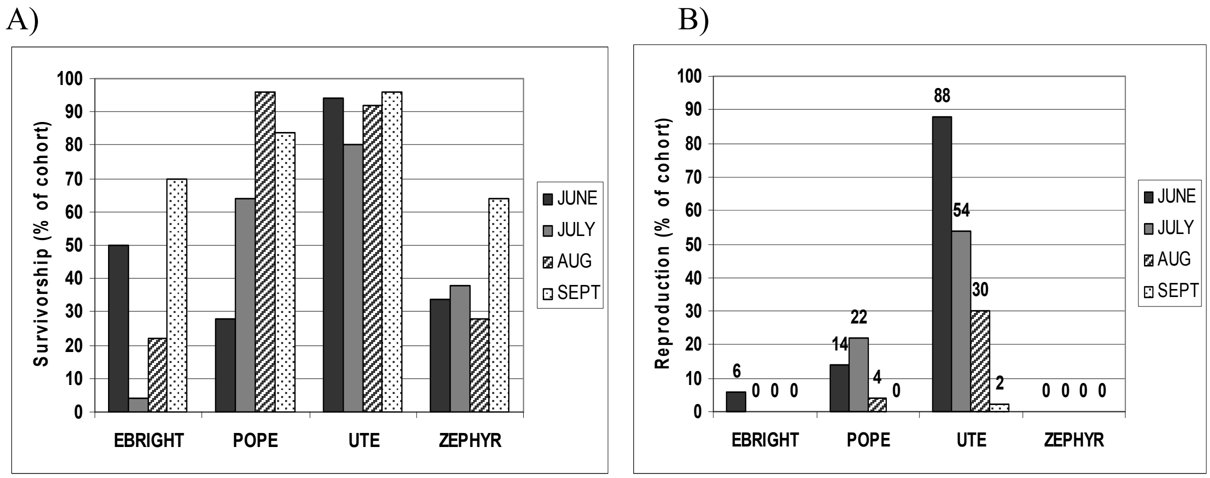


Figure 7. First year A) survivorship and B) reproduction of each 2009 founding cohort in October, 2009.

Overall survivorship of all sites combined was slightly greater in 2009 (61%) compared to 2008 (55%). These survival rates fall within the range of variation seen in total first year survivorship of all the past experimental cohorts from 2003 to 2006 (47 to 71%).However, first year reproductive performance was again very poor in 2009 (Figure 7B). A little less than 17% of the entire cohort survived to reproduce compared to 18% in 2008. Plants did not reproduce at all at Zephyr Cove and only 3 plants at Ebright from the June cohort flowered. Although low, reproduction at Pope was greatest in the June/July cohorts. In the optimal habitat at UTE, the expected decline of reproductive capacity was observed for later planting cohorts and a much greater proportion of the June cohort reproduced than all others.

Similar to the pattern observed in 2008, first year growth and reproductive output of earlier planting cohorts was greater than the late cohorts at three of the four sites (Table 5). At Ebright, the June cohort was significantly larger in size and was the only planting cohort to manage any reproduction at all. At Pope, the May cohort had a significantly greater mean canopy area than the July, August, and September cohorts and both the August and September cohorts failed to reproduce. However, there was no significant difference in mean seed production among the reproducing cohorts. The poor performance of the June cohort (only 12 surviving plants) at Pope may have been due to low quality of the container-grown plants. At UTE, total survivorship was not affected by planting time, but the June cohort vastly outperformed all other cohorts, growing significantly larger and producing a greater mean number of seeds per plant. Finally, the planting at Zephyr Cove was an unexpected failure. Regardless of planting time, the surviving plants were very small and no reproduction occurred at all.

Table 5. First year growth and reproductive output of the 2009 experimental cohort in October 2009. Numbers followed by different letters within a column are significantly different Tukey Kramer HSD (p<.05).

SITE	Cohort	Mean Canopy Area (cm2)	N	Mean no. seeds per plant	N	Survivorship (%)	Reproduction (%)
Ebright	June	17.5**a**	25	72.0	3	50.0	6.0
	July	NA	2	0.0	0	4.0	0.0
	August	4.9**b**	12	0.0	0	24.0	0.0
	September	4.9**b**	35	0.0	0	70.0	0.0
Pope	May	81.7**a**	44	244.5**a**	32	88.0	66.0
	June	59.3**ab**	14	199.8**a**	5	28.0	14.0
	July	28.2**bc**	32	204.7**a**	6	64.0	22.0
	August	17.0**c**	41	0	0	83.7	0.0
	September	33.0**bc**	48	NA	2	96.0	4.0
UTE	June	533.7**a**	47	1990.1**a**	44	94.0	88.0
	July	153.1**b**	40	600.5**b**	27	80.0	54.0
	August	58.6**b**	46	139.4**b**	15	92.0	30.0
	September	37.1**b**	45	NA	1	95.7	2.1
Zephyr	June	11.2**a**	17	0.0	0	34.0	0.0
	July	9.5**a**	19	0.0	0	38.0	0.0
	August	6.0**a**	16	0.0	0	32.0	0.0
	September	11.8**a**	32	0.0	0	64.0	0.0

3.1.3 Discussion

The regulatory window for TYC surveys and activities extends from June 15 to September 30, but the majority of the previous experimental plantings from 2003 to 2006 were conducted around the time of maximum lake elevation in June. The rationale behind the timing of planting was that water availability is greatest at peak lake level and presumably would facilitate establishment of container-grown plants. Likewise, water availability presumably declines as the season progresses and lake level drops. Therefore, one would predict that plant performance, as measured by survivorship and reproduction, would be lower in cohorts planted in August or September than those planted in June or July.

In both 2008 and 2009, planting time did not appear to strongly influence overall survivorship. Depending on the site, first year survivorship increased with increased planting time, decreased with planting time, and had no effect. The same pattern generally persisted into the second year. However, plant survivorship alone is not an adequate measure of project success because plants need to be able to reproduce to persist. Unfortunately, overall reproduction was very low in both years. Plants essentially failed to reproduce in the first year at three of four sites in 2008 and at two of four sites in 2009. The resulting small sample sizes somewhat limit our ability to determine the effect of planting time on plant performance. However, the values for mean plant canopy include non-reproductive plants, and the sample sizes are larger so the fact that both first and second year canopy size was significantly greater in cohorts from June and July than those from August or September is a significant result. Larger plants produce more seeds and mean seed production per plant was also significantly greater in earlier planting cohorts. In addition, almost all of the 2008 founders that did survive into the second year became reproductive and produced an estimated 300,000 seeds, while the 2009 cohort produced half of that amount in the first year.

The implications for restoration timing are that planting earlier results in better plant performance. At a site with optimal habitat conditions like UTE, a plant installed in June will grow about five times larger than a plant put in the ground in August or September. While a late planting in September might appear to survive for the rest of the growing season, most of the plants do not return the following year and reproduction will most likely fail completely.

However, some sites appear to provide suboptimal habitat. Among the seven sites tested, reproduction failed regardless of planting time at Ebright, Edgewood, and Zephyr Cove. Two previous plantings under higher lake levels conditions at Ebright also failed, so it was not a totally unexpected outcome there even though it was hoped that installing the fence at a lower elevation might improve performance. Naturally occurring stems have not been found in the area so the conclusion must be that that site cannot sustain TYC. The poor performance at Edgewood could be attributed to fine-scale microhabitat differences. A relatively large concentration of TYC has been present at Edgewood for several years around the area that was planted, but several characteristics of the planted area itself appear to have inhibited establishment; the planted area was about one foot higher than the adjacent area that supported natural plants, it had greater vegetation cover, and the apparently sandy substrate turned out to have a relatively thick fibrous root network from the sedges scattered across the area. Why the planted area did support about five or six natural stems but did not support container-grown plants is not clear.

The results from Zephyr Cove highlight the dynamic nature of conditions around the lake and indicate that a site that previously supported good to optimal habitat can become unsuitable within a few short years. As described in the methods, the site accommodated two experimental plots in 2003, but only accommodated one experimental plot in 2009.While the 2003 planting was very successful the planting in 2009 completely failed. In 2006, Lake Tahoe completely inundated the site and deposited several feet of cobble and gravel that apparently steepened the beach profile significantly. The coarser substrate and the steeper topography may have been two of the contributing factors that drastically reduced the ability of the site to support TYC.

At sites that supported moderate plant performance it was beneficial to plant as early as possible. Founders planted in June and July at Blackwood and Sugar Pine produced significantly more seed per plant than the later cohorts. A much greater proportion of plants installed in May at Pope Beach survived to reproduce than any other cohort but this did not translate to superior plant growth or seed production in the first year. Finally, at a site with optimal habitat conditions like UTE exhibited the expected outcome where the June cohort had the best performance, the September cohort essentially failed, and July and August had moderate growth and survival.

3.2 TRANSLOCATION

Translocation involves moving established plants in the field from one location to another. It has been used as mitigation for the disruption of sensitive species habitat and as a salvage measure to preserve individuals when habitat is destroyed. In the past, many translocation projects have lacked a rigorous experimental component and adequate monitoring. In addition, translocation projects are often undertaken with little or no knowledge of the horticultural requirements or genetic architecture of the species. However, the experimental reintroductions have paved the way for investigating translocation as a possible mitigation tool. First, the horticultural requirements of TYC have been determines through the nursery propagation. Second, genetic studies using allozymes (Saich and Hipkins 2000, DeWoody and Hipkins 2004, DeWoody and Hipkins 2006) and more recently, microsatellite DNA (see Appendix D) to assess genetic variation have concluded that TYC has very little genetic variation. Therefore, genetic contamination through outplanting efforts may not be a concern, but the microsatellite work is ongoing. 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. Given the unique circumstances of the robust research program and the adaptive management framework, an informal consultation between CDFG and the USFWS regarding the disturbance of natural populations of a candidate species resulted in a decision to support translocation research with Section 6 funds. CDFG approved a sole source contract to BMP Ecosciences in Agreement Number PO520009 to support translocation work from 2006 to 2008. The purpose of the study was to compare the methods of translocation and outplanting of container-grown plants to determine if translocation may be a potential restoration/mitigation option for unavoidable impacts of construction or other development projects on the shores of Lake Tahoe. The guiding key management question was simple: Does translocation of naturally occurring TYC and outplanting of container-grown TYC result in the same rates of survival and reproduction?

The potential use of translocation as a mitigation tool is a critical management concern in light of many proposed Lake Tahoe Environmental Improvement Projects (EIP) and the newly approved Shorezone Plan for the region. Reversing a moratorium on most new pier construction that has been in place for more than 20 years, the new Shorezone Plan allows 138 new piers, 6 boat ramps, and 235 boat slips on the shores of Lake Tahoe. Although the plan is likely to be in litigation for some time, the availability of new mitigation and restoration tools would be a valuable asset in reducing impacts to TYC if and when new development occurs. Likewise, the basin-wide EIP targets many of the creek mouths that support core TYC populations including the Upper Truckee River, Blackwood Creek, Ward Creek, and Tallac Creek for SEZ restoration and other projects that could impact the shorezone environment. In instances on both private and public lands where avoidance of naturally occurring TYC plants is not possible it will be crucial to know the effectiveness of moving plants within or between sites.

3.2.1 METHODS

Site selection
In 2007, the AMWG established a criterion for the translocation of naturally occurring TYC that specifies that donor sites must have a minimum of 400 naturally occurring stems. This threshold was based on the analysis of minimum viable population (MVP) size in the CS that identified a population size of 300 stems as affording a 75% chance of persistence over 20 years. The number was arbitrarily increased by 100 in order to provide a comfortable buffer. For experiments on National Forest System Lands, the LTBMU has taken the position that donor TYC must be "experimental" i.e. container-grown plants that were nursery-grown and outplanted as part of an experimental reintroduction, rather than a naturally occurring plant. State and federal sensitive plant regulations do not address such distinctions. In a pilot translocation in 2006 it was determined that experimental container-grown TYC must be a minimum of three years old before the root structure is sufficiently established to mimic the complex structure in naturally occurring TYC.

In order to dovetail with the experimental outplanting of container-grown plants to test timing, three of the same sites were selected for the 2009 translocation: Pope Beach, Ebright Beach, and UTE. For translocation at Pope and Ebright, three year-old container-grown TYC from the 2006 experimental planting were available at Tallac Creek and Pope Beach. A total of 50 donor plants were selected from the 99 TYC stems remaining from the 2006 founding cohort at Tallac Creek and these were translocated directly north to the temporary enclosure at Ebright. Similarly, approximately 110 TYC stems remained at Pope Beach from the 2005-2006 founding cohorts. In the translocation, 50 of the 2006 cohort were moved directly over into the new fence, leaving a total of 69 TYC stems outside the fence. All 69 of these stems were mapped using five 15 meter transects extending east from the fence. These stems were monitored for presence/absence every four weeks through October to determine if donor plants re-sprouted and if plants without fence protection succumbed to trampling. At Nevada Beach, a total of 47 experimental plants from the 2008 Edgewood translocation were selected as donor plants. While these were not originally container-grown plants, they had already been experimentally manipulated and so were considered "experimental".

Donor plants for the translocation at UTE were naturally occurring stems. With over 10,000 stems counted in the 2008 annual survey, the site fit the minimum size criterion. Donor plants were selected from a large cluster of plants present just outside of the enclosure concentrated around the riverine lagoon that formed as a result of the high lake level in 2006. These plants made ideal candidates for translocation since they were outside the zone of protection of the fence.

Nevada Beach was also selected as a receptor site because it had open habitat available in the existing enclosure and "experimental" plants from the 2006 cohort to use as donor plants. However, by the scheduled translocation date in June, only 48 stems had emerged that were identifiable as part of the 2006 cohort. These stems were still very small and it was not feasible to use these stems as donor plants. Instead, stems occurring in the eroded pit at Edgewood Golf Course were used as donor plants. A total of 855 stems were counted at the site in the September annual survey (not including any experimental plants).

Translocation experimental design
The 2008 experiment utilized a paired-design with one container-grown plant for each naturally occurring translocated plant, with 50 replicate pairs per site. For each pair, a naturally occurring plant from the donor location was translocated to the receptor location and a container-grown plant was outplanted one half meter away at the same elevation (Photo 5). At UTE and Ebright Beach the translocation was included as a treatment within the block design of the outplanting to test timing and compared against the June cohort of container-grown plants. At Pope Beach, the translocation was also included within the block design of the outplanting to test timing, but the translocation had to be conducted in May. The May cohort of container-grown plants was extra in the time series and these were compared against the translocants. At Nevada Beach, the experimental block contained only 50 translocants and 50 container-grown plants (Photo 6).

To begin the translocation at a donor site, the canopy area of each donor plant, measured as a length and a width, was recorded along with the phenology. Next, a "sharp-shooter" shovel was inserted into the sand several centimeters away from the above-ground canopy. Care was taken to cut outside of the zone of the perceived rootmass. The researcher then grasped the above ground cluster of stems and plant canopy and the rootmass was slowly extracted with a rocking motion of the shovel to capture as much root structure as possible and minimize damage. Very little soil clung to the roots once exposed because of the sandy nature of the substrate (Photo 7) However, potting mix sometimes remained attached to the roots of the three year old experimental plants from the 2006 cohort (Photo 8). The length of the bare rootmass was recorded and the plant placed in a moist plastic ziplock bag, labeled and kept in the shade. After the last plant was extracted from the donor site, plants were immediately transported to the receptor site.

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

Data analysis
The survivorship and reproductive data is presented simply as a proportion of the total cohort, not a mean of a replicated treatment, and no statistics were performed for this report. Means were calculated for canopy area and ANOVA was performed using the JMP statistical software (SAS). The Tukey HSD (Honestly Significant Difference) was used for multiple comparisons, a test that protects against the Type I error rate, particularly when sample sizes are different.

3.2.2 RESULTS

2009 cohort
First year survivorship of container-grown and translocated plants was similar in October, 2009 at three of the four sites (Figure 8A). Container-grown plants appeared to be slightly more likely to reproduce at all sites (Figure 8B). At Ebright, 50% of the container-grown plants survived compared to only 30% of the translocants. However, reproduction essentially failed at that site, with only 3 container-grown plants surviving to fruit (6%).

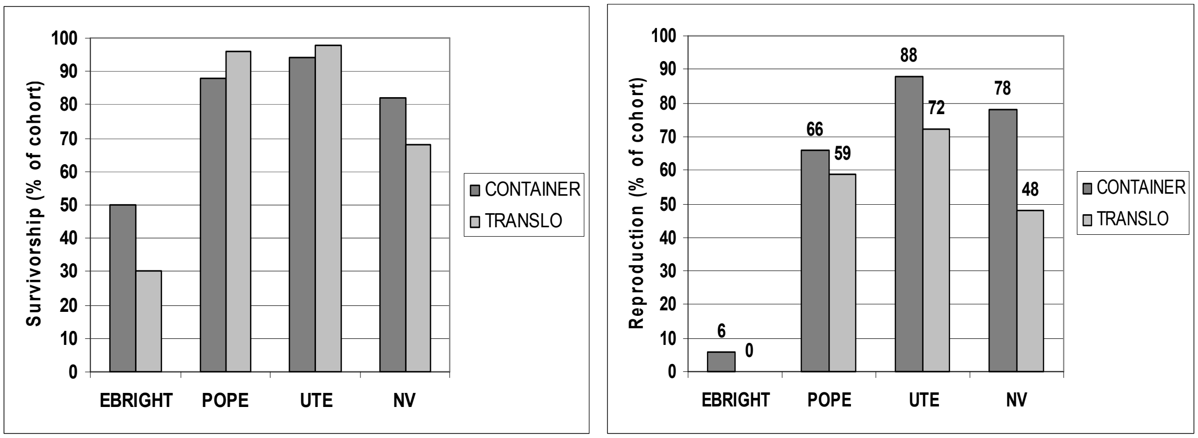


Figure 8. First year A) survivorship and B) reproduction of the 2009 cohort of translocants and container-grown TYC in October, 2009.

Despite the similar rates of survivorship, the mean canopy area of surviving TYC was significantly greater in container-grown plants compared to translocated plants at UTE and NV (Figure 9A). A similar pattern was observed in the mean number of seeds produced per plant, which is a function of canopy size (Figure 9B). Growth was so poor at Pope and Ebright that no difference was observed.

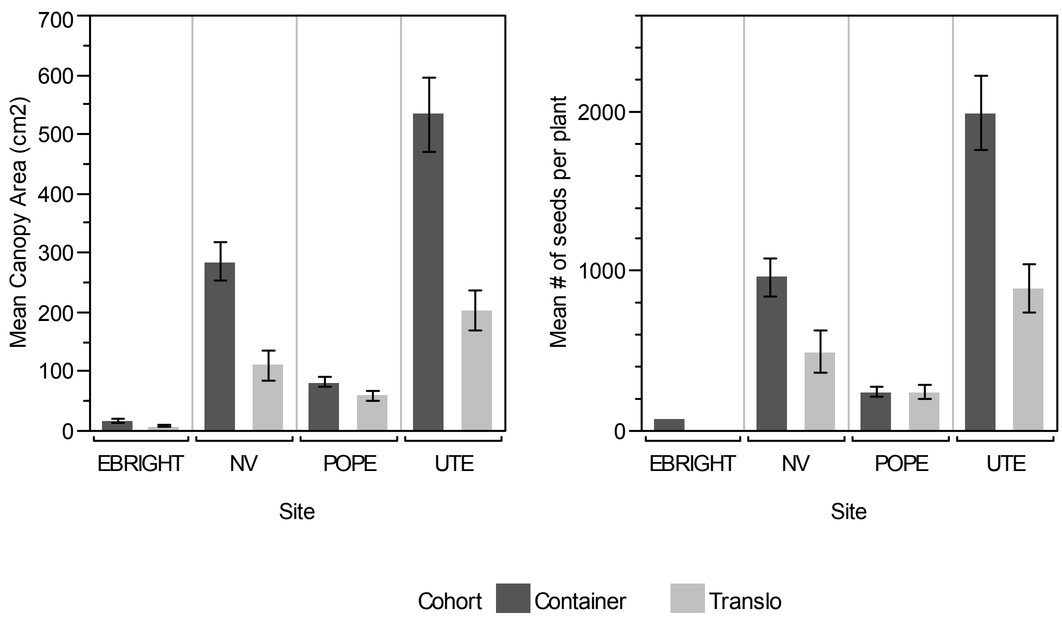


Figure 9. The mean A) canopy area (cm2) and B) seed production of translocants and container-grown TYC at four sites in October, 2009. Error bars are ± 1 standard error.
(vegetative plants are included in mean canopy area)

When measurements from all sites were pooled, the greater growth of container-grown plants compared to translocants was highly significant (Table 6). On average, container-grown plants were slightly over twice as large as translocants and consequently produced twice as much seed per plant.

Table 6. Mean canopy area and seed output per plant of 2009 translocants and container-grown TYC in October, 2009. Pooled data for all 4 sites.* ANOVA p<.0001

Source	Mean canopy area (cm2)	N	Mean # seeds per plant	N
Container	259.9*	157	1138.9*	115
Translo	112.6*	144	573.6*	79

Persistence outside fence at Pope Beach

After the translocation of 50 plants from the 2005 and 2006 experimental cohort on May 20, 2009 at Pope Beach there were 69 stems left outside of the newly constructed temporary fence. The number of stems tallied each month fluctuated. In June, there were 82 stems, of which 12 were identified as definite re-sprouts. The number fell to only 31 by July 14th and then rebounded to 41 by August 10th. On October 16th, there were again 82 stems, 35 of which were reproductive. This tally appears to represent a loss of 37 stems (119 in May – 82 in October). However, 49 of the 51 individuals survived the translocation and therefore the loss is attributable to trampling of those plants that were left unprotected by a fence.

2008 cohort

At the end of the first year at UTE, there was no apparent difference in rates of survivorship(90/96%) or reproduction (80/86%) between container-grown and translocated plants, respectively, and. measured canopy area was identical (270.0 cm^2). All of the first year survivors returned in the second year with no mortality, but in 2009, the canopy size of container grown plants was significantly greater than translocants ($p<.0001$) (Figure 10). The significant difference in canopy size also translated to significantly different mean seed production per plant; 3,297.8 seeds per plant for container-grown compared to 2,387.3 seeds per plant for translocated. With nearly all of the plants surviving, total seed production was high; container-grown plants produced an estimated 105,530 seeds while translocants produced 81,169.7 seeds.

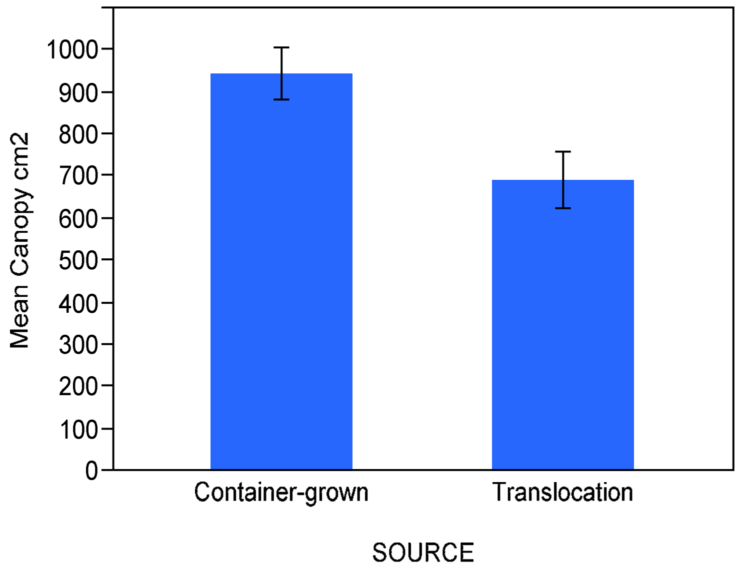


Figure 10. Mean canopy of container-grown translocation plants from the 2008 cohort at UTE in October, 2009. Error bars are ± 1 standard error.

A second year of data from the 2008 translocation at Edgewood was not available since the stakes were removed at some point over the winter or spring. In September 2008, a greater proportion of translocated (87%) than container-grown (56%) founders had survived to reproduction at Edgewood but there was no difference in the canopy size of the survivors. It is likely that the same pattern of survivorship would have persisted into the second year, but the explanation for the better performance of translocated founders over container-grown plants in the first year is not clear. It was observed that Canadian Geese may have preferentially grazed a few of the container-grown plants immediately after planting. This site also received supplemental water from run-off from the golf course, so that may have also affected the outcome.

3.2.3 Discussion

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

Although the first year of results in 2008 was inconclusive, a second year of data from both the 2008 and 2009 experimental cohorts suggests that container-grown plants perform significantly better than translocated plants, especially in optimal habitats. In sub-optimal habitat conditions, there is no evident difference, either because poor growth masks the effects or because the lack of resources negates any potential benefit of the soil tube on the container-grown plants. A second year of data from the 2009 cohort is needed before any conclusions can be drawn, but the implication for mitigation and restoration seem to be that translocation is a viable option. Translocated individuals will survive if habitat conditions are good to optimal, but using container-grown stock gives a greater pay-off of increased growth and seed output. Under sub-optimal conditions the plant source might not make much difference but container-grown plants could be used in a greater numbers and therefore could insure a higher probability of success.

3.3 GENETIC RESEARCH

The Lab for Ecological and Evolutionary Genetics at the University of Nevada Reno (UNR) is conducting the genetic analysis using microsatellite DNA. The lab, headed by Dr. Mary Peacock, set up a contract for $50,000 in SNPLMA R7 funds with the USFS in early 2008 to 1) screen 4 newly developed genomic libraries for a sufficient number of variable markers and 2) screen recently collected TYC samples from previous TYC surveys (2006 and 2007). Dr. Peacock submitted a detailed progress report for work conducted in 2008 to the AMWG on February 25, 2009. A more detailed report and proposal for expanded work was presented to the AMWG in December 2009 (please see Appendix D).

4.0 PRIVATE LANDS CONSERVATION

4.1 STEWARDSHIP PROGRAM

The Conservation Strategy specifies that a stewardship program is an integral piece of successful TYC conservation because up to 50% of TYC is located on private land. A Stewardship committee was formed in 2007 with a goal to create and distribute educational materials about the conservation of TYC to the public and private landowners and to facilitate research and active conservation on private lands. BMP Ecosciences and NRCS collaborated on the production of a tri-fold brochure called “TYC, a unique piece of Tahoe”. BMP developed the brochure content and NRCS staff in the Davis office did the graphic design. The cost to print 10,000 brochures through the Government Printing Office (GPO) totaled only $786.24 and additional brochures can be printed up at a reduced cost in the future. The initial goal was to have the brochure available for distribution by the Memorial Day weekend, however printing was slightly delayed and it was available on June 9, 2009. The USFS distributed brochures at visitor kiosks at Baldwin and Pope Beach. The CTC Land Steward handed them out at UTE, and other agencies made them available in their offices.

BMP Ecosciences also developed a website to serve as a comprehensive source of information about TYC conservation. The website address www.tahoeyellowcress.org appeared on the brochure and the website layout incorporates similar design elements as the brochure. The home page emphasizes that TYC is "one of a kind" and provides paired photos of TYC and the common western yellow cress (*R. curvisiliqua*) to aid identification. A second main page dedicated to protection lists four "Simple things you can do" to help and has three subpages focused on research, conservation, and management. The research page lists all of the sites that have been planted, the Key Management Questions that have driven the experimental process, and the key research findings to date. The conservation page briefly describes TYC population dynamics, the role of lake level in population distribution and abundance, and how the conservation strategy provides a framework for recovery of the species. The management page very briefly outlines the adaptive management framework for the AMWG.

A third main page on the website is dedicated to the "Natural history mystery of TYC". This page tells a very condensed version of the story found in the CS of how TYC may have evolved over time in response to the particular environmental forces at work in the Lake Tahoe basin. Finally, a fourth main page lists all the partners to the CS and provides links to the home page of agency websites.

4.2 PRIVATE LANDS CONSERVATION

NRCS secured Round 8 and 9 SNPLMA grants of $45,000 each to provide technical assistance to private landowners interested in protecting TYC on their lands. In August 2008, Jerry Owens (NRCS) developed a draft template for a private property Stewardship Plan. At the Executive Meeting in August 2009 the AMWG and the Executive Committee discussed ways that this type of plan could offer regulatory relief for property owners trying to complete a project. TRPA indicated that although the stewardship plan does not necessarily meet permit requirements, the agency would favor making the plan template available for project proponents as a way to give landowners a "headstart" on permitting. For example, a pre-project survey could be waived for project proponents with a stewardship plan that grants permission for annual surveys.

The Executives also discussed the merits of focusing regulatory relief efforts on down-listing the species in California through increased protection & restoration versus project-specific mitigation and plans. One proposed idea to support a certain threshold of TYC on private lands was to encourage landowners to participate in a lake-wide management plan that could be modeled on the Safe Harbors Program. Another idea was to incorporate TYC education into the BMP program as an efficient way to engage landowners. Resource Conservation Districts (RCD) conduct most Lakefront BMP evaluations and if funding were available, these programs could take responsibility for distributing brochures, signing up landowners for stewardship plans, and obtaining permission for annual survey access.

5.0 2009 AMWG CONSERVATION ACTIVITIES

5.1 AMWG MEMBERSHIP

The Adaptive Management Working Group (AMWG) consists of representatives from 11 stakeholder agencies, the Tahoe Lakefront Owner's Association, and the private consultants at BMP Ecosciences (Table 7). Although they are not signatories on the MOU, NRCS, the North Tahoe Conservation District (NTCD), and the Bureau of Reclamation (BOR) expressed intent to sign an updated MOU in 2010.

Table 7. Membership of the Tahoe yellow cress Adaptive Management Working Group (AMWG) in 2009.

Agency or Entity	AMWG Representative
TRPA	Eileen Carey, Vegetation Program
USFWS	Steve Caicco, Botanist, (meeting facilitator)
USFS LTBMU	Cheryl Beyer, Forest Botanist
	Stu Osbrack, Botanist
NDSP	Peter Maholland, Conservation Staff Specialist
NDF	Roland Shaw, Forester
NNHP	Jennifer Newmark, Administrator/Program Biologist
CDFG	Tim Nosal, Environmental Scientist
CSP	Daniel Shaw, Environmental Scientist
CTC	Adam Lewandowski, Conservancy Program Analyst II
CSLC	Eric Gillies, Environmental Scientist
TLOA	Jan Brisco, Executive Director
BMP ECOSCIENCES	Bruce Pavlik, Principal and Alison Stanton, Research Botanist
NRCS	Jerry Owens, Resource Conservationist
NTCD	Gretchen Huie,
BOR	Myrnie Mayville,

5.2 AGENCY ACTIVITY REPORTS

The CS requires a brief summary of annual agency staff time and expenditures on TYC conservation and management (Table 8). Agencies submit generalized Agency Activity Reports itemizing expenditures for staff time and other in-kind contributions for site-specific activities within their jurisdiction and for general TYC conservation activities like public outreach, consultation, and AMWG participation. The form also allows managers to list any significant disturbances to the species or its habitat that may have occurred on their sites; planned TYC conservation activities anticipated for the upcoming year; and all shorezone projects undertaken within potentially suitable habitat. Agency Activity Reports are not included in the report this year but are available on request. In 2009, the number of staff hours spent on TYC amounted to at least 1,600 hours, of which 336 hours were for the annual survey. Total in-kind cost contributed by each agency for all staff time and materials amounted to a minimum of $66, 220 (some agencies did not report expenditures), not including any contracted funding. Contracted funding is discussed in Section 6.1.

Table 8. Summary of agency hours spent on Tahoe yellow cress related activities during the 2005-2009 period.

Agency/Year	2005	2006	2007	2008	2009
TRPA	200	No report	No report	77	65
USFWS	70	60	80	80	138
USFS	980	1,240	700	520	440
NDSP/NDF	89	116	54	51	67.5
NNHP	175	190	83	85	
CDFG	334	380	209	96	48
CSP	358	233	139	133	182
CTC	606	No report	95	422	456
CSLC	235	181	110	121	68
TLOA	No report	No report	50	No report	73
NRCS			12	64	23
NTCD					30

5.3 Site-Specific Information Sheets

Site-Specific Information Sheets provide a comprehensive repository of information pertaining to TYC for all named locations. This format fulfills the intent of Appendix J in the CS, Proposed Actions for Core and High Priority Sites, and expands the number of sites to include private lands. The information is useful for project review on both public and private lands in the shorezone. AMWG members have been assigned to complete site-specific information sheets and approved forms are submitted to Eric Gillies, California State Lands Commission, for inclusion in a comprehensive file that will be periodically updated. A total of 37 forms have been completed and submitted to CSLC. However, most of these are in a draft form and still need to be reviewed by the AMWG as part of a formal review process that remains to be developed.

5.4 Funding

The annual report includes information on the five year funding strategy for the implementation of the TYC Conservation Strategy, including the year prior to the reporting year and the three years beyond. Table 9 presents awarded grants and contracted funding for the period from 2008 to 2012. For each award, the funding source, the contract amount, the contract administrator, and the recipient are identified. The tasks associated with each contract and the implementation year supported by the funding are also identified. All awards are discussed briefly below.

BMP Ecosciences received an award for $48,000 in Section 6 funds from the California Department of Fish and Game (CDFG) in 2006 to support restoration mitigation research. This contract was completed on March 31, 2009.

Several rounds of funding from the Southern Nevada Public Lands Management Act (SNPLMA) have been awarded to support TYC conservation. The Round 6 award of $350,000 to the USFS allocated $200,000 for contracting and $150,000 to support LTBMU staff time and other products. The LTBMU awarded a contract for $109,950 of the R6 funds to BMP in April 2007 to support research and AMWG participation that was completed in early 2009. A second contract for $81,000 in remaining R6 funds was awarded to BMP in April, 2008 to continue with research and additional AMWG –specified tasks. Funds from this award are available through mid- 2010. The R7 SNPLMA award of $150,000 to the USFS specified $50,000 for contracting with the remainder for LTBMU use. The LTBMU awarded $50,000 of R7 funds to Dr. Mary Peacock, University Nevada Reno (UNR), to conduct microsatellite DNA analysis. The Natural Resources Conservation Service (NRCS) received two awards of $45,000 each in Rounds 8 and 9 to provide technical support to private property owners and help to develop site-specific plans for TYC conservation. Finally, the LTBMU received a R9 award of $120,000 that has not been obligated to any specific contracting purposes. The AMWG will need to identify contracting needs and specific tasks for these funds in 2010.

TABLE 9. Contracted funding sources for the TYC Conservation Strategy for 2008 to 2012.

Funding Source	Amount	Administrator	Recipient	Tasks	Supported year 2008	2009	2010	2011	2012
USFWS Section 6	**$48,000**	CDFG	**BMP**	Nursery oversight	x				
				Mitigation/translocation feasibility experiment	x				
				Experimental outplanting	x				
SNPLMA R6	**$109,000**	USFS	**BMP**	Meta-analysis of 2003-2006 data		x			
				Experimental outplanting	x				
				AMWG	x				
				Manuscripts	x	x			
SNPLMA R6	**$81,000**	USFS	**BMP**	Experimental outplanting		x			
				Collaboration with UNR		x	x		
				AMWG		x	partial		
				Coordinate with NRCS		x	x		
SNPLMA R7	**$50,000**	USFS	**UNR**	Develop microsatellite DNA techniques	x	x			
SNPLMA R8	**$45,000**	NRCS	**NRCS**	Technical assistance on private lands	x	x	x		
				Tri-fold brochure		x			
SNPLMA R9	**$45,000**	NRCS	**NRCS**	Technical assistance on private lands				x	
SNPLMA R9	**$120,000**	USFS	**TBD**	**TBD**					
NRCS general funds	**TBD**	NRCS	**NRCS**	Publish rack-card, tri-fold		x			

5.5 PUBLIC LANDS MANAGEMENT

Many of the management activities on public lands over the last five years have focused on implementing the research agenda. Land management agencies have supported experimental outplantings within permanent enclosures and have installed temporary fencing and/or signage to protect additional plantings. However, increased levels of protection and enforcement at Core and High Priority (CHP) sites is indicated in the Conservation Strategy for TYC and has been put forth in AMWG recommendations to the Executive Officers. A list of specific conservation practices was compiled in April 2008 that each agency could draw from to develop an effective, site-specific "package" for their CHP sites that would be reviewed and evaluated by the TYC AMWG for efficacy and compliance with the Conservation Strategy. No management plans for CHP sites were developed in 2009. Fencing continues to be the primary tool for managing occupied sites on public lands.

5.6 REGULATION

The Memorandum of Understanding (MOU)/Conservation Agreement (CA) to implement the Conservation Strategy (CS) was signed in 2003 with an expiration in ten years. While the Conservation Strategy is intended to be an adaptive management document, Miscellaneous Provision G.6 of the MOU/CA states that the MOU/CA and CS may only be modified by mutual written consent of the parties. However, the AMWG has continually updated certain elements in the CS over the past 5 years, including the 5 Yr Management Plan , site rankings, Appendix C, and others. This could be problematic if the regulatory process is linked directly to the CS, such as the TRPA Shorezone Plan regulations.

At the Executive Meeting on August 5, 2009, the Committee directed the AMWG to conduct the 5 year review of the CS as specified in Clause F.1 and proposed to change the language in Section G.6 of the MOU as follows:

Change: The MOU/CA and CS may only be modified by mutual written consent of the Parties.

To: The MOU/CA may only be modified by mutual written consent of the Parties. The CS may be modified by mutual verbal consent of the Executives present at the annual Executive Committee Meeting, if a majority of the Executives are present.

The USFWS is taking the lead to secure needed signatures to implement this change. The change is expected to be approved in mid-2010.

As previously mentioned, the Executive Committee also discussed ways that the NRCS Stewardship plan could be used to offer regulatory relief for project proponents (see section 4.2).

6.0 PHOTOS

Photo 1 2009 annual survey team in a CA Dept of Fish and Game boat.

Photo 2. Temporary fence at Pope Beach with remaining founders from the 2006 cohort visible in the foreground outside the fence.

Photo 3. Temporary fence for outplanting to test timing at Zephyr Cove, June 2009.

Photo 4. 2009 planting at Upper Truckee East on the margin of the fore beach lagoon.

Photo 5. Paired design of the 2009 translocation with an A) translocated and B) container-grown TYC.

A)

B)

Photo 6. Translocation experiment in the Nevada Beach enclosure in September, 2009. Burke Creek was located just outside of the photo in the lower left corner.

Photo 7. Extracting a donor plant from Tallac Creek for translocation to Ebright Beach, June 2009.

Photo 8. Soil-less potting mix still attached to the rootmass of a three year-old donor plant at Tallac Creek, June 2009.

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8.0 APPENDICES

Appendix A: Generic Annual Field Survey Form (revised)

TAHOE YELLOW CRESS *(Rorippa subumbellata)* FIELD SURVEY FORM

Survey date: ____
Surveyor: ______________________________________ Affiliation: ______________________________________
Email: Telephone:
____

LOCATION (you may attach map showing boundaries)

Site name: ____ **Page _________ of __________**

TYC Present? Yes No Total Number of Stems: _________

Estimate the proportion (%) of the total number of stems across the entire site in each phenological stage:
Vegetative: ______ Flowering/Fruiting: ______ Senescent: ______

Survey Start Time:______________ Stop Time:_____________
Total search time: __________ x Number of surveyors_________= _________________person minutes

SURVEY BOUNDARY : **USE UTM WGS84/NAD83 ONLY**-Verify the datum on your GPS before starting.

START POINT______________E________________N

END POINT_________________E________________N

TYC GENETIC SAMPLE LOCATIONS: Use the following space to record information about genetic sampling locations. See Directions.

Sample #(s): ________ Location:______________ Sample #(s): __________ Location:_______________________
Sample #(s): ________ Location:______________ Sample #(s): __________ Location:_______________________
Sample #(s): ________ Location:______________ Sample #(s): __________ Location:_______________________
Sample #(s): ________ Location:______________ Sample #(s): __________ Location:_______________________
Sample #(s): ________ Location:______________ Sample #(s): __________ Location:_______________________
Sample #(s): ________ Location:______________ Sample #(s): __________ Location:_______________________

LAND USES AND IMPACTS (reference conditions across entire site)

Recreation intensity: None Low Medium High

Beach raking: Yes No APN(s) of raked parcels:____

List non-native weeds:____

Weed threat level: Low Medium High

Rorippa curvisiliqua present: Yes No

Describe any visible management observed that protects TYC (fencing, natural barriers, signs, enclosures):____
____
____

Add comments, recommendations, or sketches:

Appendix B: Survey Protocols for Tahoe Yellow Cress Annual Surveys

Expected lake level: 6223.5 ft LTD
Expected # of occupied sites: 43-47, about 24 with >60 stems

This year the goal is to be as comprehensive as possible in covering the entire shoreline. Each team will cover the portion of the lake specified in the team name i.e. Team 1 covers from Carnelian Bay to Tahoma. We will use generic datasheets- NOTE* the second page of the file is the map of the 2008 occurrences, so only print the number of maps that you need.

1) Use a Trimble or MobileMapper – Datum WGS84/NAD83.
2) Record start time for each site and please record the start UTM (just in case).
3) Make a separate file for each site using the site code and the date.
4) On private sites, **take a GPS point on every parcel where TYC is present.**
5) On public lands, take as many GPS points as necessary to capture distribution.
6) Record the number of stems present for the entire site, it is not necessary to record the number of stems present at each GPS point.
7) Do not include any outplanted TYC next to wooden stakes in the stem count.

In some instances it will be possible to extend the survey boundaries for existing sites. Treat previously un-surveyed locations as new sites. Chose an appropriate place name i.e. Carnelian Bay, Lake Forest, South of Sand Harbor (?) and use a new datasheet and GPS file. Record all information as for existing TYC sites. If no habitat exists, use the comments section to describe why (i.e. topography, substrate, etc). Take pictures if possible.

Genetic sampling

1) The sample unit is a single leaf from an "apparent TYC plant" or stem.

2) At sites with ≥ 60 stems, collect 60 leaves from throughout the entire site to get a representative sample.
3) At sites with <60 stems, collect as many stems as possible to get a representative sample.
4) Place each leaf sample in its own coin-sized envelope.

5) Label sample with site code and consecutive numbers from 1-60. i.e WRD 1, WRD 2 .
6) Record information about sample locations in the space on the annual survey datasheet, as described below.
7) Keep samples dry and mail to:

Mary M. Peacock, Ph.D.
Department of Biology/314
University of Nevada, Reno
mpeacock@unr.nevada.edu
(775) 784-1958

Reno, Nevada 89557

Genetic Sampling Location Description

The point of the sampling is to determine if there is genetic differentiation both among and within sites. Therefore, we would like to know the relative position of each sample or group of samples at a site and if the sample came from any sort of unique habitat feature. If plants are rather continuously distributed you may describe the position of small group of samples (<10 samples). At sites where plants are strongly clustered, the groups of samples will be larger (20 samples or more). If it seems reasonable to take GPS points for clusters, do so and note the waypoint or UTM in the location space. Use the following examples as a guide:

At large private sites that encompass many parcels (i.e. McKinney, Rubicon, Tahoe Keys)

Sample #: 1-10 **Location:** Near survey start point, north end of site
Sample #: 11-25 **Location:** 1/3 way, 0r 200m, south of start pt
Sample #: 26-30 **Location:** growing at the base of a lawn
Sample #: 31-40 **Location:** half way pt of site
Sample #: 41-50 **Location:** 2/3 way, or ¾ way south from start pt. Or ¼ way north of end pt.
Sample #: 51-60 **Location:** at south end of site, near survey end point.

At smaller sites where plant are strongly clustered (i.e. Tahoe Meadows, Blackwood N)

Sample #: 1-30 **Location:** clustered around survey start point at creek mouth
Sample #: 31-45 **Location:** growing at base of willow near site midpoint
Sample #: 46-60 **Location:** clustered in the wrack line in last 100m before survey end point.

Alison will conduct targeted sampling at selected sites. DO NOT COLLECT AT:
Nevada Beach
Taylor Creek
UTE

Appendix C: Presence (X) and Absence (0) of Tahoe Yellow Cress (1978-2009)

SITE NAME	OWNER ELEV	1978 6224	1979 6224	1980 6226	1981 6225	1982 6228	1983 6228	1986 6228	1988 6224	1989 6224	1990 6223	1991 6222	1992 6223	1993 6223	1994 6222	1995 6227	1996 6227	1997 6228	1998 6228	1999 6228	2000 6228	2001 6225	2002 6224	2003 6224	2004 6223	2005 6225	2006 6228	2007 6226	2008 6224	2009 6223
Sunnyside	Private		0	0	0	NS	NS	NS	NS	NS	0	NS	NS	X	0	0	0	0	0	0	0	0	0	0	0	0	NS	0	NS	0
Ward Creek	Private	X	50	136	20	9	121	285	186	NS	172	X	X	X	X	0	0	NS	0	0	0	NS	443	52	66	127	147	403	X	290
Kaspian Campground	USFS											11	10	NS	NS	NS	NS	0	NS	NS	0	1	0	0	1	4	0	15	8	6
Blackwood North	Private		0	78	49	152	100	197	246	NS	151	11	NS	X	X	0	0	X	0	0	30	100	60	27	54	416	21	305	15	16
Blackwood South	Private		35	25	58	56	359	1073	423	NS	814	NS	NS	X	X	0	0	X	X	X	600	205	272	168	163	18	667	2761	281	275
Tahoe Pines (Fleur Du Lac)	Private																	0	0	0	0	0	0	43	18	91	2	11	0	65
Cherry St/Tahoe Swiss Village	Private										X	NS	NS	X	X	0	0	0	0	0	0	0	36	109	51	25	0	0	9	70
McKinney North/Shores	Private													39	27	0	0	0	0	0	0	0	12	50	63	159	0	0	50	70
McKinney Creek	Private		0	NS	0	NS	NS	NS	NS	NS	19	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1	2	5000	0	42	37	32
Tahoma	Private		2	1	1	0	0	0	0	NS	0	NS	NS	X	X	0	0	0	0	0	0	0	NS	7	3	500	0	0	245	339
Sugar Pine Point State Park	CSP																					13	383	104	86	908	12	69	80	56
Meeks Bay	USFS		40	25	91	0	0	0	4	NS	152	290	148	0	0	NS	X	10	X	X	1	6	106	42	0	25	0	110	21	97
Meeks Bay Enclosures	USFS																			X	X	X	X	25	11	0	0	0	0	0
Meeks Bay Vista	Private			15	15	0	0	0	NS	NS	0	NS	NS	X	0	NS	NS	NS	0	NS	0	0	0	230	NS	0	0	0	3	0
Rubicon Bay	Private		0	NS	19	45	55	161	182	NS	35	NS	NS	X	X	NS	NS	NS	0	30	0	4	39	387	698	5000	11	158	299	1086
DL Bliss State Park	CSP		0	0	0	0	0	0	0	X	X	NS	NS	X	X	X	X	X	X	X	X	7	4	2	1	303	1	6	10	70
Emerald Point	CSP		X	0	0	0	0	0	NS	NS	X	700	440	984	X	0	0	0	0	NS	0	1	X	70	157	244	0	10	29	58
Emerald Bay Boat Camp	CSP		15	0	0	0	0	0	NS	NS	8	0	0	X	X	0	0	NS	0	NS	0	5	X	0	24	77	0	0	6	0
Eagle Creek/Avalanche	CSP		15	NS	NS	NS	NS	NS	NS	NS	27	150	220	155	X	0	0	NS	0	NS	0	51	35	265	493	601	71	404	354	373
Eagle Point	CSP											20	28	61	X	0	0	0	0	NS	0	0	0	0	15	12	0	0	4	6
CTC Cascade Creek	CTC																							31	X	54	0	22	28	71
Cascade Creek	Private		0	NS	0	NS	0	0	NS	NS	170	NS	NS	X	0	X	X	X	X	100	100	28	24	75	125	NS	0	56	192	545
Tallac Enclosure	USFS		0	NS	0	NS	0	0	NS	NS	X	NS	NS	X	0	X	X	X	X	65	70	182*	49	33	14	28	90	149	24	348
Tallac Creek	USFS		0	NS	0	0	NS	60	68	NS	11	81	75	X	X	X	X	X	X	X	X	200*	40	13	0	31	0	26	69	304
Baldwin Beach	USFS		0	35	45	0	0	0	0	NS	4	1500	1821	X	X	X	X	0	X	X	X	4	7	62	54	54	19	49	101	34
Baldwin Bch Enclosures	USFS																						X	25	24	11	213	98	211	314
Taylor Creek Enclosure	USFS		5	100	111	429	408	191	52	NS	329	383	73	X	X	X	30	X	X	3	50	882	1152	910	521	540	664	1124	2586	1557
Taylor Creek	USFS		0	0	0	0	0	0	0	NS	0	0	0	0	0	0	0	0	0	0	0	52	457	614	1102	509	2	143	595	3030
Kiva Beach/Valhalla	USFS		31	NS	X	NS	NS	NS	NS	NS	NS	614	2480	NS	NS	0	0	0	0	0	0	0	0	60	99	136	0	0	1	0
Jameson	Private																					0	0	0	0	NS	13	0	0	0
Pope Beach	USFS		21	0	11	NS	NS	86	262	NS	31	X	X	15	X	0	0	0	0	0	0	4	14	16	7	4	40	0	0	0
Lighthouse	Private		10	0	X	0	0	NS	X	NS	X	X	X	X	X	0	0	0	0	100	250	474	394	432	18	185	99	259	350	350
Tahoe Keys	Private		10	0	X	0	0	NS	X	NS	X	NS	NS	X	X	X	0	0	0	0	NS	X	921	4660	1010	1723	150	255	1959	2014
Upper Truckee West	CTC		37	20	172	148	211	80	167	NS	537	NS	NS	X	X	X	X	X	0	0	8	453	253	610	1289	425	0	50	227	428
Upper Truckee East	CTC		50	165	1000	NS	NS	1500	2895	NS	6529	NS	NS	X	X	X	415	X	X	1000	3000	3171	14434	13660	5000	5000	1872	3529	6014	10400
Regan/Al Tahoe	Private/SLT		14	0	0	0	0	0	0	NS	90	NS	NS	X	X	0	0	0	0	0	0	25	210	600	330	139	0	0	174	807

SITE NAME	OWNER ELEV	1978 6224	1979 6224	1980 6226	1981 6225	1982 6228	1983 6228	1986 6228	1988 6224	1989 6224	1990 6223	1991 6222	1992 6223	1993 6223	1994 6222	1995 6227	1996 6227	1997 6228	1998 6228	1999 6228	2000 6228	2001 6225	2002 6224	2003 6224	2004 6223	2005 6225	2006 6228	2007 6226	2008 6224	2009 6223
El Dorado Beach	City SLT		1	0	0	0	0	0	0	NS	0	NS	NS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bijou (Timber Cove Lodge)	Public																					0	2	18	25	20	0	0	0	63
Timber Cove	Private		0	NS	7	325	478	150	4	NS	22	NS	NS	0	0	0	0	0	0	0	0	0	0	1	2	26	0	27	23	72
Tahoe Meadows	Private		25	10	10	0	NS	NS	NS	NS	6	NS	NS	X	0	0	0	0	X	15	60	36	60	60	17	1070	61	X	91	133
Edgewood	Private		11	120	619	778	738	600	1235	NS	377	NS	NS	X	X	0	0	X	X	300	300	178	621	335	106	346	257	753	1254	855
4-H Camp/City Pump House	UNR/City	65	X	12	26	24	5	210	96	NS	6	NS	NS	X	0	NS	0	0	0	0	0	44	104	77	33	28	5	111	337	237
Nevada Beach	USFS	57	200	8	2	176	385	760	519	NS	66	8	13	10	X	0	0	0	0	25	100	0	1	1	1	78	82	761	751	703
Elk Point	Private		30	0	0	NS	NS	NS	NS	NS	20	NS	NS	14	X	NS	NS	NS	0	0	0	NS	NS	NS	NS	NS	NS	NS	NS	
Roundhill	USFS											50	0	15	NS	NS	NS	NS	NS	NS	NS	NS	19	45	25	19	0	0	0	6
Marla Bay	Private																					0	NS	15	10	1	11	0	0	13
Zephyr Cove	Private/USFS					X	NS	NS	X	NS	X	100	145	53	X	0	0	0	0	0	0	4	93	66	59	X	0	0	48	265
Skyland	Private		20	0	0	NS	NS	NS	NS	NS	34	NS	NS	X	X	NS	NS	NS	0	NS	NS	NS	NS	NS	64	NS	0	0	2	90
Cave Rock	NVSP										X	NS	NS	X	X	0	0	0	0	0	18	6	12	0	0	3	0	0	1	38
Logan Shoals/Vista	Private		100	12	428	0	0	309	133	NS	1430	43	64	NS	X	NS	NS	NS	0	NS	0	NS	0	NS	1135	0	50	45	590	1603
Glenbrook	Private		500	9	143	800	500	NS	NS	10	70	NS	NS	X	X	0	0	0	0	NS	0	0	NS	983	164	292	0	0	0	90
Skunk Harbor	USFS										X	0	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0	0	0	0	0
Secret Harbor	USFS										X	7	33	0	0	0	0	0	0	NS	0	0	27	92	NS	33	0	0	3	30
Chimney Rock	USFS											9	19	NS	NS	NS	NS	0	0	0	0	0	0	0	0	0	0	0	0	0
Sand Harbor	NVSP		1	0	0	NS	NS	NS	NS	NS	0	NS	NS	0	0	0	0	0	0	0	0	0	0	3	29	112	0	0	25	15
Hidden Beach	NVSP																	NS	NS	NS	NS	NS	3	19	13	7	0	0	0	1
Burnt Cedar Beach	IVGID																	NS	NS	NS	NS	NS	4	0	0	NS	0	0	0	0
Crystal Point	Private													X	X	NS	NS	0	0	NS	0	0	0	0	0	NS	0	0	0	0
Kings Beach	Private/Public					X	NS	NS	NS	NS	NS	0	NS	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Agate Bay	Private		0	0	0	NS	NS	NS	NS	NS	0	NS	NS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dollar Point	Private											X	NS	X	X	0	0	0	0	NS	0	0	10	83	315	1000	0	0	18	152
Total Sites		3	38	39	39	41	41	41	41	41	45	50	50	52	52	52	52	53	53	54	55	60	63	64	64	62	62	62	61	61
No. of Sites Not Surveyed		0	0	8	1	11	13	13	15	37	2	24	28	5	5	12	10	12	5	17	6	8	6	3	3	6	2	1	2	1
No. of Sites Surveyed		3	38	31	38	29	27	27	25	3	43	25	21	47	47	40	42	41	48	37	49	52	57	61	61	56	60	61	59	60
No. of Sites Occupied		3	25	16	22	13	11	14	18	2	35	21	17	37	31	9	9	11	11	15	17	29	40	46	47	47	24	30	43	46
No. of Sites Unoccupied		0	13	15	16	16	16	13	7	1	8	5	4	10	16	31	33	32	37	12	32	23	17	15	14	9	38	31	17	14

Population Genetic Structure in the Tahoe yellow cress (*Rorippa subumbellata)*: use of genetic data to characterize dispersal patterns.

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Project Summary

Tahoe yellow cress (*Rorippa subumbellata)*, a Tahoe Basin endemic, is listed as endangered by the State of California, critically endangered by the State of Nevada and as a candidate species under the federal Endangered Species Act. Little is known about the dispersal dynamics of this rare plant but both a metapopulation and source-sink dynamic have been hypothesized. Gene flow among sites is thought to occur via seed dispersal but dispersal pathways across the landscape remain unclear, i.e., via terrestrial and/or water pathways. Contemporary patterns of dispersal and gene flow may be difficult to characterize as dispersal events cannot be readily observed. As a result there has not been a direct test of the metapopulation or source-sink hypotheses for this species to date. Yet the distinction is important for formulating strategies that maintain connectivity among populations and preserve existing genetic variation.

None-the-less identification and conservation of "core" populations has been the cornerstone of the conservation strategy for this species (Pavlik, Murphy et al. 2002). Core populations are thought to occupy stable habitats and act as sources providing seeds for sites whose habitats vary in suitability over time and space. Direct tests of source-sink or metapopulation hypotheses may be impossible, but indirect tests using patterns of genetic variation within and among populations can be used infer dispersal patterns which can then be used to test these hypotheses.

Indirect methods for characterizing dispersal

Implicit in genetic data is the genetic history of individuals and thus the populations they comprise. The amount of genetic variation within a population can be viewed as a product of population size and rates of gene flow via individual dispersal/movement events among disjunct populations. Populations which experience frequent movement of individuals among them will maintain more genetic variation over time than isolated populations regardless of their size. The similarities and differences in the both the number and frequencies of genetic variants per genetic marker can be used to estimate both an average rate of gene flow and the direction of gene flow among a group of populations.

These data can then be used to test hypotheses about the underlying causal mechanisms of observed spatial patterns of genetic variation.

A metapopulation describes a group of independent subpopulations that collectively persist through an extinction/re-colonization dynamic such that habitats which lose local populations can be re-colonized by individuals from the remaining extant populations. In order for a metapopulation dynamic to effectively extend the persistence time of a network of populations each population must fluctuate independently, so that when one population is either very small or goes locally extinct, another in the network can provide colonists. Population asynchrony can be achieved only if two conditions are met: (1) populations experience sufficiently independent environments and (2) populations exchange very few individuals per generation. Independent environments are necessary for generating asynchrony in population fluctuations, and low inter-population exchange is necessary for maintaining this asynchrony. The asynchrony among populations on disjunct habitat patches can act to maintain genetic diversity in the larger population network as a whole. The persistence time of local populations and re-colonization rates of vacant habitats, however, may occur on time scales that are not amenable to human observation.

Conversely, source-sink dynamics describe a core group of stable populations (sources) that provide colonists to habitats that are either too small to support viable populations or are of inferior quality where populations can not persist (sinks) either through low adult survivorship or low juvenile recruitment. The sink habitats do not contribute to the maintenance of overall genetic diversity within the population network. Thus the amount of genetic variation maintained in such systems will be a function of the population size(s) of the core source populations.

Neutral genetic markers

Microsatellites are one of a class of highly variable, noncoding (selectively neutral) genetic markers called VNTRs (variable-number-tandem-repeats) that are found dispersed throughout the nuclear genome of most organisms. Because of their selective neutrality this class of markers accumulates variation at the rate of mutation resulting in a large number of variants per genetic marker. This variation provides sufficient statistical power to distinguish individual organisms and thus can be viewed as a “genetic” tag versus a physical tag in the study of dispersal. Microsatellite markers are routinely used to characterize population genetic structure and thus movement patterns among populations in conservation and landscape genetics studies.

Here we propose to use nuclear microsatellite genetic markers developed specifically for the Tahoe yellow cress to characterize: (1) the amount of genetic variation in this species at these nuclear markers compared to the published literature for other *Rorippa* species for similar genetic markers and (2) the distribution of genetic variation within and among extant populations of Tahoe yellow cress in the Tahoe Basin. These data will then be used to test metapopulation and source-sink dynamic hypotheses.

Preliminary Study

Primers were developed for 84 microsatellite loci isolated from plasmids, which had sufficient flanking regions for the development of polymerase chain reaction (PCR) primers. These loci were initially screened for variability on 16 individuals from multiple locations around Lake Tahoe. Five of these 84 loci were variable. However, we chose an additional 10 total loci for a total of 15 loci to assess for variability using our full data set of 347 samples collected from 29 locations around Lake Tahoe in 2006 and 2007. The additional 10 loci were chosen because they amplified consistently, were perfect repeats (no insertions or deletions of nucleotide bases) and were tri- and tetra-nucleotide repeat loci which can be unambiguously scored.

We conducted preliminary analyses on the 243 of the 347 samples. We excluded samples from sites that had been outplanted with container-grown Tahoe yellow cress (sourced from naturally occurring populations). Analyses included:

1) number of alleles per locus (genetic marker) per sampling location
2) levels of heterozygosity per population per locus and over all loci
3) estimation of genetic differentiation among all pairwise comparisons of sampling locations (F_{ST})
4) assessment of an isolation-by-distance pattern among populations
5) identification of distinct breeding groups among sampling locations (Bayesian clustering analysis).

A sample for analysis purposes is a single leaf collected from a Tahoe yellow cress "stem". Growth is clonal and it is virtually impossible to identify an individual plant in the field, as apparently separate plants may be connected underground through extensive root networks. Likewise, many different stems will coalesce into a single large "plant". Therefore, population size estimates from annual surveys are based on stem counts. A small vegetative ramet of 2cm will be counted as one stem, as will a large "plant" that is 40cm in diameter. A leaf samples could be collected from either type of specimen.

Results

Genetic Variation. Although only five of the 15 microsatellite loci were variable among the 243 individual samples analyzed, the sample sizes per sampling location were in many instances too small to draw robust conclusions about extant genetic variation at those sites and how genetically differentiated the sites were from each other (Figure 1). Many sampling locations had N < 5 (Table 1). Heterozygosity is an overall measure of genetic diversity in a population and ranges from 0 (no variation) to 1 (every individual is distinct) (Table 2). For instance if we look at population 1 in table 2 for the AAC31 locus we see that we have a heterozygosity estimate of 0.083 which means 8.3% of the individuals were heterozygotes - that is they had 2 different alleles at that locus. The zeros in table 2 mean that there were no heterozygotes in the population at that locus and every individual had the same genotype. This could be due to either (1) no genetic variation or (2) a small sample size that did not capture the existing variation found in the population. Given the small samples sizes the later scenario is most likely.

Genetic Differentiation. Population level genetic differentiation is summarized in table 3 (pairwise F_{ST} analysis). The yellow highlighted asterisks (*) indicate the populations that are statistically significantly differentiated from one another. The northernmost populations on the west side of Lake Tahoe (Ward Creek, Blackwood Beach north and south) are differentiated from populations at the southern end of the lake (Baldwin Beach, Taylor Creek, Tahoe Keys, and Nevada Beach). Individuals from Tallac Creek were differentiated from those at Nevada Beach. However, the comparisons that are highlighted in green (NA) in table 3 are comparisons that could not be statistically analyzed due to small sample size and lack of sufficient statistical degrees of freedom. The rest of the comparisons labeled with NS (not significant) suggest that most populations are not differentiated from each other. However, again the small sample sizes preclude robust conclusions from these analyses.

We do not see a general pattern of isolation-by-distance (shoreline geographic distance) in this dataset (Figure 2) where the expectation would be that those populations that are farthest apart would be genetically most dissimilar. Many of the sampling locations on the eastern shore were not differentiated from any other populations. Again – in order to draw robust conclusions the potential confounding factor of small sample size must be eliminated.

Distinct Breeding Groups. We identified 5 distinct breeding groups which are denoted by colors in Figure 3. This analysis uses the number of alleles per locus at a sampling site to estimate the probability of certain multilocus genotype combinations. The results show that the populations on the western side of the lake are more similar to each other (individuals belong primarily to the green group) than to the other sampling locations in the south and east where we see membership primarily in the red and yellow groups. The pink group is fairly well dispersed among sites put tends to diminish along the southeast shoreline (Edgewood and Nevada Beach sites). Despite the fact that we only had 2 individuals from the eastern most population, Logan Shoals (indicated by arrow in Figure 3), it is noteworthy to point out that those 2 individuals are more similar to the western shore populations (belong to the green and pink groups) than they are to the southern populations suggesting perhaps that seeds arrive at this site via dispersal across the lake as opposed to around the shoreline.

Research Directions

Fifteen sites were sampled in 2006 with sample sizes ranging from 5-30 leaves per site. In 2007 an additional 10 sites were sampled but sample sizes were very small, 1-8 leaves per site only. TYC growth is clonal and it is virtually impossible to identify an individual plant in the field, as apparently separate plants may be connected underground through extensive root networks. Likewise, many different stems will coalesce into a single large “plant”. Therefore, population size estimates from annual surveys are based on stem counts. A small vegetative ramet of 2cm will be counted as one stem, as will a large “plant” that is 40cm in diameter.

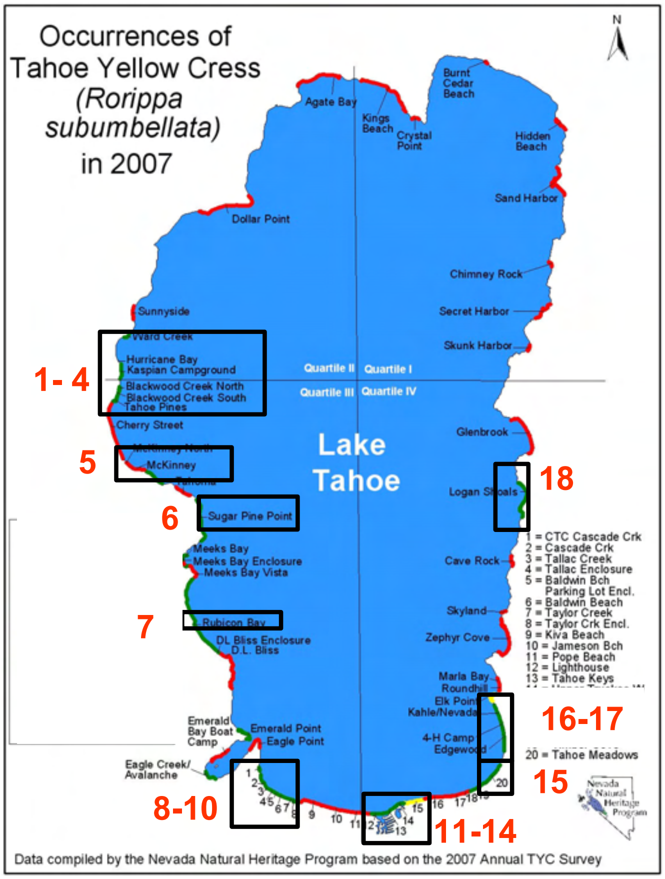
In 2009 the Tahoe yellow cress working group conducted a comprehensive sampling of all known extant TYC sites during the annual survey census. Leaf samples were collected from 60 stems at the 20 occupied sites that have the largest populations (~1420 samples). For the larger sites we employed a stratified sampling protocol which included subsampling of plants found in multiple microhabitats. Representative samples of 11 to 51 leaves were also collected from smaller populations at 21 sites (N ≈600 samples) plus an additional 38 samples were collected from 10 sites with very few stems. These samples will be used to identify (1) likely source populations or (2) whether these are remnant populations harboring unique genetic variation. We propose to genotype the ~2,064 samples at 15 loci to:

(1) Characterize genetic resources
(2) Determine dispersal patterns

Greenhouse planting. In 2002 prior to any outplanting of container-grown Tahoe yellow cress, seed was collected from 13 sites. We propose to plant the remaining seeds from these collections in greenhouses at the University of Nevada, Reno. Our aim is to compare the amount and and spatial partitioning of genetic variation from these sites with contemporary samples from these sites to assess the effects of outplanting.

Herbarium sampling. Stanton and Pavlik are also pursuing obtaining herbarium specimens collected in the early 1900s to examine genetic variation prior to implementation of lake level control.

Figures



Sampling Locations	
1) Ward Creek	N = 24
2) Kaspian	N = 2
3) Blackwood North	N = 14
4) Blackwood South	N = 33
5) McKinney	N = 4
6) Sugar Pine	N = 2
7) Rubicon	N = 4
8) Tallac Creek	N = 5
9) Baldwin Beach	N = 12
10) Taylor Creek	N = 28
11) Pope Beach	N = 4
12) Lighthouse	N = 2
13) Tahoe Keys	N = 22
14) Upper Truckee	N = 27
15) Tahoe Meadows	N = 11
16) Edgewood	N = 19
17) Nevada Beach	N = 28
18) Logan	N = 2
TOTAL	N = 243

Figure 1. Sample sizes per sampling location from 2006 and 2007.

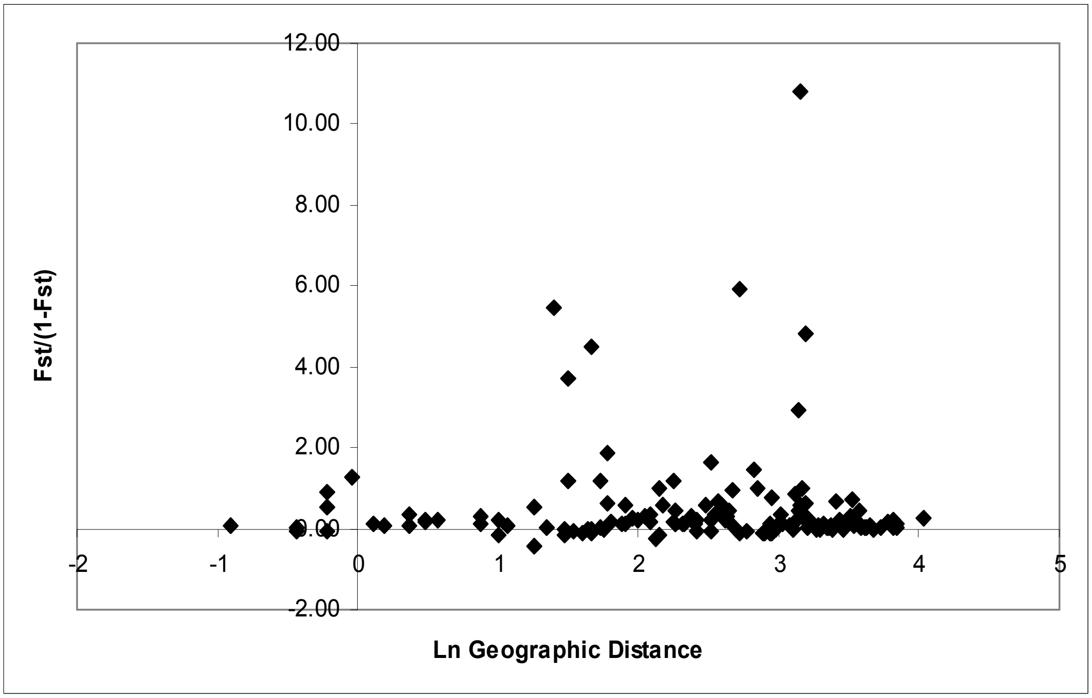


Figure 2. Pairwise F_{ST} comparisons between all sampling sites correlated with geographic distance to test for isolation-by-distance. No pattern was detected (r = -0.013, *P* = 0.873)

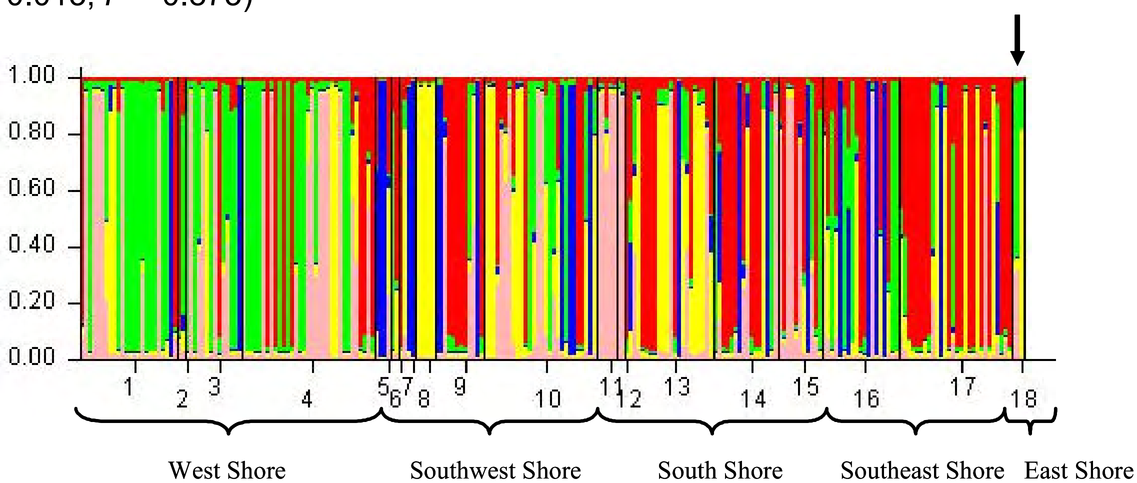


Figure 3. Results of Bayesian genotype clustering analysis. Each individual included in the study is represented in this histogram as a single column. Each color represents a distinct breeding group. If an individual (column) is assigned to multiple breeding groups (has multiple colors) this suggests the individual has ancestry which ties it to multiple breeding groups, e.g. parents came from separate breeding groups. Arrow indicates Logan Shoals (18) population on the east shore of Lake Tahoe which more closely resembles the west shore populations than the geographically most proximate populations to the south.

Table 1. Alleles sampled per variable locus per population and the total number of alleles at that locus. Population numbers correspond to the populations listed in Figure 1.

	Population																		
Locus	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	TOTAL
AAC31	2	1	2	1	2	1	2	1	2	2	1	1	2	2	2	2	2	1	2
ATG30	4	2	3	4	2	**NA**	3	2	3	4	2	1	4	4	3	4	4	1	4
TACA3	2	2	2	3	2	2	2	1	4	4	1	1	3	3	4	3	3	**NA**	4
TACA39	4	1	2	2	3	1	3	1	3	3	2	1	5	4	2	3	3	1	5
B2	3	1	2	1	2	1	2	1	2	3	1	1	3	2	2	2	2	1	3

Table 2. Heterozygosity per locus per population. Those populations that had no variation at a particular locus are indicated by a bolded zero. NA = analysis could not be performed.

	Population																	
Locus	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
AAC31	0.083	**0**	0.154	**0**	0.667	**0**	0.667	**0**	0.5	0.262	**0**	**0**	0.091	0.279	0.182	0.409	0.112	**0**
ATG30	0.305	NA	0.167	0.448	0.5	NA	0.75	0.5	0.697	0.603	0.5	NA	0.751	0.699	0.714	0.712	0.703	**0**
TACA3	0.503	NA	0.506	0.682	0.417	1	0.667	**0**	0.708	0.744	**0**	**0**	0.623	0.703	0.595	0.68	0.564	NA
TACA39	0.341	**0**	0.154	0.148	0.625	**0**	0.833	**0**	0.318	0.593	0.5	**0**	0.628	0.508	0.545	0.528	0.484	**0**
B2	0.216	**0**	0.143	**0**	0.667	**0**	0.667	**0**	0.436	0.335	**0**	NA	0.338	0.313	0.2	0.325	0.104	**0**
Mean	0.29	**0**	0.225	0.256	0.575	0.25	0.717	0.1	0.532	0.507	0.2	**0**	0.486	0.5	0.447	0.531	0.393	**0**

Table 3. Pairwise F_{ST} comparisons of populations. NS = not significantly differentiated, NA = unable to make comparison due to small sample size, * = significant at *P* = 0.000292 (corrected for multiple comparisons) obtained after 3420 permutations. Green highlights NA where populations have low sample sizes (N = 2). Yellow highlights populations which are significantly differentiated.

	pop2	pop3	pop4	pop5	pop6	pop7	pop8	pop9	pop10	pop11	pop12	pop13	pop14	pop15	pop16	pop17	pop18
pop1	NA	NS	NS	NS	NA	NS	NS	NS	NS	NS	NA	*	NS	NS	NS	*	NA
pop2		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
pop3			NS	NS	NA	NS	NS	NS	NS	NS	NA	*	NS	NS	NS	*	NA
pop4				NS	NA	NS	NS	*	*	NS	NA	*	NS	NS	NS	*	NA
pop5					NA	NS	NS	NS	NS	NS	NA	NS	NS	NS	NS	NS	NA
pop6						NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
pop7							NS	NS	NS	NS	NA	NS	NS	NS	NS	NS	NA
pop8								NS	NS	NS	NA	NS	NS	NS	NS	*	NA
pop9									NS	NS	NA	NS	NS	NS	NS	NS	NA
pop10										NS	NA	NS	NS	NS	NS	NS	NA
pop11											NA	NS	NS	NS	NS	NS	NA
pop12												NA	NA	NA	NA	NA	NA
pop13													NS	NS	NS	NS	NA
pop14														NS	NS	NS	NA
pop15															NS	NS	NA
pop16																NS	NA
pop17																	NA
pop18																	

BUDGET

The budget provided here outlines the costs to isolate DNA, amplify genetic markers, and analyze genetic data for all of the plants collected in 2009. We do not ask for funding to cover greenhouse costs or to pursue herbarium samples. We have not included cost share in this total.

Personnel:		
Laboratory technician:		
Base Salary ($4719/month), 24 weeks	$28,313.00	
Fringe benefits (40% of base salary)		$11,325.00
Total Personnel	**$39,638.00**	
Laboratory Supplies:		
Isolating DNA		
Qiagen DNeasy plant extraction kits (6, 6 plates/kit)		$ 8,262.00
DNA quantification	$ 1,800.00	
Isolating DNA sub total	**$10,062.00**	
Microsatellite analysis of 3000 Tahoe yellowcress samples at 15 working loci.		
PCR reactions, 7 reactions/tray	$15,232.00	
PCR primers		$ 1,000.00
ABI runs, 4 runs per try	$10,112.00	
Reruns 10% of PCR and ABI costs and time		$ 2,500.00
Plastics (PCR plates, tips, tubes, trays)	$ 3,000.00	
	$31,844.00	
Total Personnel and Laboratory costs		**$81,544.00**
UNR indirect cost 10% (FS allowable indirect)	**$ 8,154.40**	
TOTAL PROJECT COST	**$89,698.40**	