CONSERVATION STRATEGY FOR TAHOE YELLOW CRESS (*Rorippa subumbellata*)

August 2002

CONSERVATION STRATEGY
FOR
TAHOE YELLOW CRESS
(*Rorippa subumbellata*)

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VIII. List of Acronyms Used

AMWG	Adaptive Management Working Group
CA	Conservation Agreement
CDFG	California Department of Fish and Game
CDPR	California Department of Parks and Recreation
CESA	California Endangered Species Act
CEQA	California Environmental Quality Act
CS	Conservation Strategy
CSLC	California State Lands Commission
CTC	California Tahoe Conservancy
GIS	Geographic Information System
GPS	Global Positioning System
ITM	Intensive Transect Method
KGID	Kingsbury General Improvement District
LTD	Lake Tahoe Datum
League	League to Save Lake Tahoe
MOU	Memorandum of Understanding
NDF	Nevada Division of Forestry
NNHP	Nevada Natural Heritage Program
NVSP	Nevada Division of State Parks
NSL	Nevada Division of State Lands
PAO	Public Affairs Officers

REP	*Rorippa* Enhancement Plan
RLM	Reconnaissance Level Method
SAG	Scientific Advisory Group
TAG	Technical Advisory Group
TLOA	Tahoe Lakefront Owners' Association
TRPA	Tahoe Regional Planning Agency
TYC	Tahoe Yellow Cress
TYCSG	Tahoe Yellow Cress Stewardship Group
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service

Executive Summary

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FOR
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(*Rorippa subumbellata*)

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EXECUTIVE SUMMARY
CONSERVATION STRATEGY FOR TAHOE YELLOW CRESS

I. INTRODUCTION AND BACKGROUND

Tahoe yellow cress (*Rorippa subumbellata* Roll.) is a rare plant species endemic to the shores of Lake Tahoe in California and Nevada. It was listed as endangered by the State of California in 1982 (California Fish and Game Code 2050 *et seq.*) and is considered endangered throughout its range by the California Native Plant Society (Skinner and Pavlik 1994). Tahoe yellow cress is state-listed as critically endangered in Nevada (Nevada Revised Statutes 527.270 *et seq.*), and is considered threatened by the Northern Nevada Native Plant Society (Nevada Natural Heritage Program 2001). It is classified as a candidate species for listing under the Endangered Species Act of 1973, as amended (64 FR 57533).

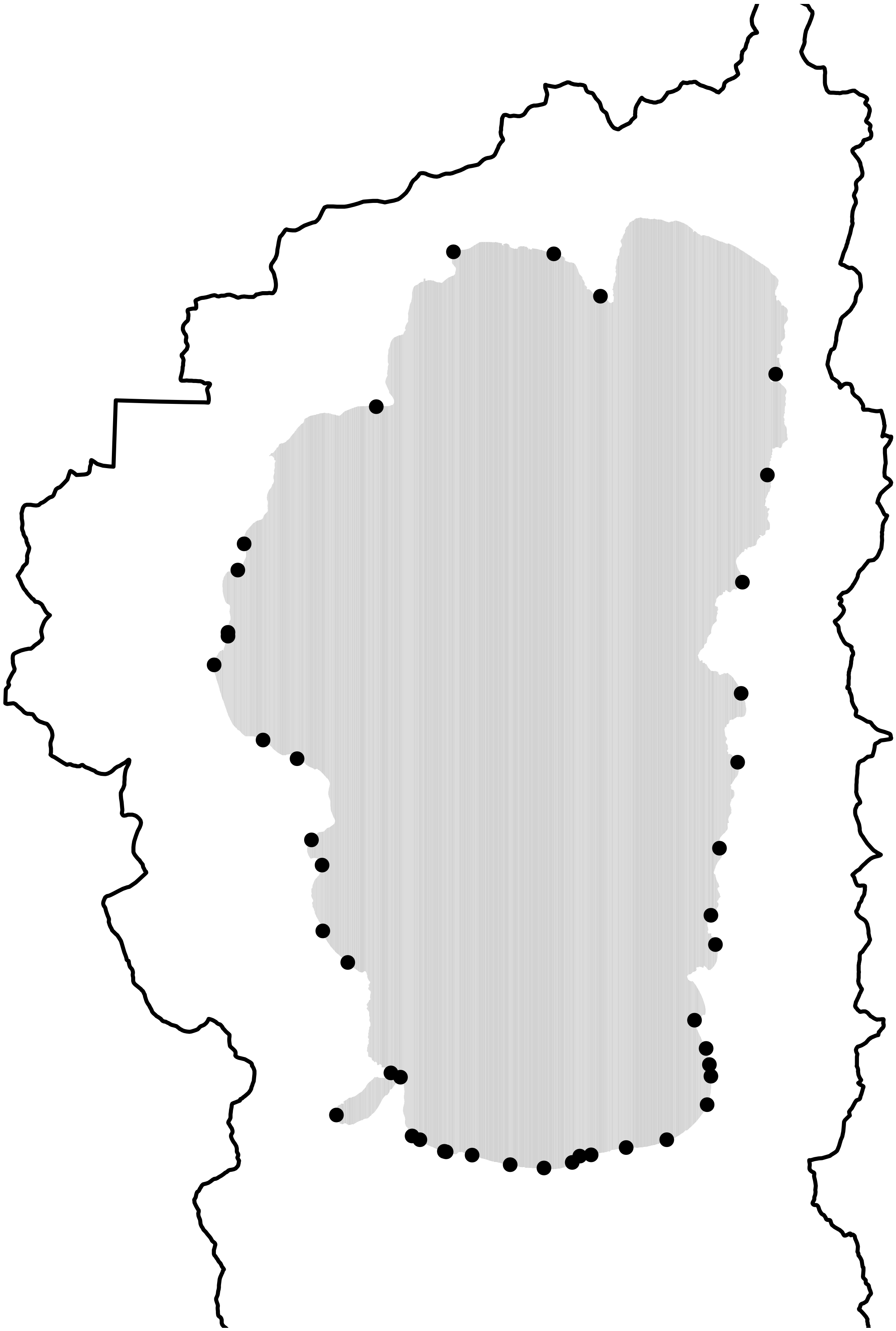
Survey results through the year 2000 showed that Tahoe yellow cress occupied only 27 percent of the known, historic sites (Figure A). Evidence suggests the current decline in the number of sites occupied by Tahoe yellow cress is primarily due to: Alterations in lake level dynamics caused by construction and operation of the Truckee River outlet dam and reservoir; destruction of actual and potentially suitable habitat by the construction of piers, jetties, and other structures; high levels of recreational activity associated with beaches and dunes; disturbance of the sand by public and private property maintenance activities; and possibly random environmental events. Because of the imminent threats facing the species, a task force has been formed to develop and implement a conservation strategy for Tahoe yellow cress. The strategy is coupled with a Memorandum of Understanding (MOU)/conservation agreement (CA) signed by the participating entities that demonstrates the commitment of all involved to the long-term protection of the species.

Implementation of the strategy is a cooperative effort being carried out under the auspices of a multi-agency and private interest group task force. The task force is composed of a technical advisory group (TAG) and an executive committee (Appendices A and B). The TAG is comprised of biologists and public land managers who represent the resource and regulatory agencies around the Lake Tahoe basin. In addition, TAG members include representatives of private property owners and environmental groups. The executive committee is made up of managers and directors representing public and private interests in the basin. The TAG and executive committee, together with academicians with expertise in rare plant ecology and conservation biology, developed this strategy. The TAG will bring future management recommendations to the executive committee. These recommendations will be based on the previous year's data and historical knowledge. The executive committee will act in the decision-making capacity and continue to oversee the implementation of conservation and management actions through the adaptive management process.

The following entities have committed to the implementation of the conservation strategy and are signatory to the MOU/CA:

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

This list is of those entities that developed the conservation strategy. It is hoped that other private landowners and local agencies will also wish to participate in the conservation strategy in the future.



TAHOE REGIONAL PLANNING AGENCY

Figure A
Known Tahoe Yellow Cress Sites

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II. Conservation Strategy

Tahoe Yellow Cress and Lake Tahoe

It is impossible to know exactly how Tahoe yellow cress came to be. Almost all of its relatives are plants associated with flowing water - inhabitants of rivers, streams, and meadow edges. Such habitats undoubtedly existed in the Lake Tahoe basin over the millennia and, in fact, still do. Tahoe yellow cress is largely confined to the sandy beach and dunes associated with the ever-changing margin of the lake and the mouths of its tributaries. Such habitat preference is unusual because no other lakeside endemics are known from the Sierra Nevada. Perhaps other lakes are simply too young to have fostered the development of a unique lakeshore plant. Lake Tahoe has existed for about two million years, never displaced by glaciers and never static in size, shape, or other essential qualities. Age and environment have thus conspired to create a singular species in a place as singular as the clear blue waters.

The lake itself, especially its age, complex history, and dynamics, is theorized to be the primary force in the evolution of Tahoe yellow cress. Great oscillations in climate caused glaciers to advance and retreat, with corresponding fluctuations in precipitation, runoff, evaporation, and groundwater recharge. Lake levels rose and fell, sometimes slowly and sometimes catastrophically over short periods. Submerged tree trunks indicate lake levels 20 to 40 feet (ft) (6 to 12 meters (m)) lower in the recent past, but other evidence shows levels were more than 570 ft (175 m) lower over the last 160,000 years. If a 1-ft (0.3-m) drop in water level today could create roughly 200 acres (ac) (80 hectares (ha)) of sandy shoreline habitat suitable for Tahoe yellow cress, imagine the potential habitat created by lake recession during the distant past.

Only Lake Tahoe, never static and never fully glaciated, could have fostered this unique plant.

With such a long history of rapid, unpredictable change, it is remarkable that this plant has persisted. Extreme climate change, extraordinary high waters, even landslides and lake tsunamis could have led to extinction of Tahoe yellow cress, especially when it was composed of a few, small, isolated populations. The tenacity of those populations probably results from the possession of a perennial habit and spreading rootstocks. The rootstocks can branch and grow in many directions, allowing a long-lived individual to occupy upslope and downslope habitat and be less susceptible to stresses imposed by the water's edge. They can rapidly spread into new, open sands as the lake recedes, provide upslope anchorage and refuge when the lake advances, and remain dormant during erosion caused by wave action. The rootstocks are apparently tolerant of low sediment oxygen because despite years of inundation they are able to germinate and produce leafy shoots. Under extreme conditions, rootstocks and seeds are liberated by the churning waters and float to new sites for possible colonization. This diminutive, unassuming plant has proven itself ferocious in its quest for existence, not only weathering the severe forces of Lake Tahoe for hundreds of thousands of years, but incorporating those forces into a unique physical and physiological form.

Biological Overview of Tahoe Yellow Cress

The current treatment of *Rorippa* (Brassicaceae, or mustard family) in the *Jepson Manual: Higher Plants of California* (Hickman 1993) recognizes about 75 species worldwide, with 21 native to North America, and 7 having been introduced to the continent. There is a concentration of taxa, some common and some rare, associated with the mountainous regions of the western United States (Stuckey 1972). California has 11 species, one of which is introduced from Europe, and one that is considered worldwide in its distribution (water cress, *R. nasturtium-aquaticum*). Nevada has eight species. All are associated with open, damp, or wet habitats (springs, marshes, meadows, mudflats, playas, and the shores or banks of lakes, streams, and rivers) that are often naturally disturbed by flowing water. Anthropogenic wetlands also provide habitat, especially irrigation ditches, farm ponds, and road culverts.

Tahoe yellow cress is a low-growing, somewhat fleshy, herbaceous perennial that branches profusely. Flowers are yellow and have four petals. Flowering occurs between late May and late October. Seed and fruit development is continuous during the flowering period, truncated by inundation or the first winter storms. Tahoe yellow cress has a strong preference for sandy beach habitat. A quantitative 1990 survey indicated that nearly 60 percent of known Tahoe yellow cress occurrences were on substrates composed of greater than 75 percent sand, while only 16 percent were on substrates with less than 50 percent sand (California State Lands Commission (CSLC) 1998).

Conceptual Model of Metapopulations Dynamics

Tahoe yellow cress can persist over long periods because it possesses a population dynamic in which extirpation is countered by colonization. New, unoccupied sites can be colonized, old occupied sites can be recolonized or extirpated, and the timing and probabilities of these events could be influenced by many factors.

This population dynamic is referred to as a “metapopulation dynamic.” Hanski and Gilpin (1991) defined metapopulation as a “set of local populations within some larger area, where typically migration from one local population to at least some other patches is possible.” The elements of a metapopulation dynamic for Tahoe yellow cress can be summarized by the relationship:

$$dP/dt = CP(1-P) - E(P)$$

Where:

- **dP/dt** the metapopulation dynamic (positive or negative change in occupied sites/unit of time)
- **P** the proportion of occupied sites (i.e. actual habitat)
- **1 – P** the proportion of unoccupied sites (i.e. potential habitat)
- **C** colonization probability
- **E** extirpation probability (Hanski and Simberloff 1997; Ricklefs 1997)

A positive dynamic (rate of population gain greater than 0) is determined by a high colonization probability, a low extirpation probability, and a medium-high proportion of unoccupied sites (i.e. an abundance of potential habitat).

Several indirect lines of evidence support the hypothesis that Tahoe yellow cress exists as a complex of metapopulations. First, local extirpation and colonization have been observed over the 22-year history of Tahoe yellow cress monitoring along the shores of Lake Tahoe. The second line of evidence for metapopulation dynamics is that seedlings of Tahoe yellow cress are often observed in the "bathtub" ring of organic matter deposited on berms, in beach depressions, and on foredune areas by rising lake levels, tides, wind, and storm waves (Ferreira 1988; CSLC 1998; M. Falkner, CSLC, pers. comm. 2000). Finally, the apparent lack of genetic variation among surveyed Tahoe yellow cress populations is consistent with the idea of migratory exchange of alleles in a highly mobile, outbreeding species.

Fundamentally, the conservation of this species relies on our understanding of the metapopulation biology of this species (Section II.C, Conceptual Model of Metapopulations Dynamics). The key aspects of the biology of this plant are the colonization rate, the extirpation rate, the number of occupied sites, and the number of unoccupied sites. Table 5 lists the elements that are readily manipulated by resource management that may affect aspects of the species' biology. These elements are the focus of the conservation strategy in general and the focus of public and private lands specifically.

Analysis of Existing Data

Since it was first scientifically described by Dr. Reed Rollins in 1941, Tahoe yellow cress has been collected or observed at 51 locations around the lake. Not all known occurrences have been occupied by Tahoe yellow cress at the same time. The greatest number of occupied sites was 35 in 1993 (79 percent occupation of those sites surveyed in that year), while the fewest was 7 during the 1995 to 1997 period (about 20 percent occupation of those sites surveyed). The last complete survey (September 2000) found 14 occupied sites (33 percent occupation of those sites surveyed). It is not known exactly how many sites Tahoe yellow cress should occupy in a given year to secure its future, but the vast majority of endangered plants of highest conservation concern are found in five or fewer occurrences. Tahoe yellow cress finds itself on the cusp of endangerment, occupying 20 percent of its actual habitat during the worst of times and less than 80 percent during the best.

Twenty-two years of monitoring data for Tahoe yellow cress were analyzed and evaluated. This analysis consists of 30 pages of text, 14 figures, 5 tables, and 14 pages of description of the methods in the appendix. One of the derived products from this analysis is a ranking of the known Tahoe yellow cress sites (Table A – corresponds to Table 13 in strategy). Based on a viability index, four categories were developed: Core sites, high priority restoration sites, medium priority restoration sites, and low priority restoration sites. Sixteen sites are currently unranked, but will be ranked by the TAG in early 2002.

Table A. Ranking of known Tahoe yellow cress sites (ownership/management in parentheses).

Core Sites	Medium Priority Restoration Sites	Low Priority Restoration Sites
Taylor Creek (USFS)	Upper Truckee W (CTC)	Pope/Kiva (USFS)
Upper Truckee E (CTC)	Rubicon Bay (Private)	Sand Harbor (Nevada)
Tallac Creek (USFS)	Emerald Point (CDPR)	El Dorado Beach (City SLT)
Edgewood (Private)	Zephyr Cove (USFS)	Secret Harbor (USFS)
Blackwood S (Placer Co)	4-H (U Nevada)	Regan/Al Tahoe (Public/Private)
Blackwood N (Private)	Baldwin Beach (USFS)	
	Timbercove (Private/Public)	
High Priority Restoration Sites	Logan Shoals (Private)	
Kahle/Nevada Beach (USFS/Pvt)	Eagle Point (CDPR)	
Glenbrook (Private)	Tahoma (Private)	
Eagle Creek (CDPR)	Tahoe Keys/Lighthouse (Private)	
Ward Creek (Private)	Tahoe Meadows (Private)	
Meeks Bay (USFS)		
Cascade (Private)		

Conservation on Public and Private Lands

This species, regardless of the actions of public agencies, cannot be protected without a stewardship ethic of private landowners.

The encouragement of this stewardship will be the central challenge of this conservation strategy.

The difference in conservation focus on public verses private lands is based on affecting different aspects within the metapopulation model: **$dP/dt = CP(1-P) - E(P)$**. The types of impacts and the ability of resource managers to influence those impacts are variable. Attempting to implement identical conservation and management practices on public and private lands may have vastly different results.

This species, regardless of the actions of public agencies, cannot be protected without stewardship by private landowners. Only two-thirds of the core and high priority sites and half of the medium priority sites are under public management (Table A). In addition to the ownership/management of populations, colonization of potentially suitable habitat is critical to this species, and private landowners manage a majority of potential habitat within the basin. To meet the ecological requirements of this species, which exhibits a metapopulation dynamic, both public and private lands are necessary for successful conservation. Engaging private landowners and encouraging their support of a stewardship program will be the central challenge of this conservation strategy. There are a number of barriers to private stewardship: 1) Concern that having Tahoe yellow cress on one's property will prevent a landowner from developing their land; 2) a lack of awareness about Tahoe yellow cress; and 3) timing of the project review process. Each of the barriers has been addressed within this conservation strategy.

The policies and guidelines of the responsible agencies direct conservation of Tahoe yellow cress and its habitat on public land (Appendix H). In general, most public agencies are mandated to protect Tahoe yellow cress and other listed and sensitive species and their habitats. Appendix J identifies the proposed conservation actions for core and high priority restoration sites owned by public agencies. However, there are three primary barriers to conservation on public lands: 1) Balancing stewardship with development and use of recreational facilities and access; 2) balancing stewardship with other land use; and 3) funding and resource allocation.

Conservation Goals, Objectives, and Associated Actions

The following conservation goals were developed to guide the management of Tahoe yellow cress and its habitat by participating entities. The protection afforded this species through existing policies and guidelines (Appendix H) is not affected by this conservation strategy, nor is the strategy intended to alter the current regulatory requirements of each appropriate agency. The conservation strategy has been developed not only to provide conservation and management guidance for Tahoe yellow cress, but also to affect the federal listing decision process. Successful implementation of the conservation strategy may preclude the need to federally list the species as well as provide grounds to downlist the species at the California and Nevada state levels. The goals and objectives that will serve as the foundation of the conservation strategy are articulated in Section II.F. Briefly, the goals are identified below:

Goal 1: Protect occupied habitat and potentially suitable habitat that does/could support natural populations.

Goal 2: Improve Tahoe yellow cress populations.

Goal 3: Promote conditions that favor a positive metapopulation dynamic.

Goal 4: Conduct research that directly supports management and restoration.

Goal 5: Revise and continue the monitoring program for Tahoe yellow cress.

Goal 6: Implement an interagency adaptive management framework.

Associated with each goal is a set of objectives and associated actions intended to achieve that goal. The actions described are general in nature. Site-specific actions for core sites and high priority restoration sites are listed in Appendix J. Additional actions not related to specific sites are listed in Table 14.

Description and Prioritization of Management Actions

The goals and objectives of the conservation strategy for Tahoe yellow cress are focused on affecting the conditions that influence a positive metapopulation dynamic. The following management actions were developed to ensure the conservation goals and objectives are directly supported through management. Efforts will largely focus on increasing the number of plants and populations across the species' historic range. This requires equal protection on public and private lands, restoration efforts, monitoring, periodic evaluation and review, and ongoing adaptive management. These efforts should be designed to secure current populations against extirpation and to increase their numbers, to expand the current distribution of populations to new and historic sites, to sustain existing and newly established populations over the long-term, and direct future management action though adaptive responses informed by monitoring and research. The following actions provide the necessary support for the Tahoe yellow cress conservation strategy and its goals and objectives.

- Protect priority ranked sites that support persistent natural populations.
- Develop site-specific management/action plans for each core and high priority restoration sites.
- Manage all sites that currently support Tahoe yellow cress.
- Carry out experimental reintroduction efforts.
- Monitor natural and reintroduced populations.
- Develop an interagency low population fencing and management permit.
- Maintain a site ranking for every site based on new and historic information.
- Identify management and monitoring responsibilities (Table 14).
- Consider revisions to existing TRPA MOUs.
- Consider development of a "Safe Harbor" program.
- Solicit recommendations from the Tahoe Yellow Cress Stewardship Group (TYCSG).
- Address water level management within Lake Tahoe.

Adaptive Management Framework

The Tahoe yellow cress conservation strategy depends on successful implementation of an adaptive management framework designed to integrate new information immediately into management direction. A step-down outline of the framework is presented in Figure B (corresponds to Figure 18 in strategy). It briefly describes the key steps in acquisition, transfer, storage, analysis, and assessment of data from monitoring and research. It is important to recognize that while participating entities will be committed to implement the conservation strategy, they may chose to go beyond expected responsibilities or dissect described steps to better articulate intended tasks. Each of the steps presented in Figure B are requisite to ensure the success of the conservation strategy. It is critical that the signatories provide the resources necessary to ensure successful implementation of the adaptive management framework. Until an adaptive management working group is established, the TAG will report to the executive committee.

Imminent Extinction Contingency Plan

A necessary component of any conservation strategy and/or adaptive management framework is to define the types and degree of actions to be taken when the number of populations and/or the sizes of populations become critically low. This kind of pre-planning for future actions is necessary for the following three reasons: 1) There may be insufficient time between the identification of an imperiled population and need to take action; 2) the description of possible actions to be taken to save the species will be known to all stakeholders in advance; and 3) the level of effort and resource commitment is acknowledged by all agencies and stakeholders. Four levels of contingency plans based on the number of occupied core sites and other sites have been identified (Section II.I). In general, when the number of occupied population sites decrease, effort will increase to conserve this species.

Stewardship, Education, and Outreach

Successful implementation of the conservation strategy shall include the development of a stewardship program in which private landowners and public agencies may participate (Section II.J). The stewardship program will be designed to be a cooperative educational effort that encourages public and private landowners, facility managers, and non-governmental agencies to manage for the conservation of Tahoe yellow cress and, if possible, generate site-specific management plans. The Tahoe Lakefront Owners' Association has volunteered to organize a Tahoe Yellow Cress Stewardship Group. This will be a non-profit group whose mission will be to encourage the conservation of Tahoe yellow cress on private lands. Although this group has yet to be formed, Tahoe Lakefront Owners' Association currently plays an integral role in communicating to those it represents the importance of conserving Tahoe yellow cress on private lands. Establishing this foundation will assist in the promotion of the stewardship program.

Monitoring, Science, and Research Agenda

An effective survey protocol will be implemented that includes a reliable census of known populations and systematic searches of unoccupied but suitable habitat areas (Section II.K). In addition, physical and biotic conditions that are thought to determine Tahoe yellow cress presence and abundance should be assessed in order to develop a more complete understanding of the environmental correlates of habitat suitability. That knowledge will then be used to guide future management actions, especially to provide early warnings of imminent species declines.

Hope for the Future

Through this cooperative effort, parties to this conservation strategy hope to successfully conserve Tahoe yellow cress and its habitat well into the future. Implementing this strategy and remaining committed to an adaptive management process will allow new information to be incorporated into existing management and provide a mechanism for an unprecedented level of cooperation between regulatory and resource agencies and private entities in the Lake Tahoe basin.

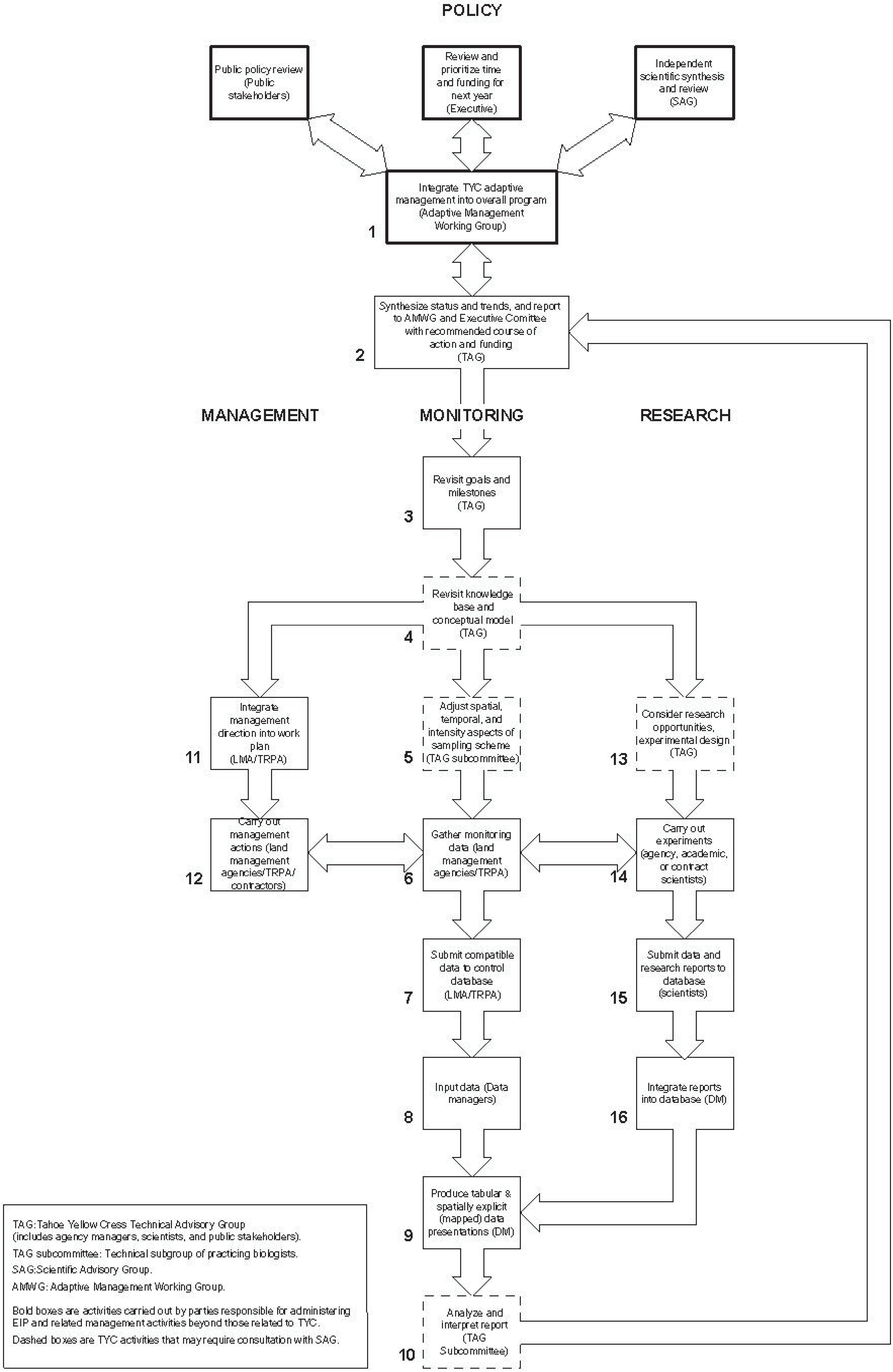


Figure B. Adaptive managment framework and assignments

Chapter I
Introduction

I.A. Background

Tahoe yellow cress (*Rorippa subumbellata* Roll.) is a rare plant species endemic to the shores of Lake Tahoe in California and Nevada. It was listed as endangered by the State of California in 1982 (California Fish and Game Code 2050 *et seq.*) and is considered endangered throughout its range by the California Native Plant Society (Skinner and Pavlik, 1994). Tahoe yellow cress is state-listed as critically endangered in Nevada (Nevada Revised Statutes (NRS) 527.260 *et seq.*), and is considered threatened by the Northern Nevada Native Plant Society (Nevada Natural Heritage Program (NNHP) 2001).

In 1980, the U.S. Fish and Wildlife Service (USFWS) identified Tahoe yellow cress as a category 1 candidate species for listing under the Endangered Species Act of 1973, as amended (ESA), indicating sufficient information on biological vulnerability and threats were available to support a listing proposal (45 FR 82479). During a 1994-1995 periodic review, the USFWS assessed the need to propose Tahoe yellow cress for listing as a threatened or endangered species. During that same period, a regional drought resulted in a significant drop in lake elevations. The lower lake elevations exposed large expanses of contiguous potentially suitable habitat for Tahoe yellow cress. The species responded by colonizing many of these areas. As a result of the species' response to low lake elevations, as well as changes to the USFWS' method of categorizing species, Tahoe yellow cress was downgraded from category 1 candidate status to a species of concern in 1996 (61 Federal Register 7595).

The drought ended in the mid-1990s and lake elevations began to rise, inundating most established Tahoe yellow cress occurrences and its shoreline habitat. Prolonged periods of inundation coupled with increased recreation in the shorezone prompted the USFWS to again review the status of the species. In 1999, Tahoe yellow cress was again added to the candidate list (64 FR 57533). Surveys conducted in September 2000 documented 14 occupied sites, down from a high of 35 sites in 1993 and a total of 51 known sites. Based on those surveys, it was determined that Tahoe yellow cress occupied only 27 percent of the known, historic sites. Evidence suggests the current decline in the number of sites occupied by Tahoe yellow cress is due to a variety of causes, including the combined effects of sustained high lake elevations and increased human use of lakeshore habitats. Because of the imminent threats facing the species, a task force has been formed to develop and implement a conservation strategy (CS) for Tahoe yellow cress. The CS is coupled with a Memorandum or Understanding (MOU)/conservation agreement (CA) signed by the participating entities that demonstrates the commitment of all involved to the long-term protection of the species.

Implementation of the CS is a cooperative effort being carried out under the auspices of a multi-agency and private interest group task force. The task force is composed of a technical advisory group (TAG) and an executive committee (Appendices A and B). The TAG is comprised of biologists and public land managers who represent the resource and regulatory agencies around the Lake Tahoe basin. In addition, TAG members include representatives of private property owners and environmental groups. The executive committee is made up of managers and directors representing public and private interests in the basin. The TAG and executive committee, together with academicians with expertise in rare plant ecology and conservation biology, developed this strategy. The TAG will bring future management recommendations to the executive committee. These recommendations will be based on the previous year's data and historical knowledge. The executive committee will act in the decision-making capacity and continue to oversee the implementation of conservation and management actions through the adaptive management process.

The following entities have committed to the implementation of the CS and are signatory to the MOU/CA:

- Tahoe Regional Planning Agency (TRPA)
- U.S. Fish & Wildlife Service
- U.S. Forest Service (USFS)
- Nevada Division of Forestry (NDF)
- Nevada Division of State Lands (NDSL)
- Nevada Division of State Parks (NDSP)
- Nevada Natural Heritage Program
- California State Lands Commission (CSLC)
- California Department of Fish & Game (CDFG)
- California Department of Parks & Recreation (CDPR)
- California Tahoe Conservancy (CTC)
- Tahoe Lakefront Owners' Association (TLOA)
- League to Save Lake Tahoe (League)

The TRPA is a bi-state regional planning agency that has regulatory authority within the Lake Tahoe basin. The Tahoe Regional Planning Compact (Compact) creating TRPA was adopted by the state legislatures of California and Nevada and ratified by the U.S. Congress in 1969. The Compact was amended and signed into law in December 1980 (Public Law 96-551, 94 Statute 3233). Pursuant to the Compact, TRPA adopted environmental threshold carrying capacities (thresholds) that are necessary to maintain certain values specified in the Compact. The Compact also provided for the planning and regulation of the shorezone, which is necessary to achieve or maintain many of the thresholds. Vegetation is one of the nine categories of thresholds and Tahoe yellow cress is identified as a threshold species (TRPA 1995).

The CSLC is involved with the protection of Tahoe yellow cress through review and analysis of discretionary projects under the provisions of the California Environment Quality Act (CEQA) and the California Endangered Species Act (CESA). During project review, CSLC is required to consult with CDFG. The CSLC administers California's fee ownership of the bed of Lake Tahoe from elevation 6,223 feet (ft) (1,896.77 meters (m)) Lake Tahoe Datum (LTD) lakeward and a public trust easement between elevation 6,223 ft (1,896.77 m) LTD and 6,228.75 ft (1,898.52 m) LTD for the people of the State of California for the purposes of fishing, navigation, swimming, and other water recreation.

The mission of CDFG is to manage California's diverse fish, wildlife, and plant resources and the habitats upon which they depend. These are to be managed for their ecological values and for their use and enjoyment by the public. Under CESA, the take of plant species designated by CDFG as threatened or endangered is prohibited without a permit. Full administrative responsibilities over protection of plant species listed under CESA are afforded CDFG.

The mission of CDPR is to provide for the health, inspiration, and education of the people of California by helping to preserve the state's extraordinary biological diversity, protecting its most valued natural and cultural resources, and creating opportunities for high-quality outdoor recreation.

The CTC mission is to preserve, protect, restore, enhance, and sustain the unique and significant natural resources and recreational opportunities of the Lake Tahoe basin. It is not a regulatory agency, rather it was established to develop and implement programs through acquisitions and site improvements to better the water quality in Lake Tahoe, provide public access, preserve wildlife habitat, and manage and restore lands to protect the natural environment.

The NDF is the state agency responsible for monitoring and issuing permits for projects that may impact a plant species on Nevada's List of Fully Protected Species (NRS 527.260 *et seq.*). NDF has full administrative responsibilities to protect critically endangered species, and take of a listed species can only be authorized by special permit issued by the state forester firewarden.

The NNHP is responsible for developing and maintaining the state's database and information system on the biology, locations, and conservation status of all sensitive plant and animal species in Nevada. By agreement with CDFG's Natural Diversity Database (CNDDB), NNHP is compiling a consolidated database for all California and Nevada occurrences of Tahoe yellow cress, and is acting as the lead repository for all historical and new survey and monitoring data from both states. All data will continue to be shared with CNDDB and other involved agencies.

The NDSL administers the Nevada state-owned lands from the bed of Lake Tahoe up to the low water elevation (6,223 ft; 1,896.77 m LTD) and regulates construction of structures up to the high water elevation (6,229 ft; 1,898.60 m LTD). The public has the right to lateral access across the shorezone at and below elevation 6,223 ft (1,896.77 m) LTD on the Nevada side of the lake.

The NDSP plans, develops, and maintains a system of parks and recreation areas for the use and enjoyment of residents and visitors. It also preserves areas of scenic, historic, and scientific significance in Nevada.

The mission of the USFWS is working with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. The Fish and Wildlife Coordination Act (16 USC 661 *et seq.*) authorizes the USFWS to review proposals for any actions requiring federal permits, including, but not limited to, the construction of structures in navigable waters. The ESA authorizes the USFWS to determine whether species are endangered or threatened because of threats to their continued existence. As such, the USFWS conducts periodic species status reviews.

Caring for the land and serving people is the guiding mission of the USFS. Through various programs, including fire management, vegetation management, watershed restoration, and wildlife monitoring, the USFS, Lake Tahoe Basin Management Unit (LTBMU), works to protect this unique environment while managing recreation and enhancing forest values.

I.B. HISTORY OF SPECIES CONSERVATION

Until recently, interagency coordination on annual surveys was infrequent. Beginning in September 1997, CSLC formed a multi-agency survey team to perform annual lake-wide surveys for the presence or absence of Tahoe yellow cress. Each agency involved in the effort contributed various amounts of in-kind services. Examples of in-kind services include staff to conduct the surveys, survey equipment (boats, Global Positioning System (GPS) units, aerial photographs, etc.), or post-survey data compilation. Since the late 1970s, various management efforts and field surveys for Tahoe yellow cress have been conducted, offering important information regarding the recent historic distribution of the species.

Tahoe Regional Planning Agency: In 1987, TRPA adopted its Regional Plan, which is designed to bring the Region into conformance with the threshold standards established for nine resource categories. One of the threshold categories is "Vegetation" and includes Tahoe yellow cress. A Numerical Non-degradation Standard was adopted, setting the minimum number of population sites for Tahoe yellow cress at 26.

Every 5 years TRPA is required to evaluate progress made on threshold attainment and assess threshold status. Beginning in 1993, TRPA implemented a Tahoe yellow cress monitoring program. During the period 1993 to 1994, TRPA surveyed 100 percent of the ground surface on all littoral parcels. Two survey methods were employed: Reconnaissance level method (RLM) and intensive transect method (ITM). In conjunction with the RLM, a field data sheet was developed, which draws on information from CNDDB Species Field Form, NNHP Field Survey Form, and TRPA's database sheet. For public lands managed by USFS, CDPR, and CTC, the RLM and associated data sheet are being used. Staff currently participate in annual lake-wide surveys for Tahoe yellow cress.

California State Lands Commission: In 1989, in response to several permit applications for new pier construction and maintenance activities on existing piers, CSLC developed a *Rorippa* Enhancement Plan (REP). Under the aegis of CSLC and TRPA staff, a group of state and federal agencies met to develop a process whereby CSLC could consider relevant projects and meet its obligations under the law. To supplement the REP, an interim management program was developed that identified construction, access, and conservation guidelines. Additionally, fees were collected from applicants to be used to fund the preparation of a biological assessment. A draft biological assessment for Tahoe yellow cress was prepared in 1994 and revised in 1998. Staff from CSLC organize and participate in annual lake-wide surveys for the species.

California Department of Parks and Recreation: In 1989, through a grant from CTC, CDPR implemented an experimental outplanting project, introducing 1,168 Tahoe yellow cress seedlings to D.L. Bliss State Park, a historical site. The site was fenced and informational signs were installed. Annual monitoring of the site is conducted in conjunction with other resource agencies.

California Tahoe Conservancy: In 1988, through a grant to CDPR, CTC funded a reintroduction project at Lester Beach. The effort included propagation of seed, site preparation, and the introduction of 800 Tahoe yellow cress seedlings. The CTC participated in the CSLC management plan development process from 1993 to 1995. From 1994 to 2001, CTC, working in cooperation with the Tahoe Baikal Institute (TBI), lead cooperative Tahoe yellow cress surveys, developed a Geographic Information System (GIS) database of population locations and their extent, and presented educational programs at the USFS visitor center specific to the biology and status of the species. The CTC has participated in a number of fencing projects over the years, which serve to protect the species from human impacts at public beaches.

In 2001, CTC purchased the Barton property (Upper Truckee East), which supports the largest Tahoe yellow cress population. A fence was constructed around the population and was subsequently expanded to include individuals that germinated outside of the original fence. Access is restricted within the enclosure and a land steward is frequently present on-site to provide public outreach and education.

Staff from CTC also participate in the annual lake-wide population survey and conduct intensive monitoring at the Baldwin Beach and Barton sites on an annual basis.

Kingsbury General Improvement District (KGID), Kahle Beach Mitigation: In 1991, Western Botanical Services planted 119 seedlings at the KGID's Nevada/Kahle site (Etra 1994). After one year, 26 seedlings survived resulting in a 14 percent survival rate. In 1994, only four plants remained at the site. These plants were eventually removed to evaluate Tahoe yellow cress root morphology. The roots varied among the plants with a lateral spread of main roots ranging from 4 to 20 inches (in) (10 to 50 centimeters (cm)). A rooting depth of up to 20 in (50 cm) was observed. Two plants were primarily tap rooted with many fibrous roots attached. All root systems had primordial shoots growing from root nodes. Some of these shoots were well developed extending as far as 20 in (50 cm) from the main root. This may indicate that the plants are more clonal than previously thought. This suggests that the current method of counting the plant by aerial stems overestimates actual numbers in existence.

Western Botanical Services concluded that the depth of these root systems indicate that plants are capable of tripling their rooting depth in 3 years, with up to 2 years of supplemental watering, and that plants may spread farther than previously thought (Etra 1994).

U.S. Fish and Wildlife Service: The USFWS periodically evaluates the conservation status of Tahoe yellow cress to determine the need for protection under the ESA. In 1995, the USFWS funded a study to determine the genetic characteristics of this species. The study was designed to address questions related to the evolutionary and ecological consequences of periodic fluctuations in population size. In 1999, genetic material was analyzed from 140 Tahoe yellow cress individuals from 11 sites observed that year. Among the populations sampled, Tahoe yellow cress exhibited low genetic variability. These data suggest that the sites around the lake may be one population. Based on this information, conducting experimental introductions throughout the historic range of the species may be unencumbered. However, because of the small sample size and some variation at three sites, additional genetic studies will be conducted prior to implementation of an experimental outplanting program. Staff also participate in annual lake-wide surveys for Tahoe yellow cress.

U.S. Forest Service: The USFS, LTBMU, developed a Species Management Guide for Tahoe yellow cress (Knapp 1980) and a Sensitive Plant Interim Management Prescription (Reed 1982). These plans were drafted under a mandate contained in the Forest Service Manual to conserve and manage endangered species and their habitat on USFS lands and provide for their existence in perpetuity (USFS 1980).

Management actions under these plans called for annual monitoring of Tahoe yellow cress, active protection of existing occurrences and associated habitat, and the exploration of methods to reintroduce the species to new and historic sites on National Forest System lands. Three enclosures were constructed around existing Tahoe yellow cress populations in the 1980s. Enclosures were constructed in 1981 around the Meeks Bay and Taylor Creek populations and, in 1986, around the Tallac Creek population.

Propagation and outplanting of Tahoe yellow cress was initiated in 1986. In the summer of 1988, 500 seedlings per site were introduced at 3 locations. Two of the outplanting sites supported existing plants, and new plants were placed in unoccupied areas of these sites. The sites were fenced and interpretive signs were constructed. Currently, four Tahoe yellow cress enclosures are maintained on National Forest System lands. Two of the enclosures were enlarged and rebuilt in July 2000. Staff also participate in annual lake-wide surveys for Tahoe yellow cress.

CHAPTER II
CONSERVATION STRATEGY

II.A. TAHOE YELLOW CRESS AND LAKE TAHOE

History

Tahoe yellow cress most likely evolved in the ancient mountain basin of the Truckee River. Its ancestor, probably from the Columbia River drainage, became stranded many hundreds of thousands of years ago beside an immense, glacial-fed lake that had slowly drowned the lower reaches of its Sierran tributaries. Perhaps seeds had found this basin by accident, carried in the gut or plumage of migratory waterfowl. Alternatively, the ancestral plant may have descended from a more widespread species that inhabited the Region during a distant geological period. In either case, its arrival long preceded human occupation of the continent and its evolution was guided by endless cycles of rising and falling waters.

It is impossible to know exactly how Tahoe yellow cress came to be. Almost all of its relatives are plants associated with flowing water - inhabitants of rivers, streams, and meadow edges. Such habitats undoubtedly existed in the Lake Tahoe basin over the millennia and, in fact, still do. Tahoe yellow cress is largely confined to the sandy beach and dunes associated with the lake's ever-changing margin and the mouths of its tributaries. Such habitat preference is unusual because no other lacustrine endemics are known from the Sierra Nevada. Perhaps other lakes are simply too young to have fostered the development of a unique lakeshore plant. Lake Tahoe has existed for about two million years, never displaced by glaciers and never static in size, shape, or other essential qualities. Age and environment have thus conspired to create a singular species in a place as singular as the clear blue waters.

What were the peculiar environmental forces that molded Tahoe yellow cress into the species we see today? Some have suggested the qualities of the beach sand as being important - its granitic and volcanic mineralogy, grain size distribution, and armor coating. There is no evidence that any of these sand features are unique to the Lake Tahoe basin. In fact, this species has been observed growing in silty soils among boulders, in organically enriched dune slacks and meadows, in greenhouse potting mix, and even within a beachfront lawn. Sand may appear to be important to the ecology of Tahoe yellow cress because other, taller, more luxuriant species find it to be excessively dry and nutrient poor. The low-growing, widely foraging Tahoe yellow cress can thus escape the sun-blocking canopies and nutrient-grubbing roots of tall willows (*Salix* spp.), alder (*Alnus incana* var. *tenuifolia*), and wetland rushes (*Juncus* spp.).

Instead of sand as a selective force in the evolution of Tahoe yellow cress, we suggest the lake itself, especially its age, complex history, and dynamics, as the primary force. Great oscillations in climate caused glaciers to advance and retreat, with corresponding fluctuations in precipitation, runoff, evaporation, and groundwater recharge. Lake levels rose and fell, sometimes slowly and sometimes catastrophically over short periods of time. Submerged tree trunks indicate lake levels 20 to 40 ft (6 to 12 m) lower in the recent past, but other evidence shows levels were more than 570 ft (175 m) lower over the last 160,000 years. If each 1 ft (0.3-m) drop in water level today creates about 200 acres (ac) (80 hectares (ha)) of sandy shoreline habitat suitable for Tahoe yellow cress, imagine the potentially suitable habitat created by lake recession during the distant past. Perhaps low lake periods produced large expanses of contiguous sediments, reworked into dunes and beaches by the wind. Succession by upland plant species would ensue, but not before millions of Tahoe yellow cress-like ancestors colonized vast, open areas near the retreating lakeshore. Perhaps these were times for widespread genetic exchange, as formerly isolated populations intermingled at lower elevations. Similar but smaller-scale expansions are still observed under drought conditions (e.g. 1987 to 1993), and plants grow rapidly and flower profusely. With the return of high waters most established sites would be inundated and individuals lost, except for those upslope and those which were carried to new shores as floating seeds or rootstocks. Such catastrophic changes in population size are known to have significant and rapid effects on gene pool composition, and could thus affect the rate and direction of evolutionary change. Tahoe yellow cress would, as a species, reflect eons of these lake-driven fluctuations in its distribution and abundance.

With such a long history of rapid, unpredictable change it is remarkable that this plant has persisted. Extreme climate change, extraordinary high waters, even landslides and lake tsunamis could have led to extinction of Tahoe yellow cress, especially when it was composed of few, small, isolated populations. The tenacity of those populations probably results from the possession of a perennial habit and spreading rootstocks. The rootstocks can branch and grow in many directions, allowing a long-lived individual to occupy upslope and downslope habitat and be less susceptible to stresses imposed by the water's edge. They can rapidly spread into new, open sands as the lake recedes, provide upslope anchorage and refuge when the lake advances, and remain dormant during erosion by wave action. The rootstocks are apparently tolerant of low sediment oxygen because they may produce leafy shoots after years of inundation. And, under extreme conditions, rootstocks and seeds are liberated by the churning waters and float to new sites for possible colonization. This diminutive, unassuming plant has proven itself ferocious in its quest for existence, not only weathering the severe forces of Lake Tahoe for hundreds of thousands of years, but incorporating those forces into a unique physical and physiological form.

Tahoe Yellow Cress Today

Since it was first scientifically described by Dr. Reed Rollins in 1941, Tahoe yellow cress has been collected or observed at 51 locations around the lake. Each location is referred to as an "occurrence" or a discreet collection of one or more individual plants occupying an area of actual habitat. The word "occurrence" is synonymous with "record" or "population", meaning there is an official document on file that establishes the species as present at a particular location at a particular time. Therefore, with respect to the locations that have been surveyed, there is a high degree of confidence as to where Tahoe yellow cress has occurred in the recent past. Regarding the locations that have not been surveyed, neither records nor confidence exists. Given the dynamic nature of this species and the lake environment, there are probably many other stretches of sandy beach it has occupied in the past for which we have no documented collections or observations. These places now appear devoid of Tahoe yellow cress, but may possess all of the necessary attributes and may have supported a significant number of plants in the past. These places are referred to as potentially suitable habitat, and they may be as important to the overall conservation of the species as actual habitat. They may represent optimal, but temporarily abandoned sites awaiting recolonization or refuges that become more suitable for occupation when environmental conditions inevitably change. Therefore, we conclude that Tahoe yellow cress has persisted into the 21st century using 51 known occurrences of actual habitat, and an unknown quantity of potentially suitable habitat.

Not all known occurrences have been occupied by Tahoe yellow cress at the same time. The greatest number of occupied sites was 35 in 1993 (79 percent of those surveyed in that year), while the fewest was 7 during the 1995 to 1997 period (about 20 percent of those surveyed). The last complete survey (September 2000) found 14 occupied sites (33 percent of those surveyed). It is not known exactly how many sites Tahoe yellow cress should occupy in a given year to secure its future, but the vast majority of endangered plants of highest conservation concern are found in five or fewer occurrences. Tahoe yellow cress finds itself on the cusp of extinction, occupying 20 percent of its actual habitat during the worst of times and less than 80 percent during the best.

Of equal concern is that fact that each known occurrence may not represent a functioning population of significant size. A population is a collection of genetically distinctive, possibly interbreeding individuals, each with its own, independent life. The growth form of Tahoe yellow cress makes the determination of individuals difficult because a single spreading, underground rootstock can produce multiple, above-ground stems. Each of the stems can bear a rosette with branches, leaves, flowers and fruit, and thus appear to be separate individuals. Therefore, stem counts have been substituted for population censuses and those counts have been perilously low in the recent past. The entire existence of Tahoe yellow cress was comprised of only 771 stems in 1980 from a total of 16 occurrences (48 stems per occurrence). A high value of 11,110 stems was recorded in 1990 (463 stems per occurrence). Even if we assume each stem represented an individual plant, conservationists have determined that populations of herbaceous perennials with fewer than 500 individuals are not likely to maintain themselves into the indefinite future. Therefore, based on this assumption, Tahoe yellow cress is currently composed of too few, too small populations occupying only a fraction of their actual habitat to be considered sustainable.

What are the responsible factors? The major contributors to the current status of Tahoe yellow cress are: Alterations in lake level dynamics caused by construction and operation of the Truckee River outlet dam and reservoir; destruction of actual and potentially suitable habitat by the construction of some types of structures; high levels of recreational activity associated with beaches and dunes; disturbance of the sand by public and private property maintenance activities; and possibly random environmental events. The relative importance of these factors is not currently known. Since the installation of the Truckee River outlet dam in 1874, lake level has been regulated for purposes of meeting downstream water rights appropriations and generating hydroelectric power. The Truckee River dam adds an additional 6 feet of lake storage above the natural rim of Lake Tahoe. Records kept since 1900 show high lake levels that would isolate and reduce Tahoe yellow cress populations to higher beach elevations. Approximately 7 high-level peaks encompassing 53 years can be delineated from the record, including 29 years that exceeded the legal upper limit of 6,229.1 ft (1,898.63 m) LTD. In comparison, there were about 5 low-level troughs comprised of 32 years, with only 21 years that were at or below the lower limit of 6,223 ft (1,898.77 m) LTD, the lake's natural rim. From the standpoint of Tahoe yellow cress, less favorable, peak years have occurred almost twice as often as more favorable, low-level years. Secondly, there has been widespread and intensive destruction of beach and dunes since European settlement. A wide variety of structures, including 27 marinas and boat launch facilities, hundreds of private residences and piers, and a large number of public works and commercial developments have been sited in the shorezone of actual and potential Tahoe yellow cress habitat. Ongoing maintenance activities can be as destructive as the original construction. Associated with lakeshore development and access are recreational impacts, which become most intense when lake levels are high. This is because both people and Tahoe yellow cress become concentrated in fewer, upslope areas of the beach. More people are also attracted to the basin and its recreational facilities in years of high precipitation and water levels. Finally, the land management and maintenance practices of private individuals and public agencies are detrimental to the species and its habitat. Removal of wrack (organic matter) and debris by raking; trimming native vegetation; introduction of invasive, nonnative plants; and even attempts at ecological restoration have impacted Tahoe yellow cress directly by uprooting seedlings and adult plants and indirectly by altering the sand, the natural community, and hydrology of its habitat.

Another, less obvious set of conditions has contributed to the current status of Tahoe yellow cress. There is a complicated and sometimes contradictory web of public and private interests involved in the management of the natural resources in the Lake Tahoe basin. Public agencies are mandated to provide goods and services to taxpayers (e.g. timber, recreational access, water for power generation) while also charged with protecting valuable and vulnerable natural resources (e.g. old growth forests, beachfront, sensitive species and habitats). Private individuals and businesses seek opportunities to fulfill their desires and economic needs (e.g. second homes or a modern marina) and require investment returns derived from increasing valuation (e.g. an improved beach aesthetic, growing visitation). Because of these potential conflicts, conservation actions on behalf of a resource such as Tahoe yellow cress require time and commitments by a variety of stakeholders. Herein we seek a more cooperative, proactive, scientifically based approach to Tahoe yellow cress conservation. Our objectives are to increase the number and size of Tahoe yellow cress occurrences, restore vital dynamics to the species and its habitat, implement an adaptive management framework with participation of all stakeholders, and raise pubic awareness and sympathy for this species as a unique and important element in the greater Lake Tahoe ecosystem. The ultimate goal is to retain Tahoe yellow cress and its essential ecological characteristics as a tribute to the lake and its resilient human community.

II.B. BIOLOGICAL OVERVIEW OF TAHOE YELLOW CRESS

Systematics

E.L. Greene first collected Tahoe yellow cress for science prior to 1891. Greene had mistaken it for the species *Rorippa sinuata* that is widespread west of the Mississippi River. Considerable taxonomic confusion prevailed at the time, largely because all water cresses, yellow cresses, and hidden-cresses (*Clandestinaria*) were included within the genus *Nasturtium* by DeCandolle (1821). This European treatment did not easily accommodate the many new species described during early botanical explorations of North America. Arguments about the validity of *Rorippa* as a separate genus had lasted until the 1930s (Stuckey 1972). It was finally determined that the genus would include marsh and shore species that had short, elliptical or rounded siliques that readily dehisce (open), and white to yellow flowers. Excluded were species having linear siliques and apetalous or micropetalous flowers. Members of the genus can be found on every continent except Antarctica, with centers of diversity in temperate North America and Europe.

The current treatment of *Rorippa* (Brassicaceae, or mustard family) in the *Jepson Manual: Higher Plants of California* (Hickman 1993) recognizes about 75 species worldwide, with 21 native to North America, and 7 having been introduced to the continent. There is a concentration of taxa, some common and some rare, associated with the mountainous regions of the western United States (Stuckey 1972). California has 11 species, one of which is introduced from Europe, and one is considered worldwide in its distribution (water cress, *R. nasturtium-aquaticum*). Nevada has eight species. All are associated with open, damp, or wet habitats (springs, marshes, meadows, mudflats, playas, and the shores or banks of lakes, streams, and rivers) that are often naturally disturbed by flowing water. Anthropogenic wetlands also provide habitat, especially irrigation ditches, farm ponds, and road culverts.

The collection and assessment of specimens from Meeks Bay (El Dorado County) allowed Rollins to describe Tahoe yellow cress as distinctive species (*subumbellata*) under the genus *Rorippa* (Rollins 1941). Rollins considered it endemic to the shores of Lake Tahoe, even though early collections by Greene were labeled "Truckee" and "Tallac Lake". Attempts to relocate the latter two populations have failed (CSLC 1998), reinforcing the widely held conclusion that Tahoe yellow cress is exclusively associated with Lake Tahoe *sensu stricto* (Mason 1957; Munz and Keck 1959; Hickman 1993; Skinner and Pavlik 1994).

Tahoe yellow cress is distinguished from other California and Nevada members of the genus by its yellow petals, perennial, creeping rootstocks, lobed cauline leaves, and roundish, hairless fruits with persistent, hairless sepals (Rollins 1993). It is a low-growing (usually less than 4 in; 10 cm tall), somewhat fleshy herb with many branches that can be 2 to 8 in (5 to 20 cm) long. Leaves are up to 1 in (3 cm) long, 0.12 to 0.4 in (0.3 to 1.0 cm) wide, short petioled or sessile, with wavy or deeply lobed (nearly pinnate) margins. The flowers are clustered together at the ends of short branches and have sulfur yellow petals (0.1 to 0.14 in; 0.25 to 0.35 cm from base to tip) that are longer than the dull yellow sepals. Fruits are distinctive, with a round to oblong shape (less than 0.2 in; 0.5 cm long, “plump” or weakly inflated), narrow stigma, and a lack of external hairs, held within the cup-like whorl of sepals (see photo Appendix L). The only other *Rorippa* likely to be found in the Tahoe basin is the widespread *R. curvisiliqua*, which is tall (4 to 16 in; 10 to 40 cm), possesses long leaves (up to 3 in; 7 cm), short, yellow petals (less than 0.08 in; 0.20 cm) that do not extend beyond the sepals, and elongated, narrow fruits (0.24 to 0.6 in; 0.6 to 1.5 cm long).

Evolutionary relationships within the genus have yet to be elucidated using modern molecular approaches. More traditional analyses of morphological traits and distribution by Stuckey (1972) have placed the most primitive species in the section Sinuatae. These are fleshy perennials with decumbent to prostrate stems that could spread underground by means of horizontal rootstocks and thus form large clones. In North America there are six of these species (*R. calycina, R. columbiae, R. subumbellata, R. sinuata, R. ramosa, and R. coloradensis*). Stuckey postulated that an ancestral complex, perhaps most similar to *R. sinuata*, radiated several morphological segregates with varying degrees of geographical isolation. One segregate, now known as *R. columbiae*, adapted to the volcanic soils of the Columbia River lava plateau of Tertiary age (late Pliocene). Stuckey noted that its entire distribution is associated with ancient, widespread lava soils, including those found in the Klamath-Siskiyou region. He concluded that *R. columbiae* “is an isolated relic probably once more abundant and widespread than today.” Another segregate evolved into *R. calycina*, which is only found on the sandy banks of the Yellowstone River in eastern Montana and western North Dakota. Gradual evolutionary trends in the morphological characteristics of *Rorippa* species included shifts towards shorter petals, anthers, pedicels, styles and seeds, and more seeds per fruit. All other North American members of the genus were derived in this way, radiating toward the south during the Pleistocene glaciations and north or east during the interglacial periods.

According to Stuckey, Tahoe yellow cress (*R. subumbellata*) is another segregate of the ancestral complex “most closely allied to *R. columbiae*.” This would imply that Tahoe yellow cress is somewhat younger than *R. columbiae*, but still quite ancient since he believed that the latter species could have been in existence during the late Tertiary. Although Lake Tahoe is generally regarded as 1.9 to 2.3 million years old (Hyne *et al*. 1972; Gardner *et al*. 2000), rivers in the basin must have preceded lake filling, possibly providing an even older ancestral habitat. Derivation of *R. subumbellata* from *R. columbiae* occurred as stems became less flexible, leaves more fleshy, stigmas and styles less expanded, seeds larger and fruit wall completely glabrous by the loss of pilose hairs.

Genetics

Despite the widespread nature of the genus *Rorippa*, there has been no systematic attempt to characterize some of the most basic genetic features of its species. Chromosome numbers are known for only a few European or widespread taxa. Austrian field-cress (*R. austriaca*) appears to be typical, with a diploid number of 2n = 16 (Darlington and Wylie 1955; Rollins 1993). Three other species are also 2n = 16, suggesting a base number of x = 8. Other closely related genera (e.g. *Armoracia*, *Cardamine*, *Cardaria*) also have this base number. This makes water cress (*R. nasturtium-aquaticum*) an apparent tetraploid (2n = 32). No counts are available for any of the primitive North American members of section Sinuatae, including Tahoe yellow cress. Given this lack of chromosome data, it is not surprising that other, more sophisticated forms of genetic information (e.g. common garden studies, synthetic hybridizations, pollen and seed viability) are also unavailable.

Fortunately, concerns over the conservation status of Tahoe yellow cress produced a useful appraisal of the quality and abundance of its genomic variability. A pilot study was conducted using vegetative samples collected in July 1996 from Upper Truckee East (Barton Beach) (n = 16 apparent individuals) and Taylor Creek (n = 15) (Bair 1997). A total of 14 enzyme systems were resolved on starch gels using isozyme electrophoresis. No variation was found at 18 of 19 loci examined. A single polymorphism was observed in one sample from Taylor Creek at the UGPP (uridine diphosphoglucose pyrophosphorylase) locus. The lack of genetic variability from sites more than 2.5 miles (mi) (4 kilometers (km)) apart was "somewhat surprising", but the band resolution was good and further efforts were warranted.

A more robust genetic inventory of Tahoe yellow cress was subsequently performed (Saich and Hipkins 2000) which also used isozyme electrophoresis to characterize 140 individuals from 11 populations around the south shore of the lake (Table 1). A total of 16 enzyme systems were resolved on starch gels and interpreted under the assumption that Tahoe yellow cress is diploid. Large populations (Upper Truckee East and Blackwood South) contributed the customary sample size of 27 to 30 plants each (Falk and Holsinger 1991), with some effort to choose spatially separated "individuals". Material was collected from all individuals of small populations (e.g. Upper Truckee West and Tahoe Meadows with two to eight plants each). Because so few populations were observed the year of the study, care should be taken when interpreting the data beyond the whole taxon level to population or ecogeographic (i.e. ecotypic) levels that require larger sample sizes per population and more populations from the entire, extant range.

The 16 enzyme systems revealed a total of 23 loci: PGI (phosphoglucoisomerase) had its typical two loci contributing subunits, as did PGM (phosphoglucomutase), TPI (triose phosphate isomerase), and 6PGD (6-phosphogluconate dehydrogenase), while FEST (fluorescent esterase) had four. Among all sampled populations, a single alternative allele was detected at the PGI-1, UGPP-1 (uridine diphosphoglucose pyrophosphorylase) and DIA-1 (diaphorase) loci. Therefore, the proportion of all loci that were polymorphic (P) was 13 percent, with an average of 1.13 alleles per locus (A) (Table 1). The alternative alleles were detected in the Taylor Creek (PGI-1 and UGPP-1 loci), Upper Truckee East (UGPP-1) and Tahoe Meadows (DIA-1) populations. The Tahoe Meadows variant was unique and relatively frequent (three of eight individuals sampled, caution on sample size), marking the population as the most genetically distinctive. Heterozygotes were found at the Taylor Creek site (10 individuals sampled) and were very rare overall (observed frequency of 0.0003, Ho). Most sites were monomorphic and completely homozygotic with respect to all loci (Blackwood South, Baldwin Beach, Edgewood, Kahle/Nevada Beach, Lighthouse, and Upper Truckee West).

Compared to other plants that have been inventoried by starch gel electrophoresis (Hamrick *et al*. 1979, 1991), Tahoe yellow cress has very low levels of isozyme variation (Table 1). Geographically restricted species on average have P = 24 percent and A = 1.4, while widespread taxa average 30 percent and 1.6, respectively. Low genetic diversity in rare plants is generally due to extreme and rapid reductions in population ("bottlenecks") that non-selectively eliminate variant individuals (Barrett and Kohn 1991; Guerrant and Pavlik 1997). This may be the case for Tahoe yellow cress because wide fluctuations in population sizes have been observed at most sites since monitoring began in 1978 (see below). It is also possible, however, that the demographic composition of the populations and, therefore, the array of samples for this inventory, has been dominated by clonal growth rather than reproduction from seed. The former produces genetically identical ramets by vegetative segmentation, rather than genetically independent genets by sexual reproduction (Harper 1977). The observed lack of genetic variation is probably an artifact of sampling small populations of ramets because data suggest that species with clonal reproduction are as variable, perhaps even more variable, than species that sexually reproduce (Table 1). Finally, self-fertilization, rather than outcrossing, would tend to confine gene exchange within each population. This would reduce the proportion of interpopulational variation and increase the probability of interclonal mating that would further erode heterozygosity (Saich and Hipkins 2000).

The limited data suggest that Tahoe yellow cress populations are somewhat differentiated from each other, but that no strong ecogeographic pattern has yet been detected. Some populations apparently contain unique alleles (Taylor Creek, Upper Truckee East, and Tahoe Meadows) due to limited gene flow, thus contributing to a modest value of Fst (0.22, the proportion of variation found among, rather than within, populations). All three sites are located within 7.5 mi (12 km) of each other along the south/southwest shore, but are flanked by other sample sites that did not possess the alleles. Perhaps more intensive sampling (i.e. more "individuals" per site) will reveal a wider or more consistent pattern of allelic variation. Overall, the sampled populations are more than 99.2 percent similar, with Tahoe Meadows and Taylor Creek having the greatest genetic distance between them. Only more extensive sampling (i.e. from sites along the west, north, and east shores of the lake) could find additional unique alleles, more population differentiation, and more ecogeographic patterning.

Table 1. Genetic variability in Tahoe yellow cress and other categories of plants determined from isozyme electrophoresis. pl = # plants sampled, sp = # species sampled, P = percent of loci which are polymorphic, A = mean number allelels per locus, Ho = observed heterozygousity, Fst = proportion of total variation found among populations.

Study	Sites or category	n	Polymorphic loci	P	A	Ho	Fst
Bair 1997	Taylor Creek	15 pl	UGPP	5.2	1.05	0	
	Up Truckee E	16	0	0	1.0	0	
Saich & Hipkins 2000	Blackwood S	27 pl	0	0	1.0	0	
	Baldwin W	13	0	0	1.0	0	
	Baldwin N	4	0	0	1.0	0	
	Taylor Creek	10	UGPP-1 PGI -1	8.7	1.09	0.0043	
	Lighthouse Be	7	0	0	1.0	0	
	Lighthouse	11	0	0	1.0	0	
	Up Truckee W	2	0	0	1.0	0	
	Up Truckee E	33	UGPP - 1	4.4	1.04	0	
	Tahoe Meadows	8	DIA - 1	4.4	1.05	0	
	Edgewood	18	0	0	1.0	0	
	Kahle/Nevada	7	0	0	1.0	0	
	all Tahoe yellow cress	140 pl	UGPP - 1 PGI - 1 DIA - 1	13.0	1.13	0.0003	0.213
Hamrick 1979, 1991	endemics	17 sp		23.5	1.43		0.200
	narrow distrib	22		36.7	1.60		0.275
	widespread	35		30.4	1.58		0.253
	asexual repro	1 sp		50.0	1.91		0.080
	sexual repro	95		35.6	1.63		0.284
	both	17		41.7	1.67		0.209
	early seral	54		29.7	1.60		0.574
	late seral	10		62.8	2.14		0.071

Life History Traits

Tahoe yellow cress is a low-growing, somewhat fleshy, herbaceous perennial that branches profusely. Its shoots often appear circular in outline with short internodes that give the impression of a rosette growth form. Flowering is accompanied by internode lengthening, thus reducing the compact appearance later in the season. Typical shoot diameters of established plants range from 2 to 5 in (5 to 12 cm) in mid-May, becoming 6 to 7 in (15 to 18 cm) by early July (Ferreira 1987). Growth appears best when surface sands are dry and moisture is visible at 5 cm depth (Ferreira 1987). Soil saturation during the spring and summer inhibits vegetative growth and delays the onset of flowering. When maximum lake level exceeded 6,229 ft (1,898.60 m) LTD during the winter and spring of 1986, floral production and anthesis began in late September (CSLC 1998). This compresses the length of the growing season and restricts plant size because shoots do not overwinter. Dried remains of shoots sometimes mark the location of the previous year's population, but otherwise the plants are imperceptible until new shoots are produced in spring (typically late March and April).

Although the word "rhizomatous" has been used to describe Tahoe yellow cress, there is no reference to rhizomes in descriptions of *Rorippa subumbellata* or closely related taxa given by Stuckey (1972) or Rollins (1993). Other members of the genus have underground stem systems that root at the nodes, but Rollins excludes the characteristic (or at least discounts it) in his key to California members of section Sinuatae. Clonal growth in Tahoe yellow cress is, therefore, the result of a spreading underground system of horizontal roots (Stuckey 1972; TBI-CTC 1997). These originate at the base of the rosette, as a dense aggregation called a rootstock. Excavations of 3 year-old transplanted individuals by Etra (1994) revealed fragile roots that spread laterally up to 20 in (50 cm) and downward by about the same amount (3 times their starting lengths). All roots bore shoots in various stages of development, including those at the greatest distance from the parent. One 20 in (50 cm) long root had a total of 8 shoots, 3 of which were well developed. These were watered plants in sub-optimal habitat, so the rate of spread is probably not typical. Nevertheless, these measurements indicate that the potential for vegetative segmentation and rapid spread are high in this species, as they are in *R. columbiae* (Crone and Gehring 1998).

There has been no comprehensive study of Tahoe yellow cress breeding biology, so an analysis of factors limiting seed production (Pavlik *et al*. 1993) is not possible. It appears that flowering is indeterminate, with first floral buds produced during mid to late May and continuing into the summer and early fall (Ferreira 1987). Floral anthesis begins in late May and has been observed on warm days in late October. It is not known if Tahoe yellow cress has an inbreeding, outbreeding, or mixed breeding system. The high proportion of flowers that produce fruits would indicate that the species is an inbreeder with no pre- or post-zygotic outcrossing mechanisms. A detailed examination of hand pollination trials and measurements of fruit/flower and seed/ovule ratios would be required to detect pollination, fertilization, and predation limits on seed output (Pavlik *et al*. 1993). Observations at Baldwin Beach indicated that flowers are most often visited in the morning (9 am to 10 am) by small flies in the families Dolichopodidae, Syriphidae, and Muscidae and by bees in the families Megachilidae, Tiphiidae, and Andrenidae (Gordeev 1997). Dolichopods were particularly abundant and had a preference for Tahoe yellow cress flowers, but there was no evidence presented that demonstrated pollen transport or effectiveness at stigmatic deposition. Bagging flowers would establish whether or not any pollinators are required for successful seed output in the species. Seed and fruit development are continuous during the flowering period, truncated by inundation or the first winter storms.

Sexual reproduction from seed is possibly associated with the following: 1) Wind or water transport of the slightly inflated, indehisced fruits; 2) wind or water transport of seeds liberated from dehisced fruits; and/or 3) gravitational transport of seeds liberated from dehisced fruits into the interstitial spaces of the sandy substrate near the parent (CSLC 1998). The relative importance of these potential dispersal processes is not known. Small plants are often observed among the "bathtub" ring of beach wrack in late spring and early summer, but they could originate from floating rootstocks was well as floating seeds or fruit (Ferreira 1987; CSLC 1998; M. Falkner, CSLC, pers. comm. 2000). If originating from a transported fruit, we might expect to see clusters of germinules within the wrack, as also observed in sand dune species of *Astragalus* (Pavlik and Barbour 1988). Each fruit (silique) can produce 20 to 30 seeds (Stuckey 1972), with many (perhaps hundreds) on a single large individual each year. The yearly reproductive output of such a plant would, therefore, be measured in the thousands. The small seeds have very high germination rates (close to 100 percent in the laboratory, Ferreira 1987) and readily establish new plants under greenhouse conditions (D. Greytak, NDF, pers. comm. 2000). In the field, Ferreira (1987) speculated that reproduction from seed within a site was commonly observed and that recolonization after inundation for more than 2 years was most likely due to seeds.

A few demographic characteristics can be inferred from sporadic observations of natural and reintroduced populations. The stage structure at Baldwin Beach in 1997 was composed of many, small juvenile shoots (89) and many larger, reproductive shoots (74), with only one large, vegetative and no senile shoots (TBI-CTC 1997). This would suggest that there was a critical, minimal size that had to be obtained in order to allow flowering. Once a shoot reached that size, however, reproduction was readily completed. Unfortunately, seedlings were not included in the study and no definitions of the stage categories were presented. At the same time, the population at Upper Truckee East was almost entirely composed of juveniles (118) with only one reproductive shoot. Flooding was observed in this high lake level year, so reproduction (transition to another stage class) may have been inhibited or delayed.

Survivorship data are not available from natural populations, but some limited conclusions may be drawn from reintroductions conducted at six sites during the late 1980s and early 1990s (Appendix C; USFS 1987a, 1987b; Kundert 1990; Etra 1992, 1994; CSLC 1998; NNHP 2000). These were years of drought and low lake level, and selection of outplanting microsites was not apparently based on hydrological criteria. Propagated plants, mostly one year old prior to transplantation, were not irrigated at five of the sites (Meeks Bay, D.L. Bliss, Tallac Creek, Baldwin Beach, and Taylor Creek). Despite these conditions, first year survivorship (i.e. one year post-transplant) ranged between 33 and 93 percent (mean of 65.9 percent). This dropped to 24 percent in the second year and 13 percent in the third, demonstrating a decay curve typical of Deevey type III survivorship and found in many perennial plant species (Harper 1977). All populations had individuals that produced flowers and fruit and at least one demonstrated an increase in the number of stems after 8 years had elapsed (Taylor Creek). The reintroduced populations persisted at 2 sites for 11 years (D.L. Bliss and Taylor Creek), but it is not known if these plants were vegetatively derived from founders or if they came from a cohort of seeds produced *in situ* by the founders. We also do not know if there was differential survival of founders depending on their original hydro-topographic position on the beach. Such data, useful in subsequent reintroductions, would be obtained only if the outplanting program had a demographic monitoring component for determining factors that limit population growth and persistence (Pavlik 1994, 1996).

Habitat Features

Climate in the Lake Tahoe basin is largely determined by elevation, slope, exposure, and distance east from the Sierra crest. With respect to Tahoe yellow cress, elevation range is extremely narrow (6,222 to 6,230 ft; 1,896.47 to 1,898.90 m LTD), slope is 0, and exposure is 360°, so that the only macroclimatic determinant would be distance east from the crest. This is because of the pronounced precipitation gradient caused by the Sierran rainshadow. At Tahoe City along the west shore, mean annual precipitation is 32 in (80.6 cm) while at Glenbrook along the east shore it is 19 in (47.4 cm) (Thodal 1997). More than half of the precipitation falls as snow from January to March and less than 3 percent falls as rain in the summer (June to September). The precipitation gradient, combined with summer drought, provides an additional challenge to Tahoe yellow cress populations that lie to the east of the 129° W meridian (roughly east of a line drawn from Crystal Point to Tahoe Keys). Over the whole of the basin, temperatures during the summer are warm (59.9° F; 15.5° C mean, 64.9° F; 18.3° C mean maximum) and during the winter are cold (30° F; -1.1° C mean, 26° F; -3.3° C mean minimum). Between 70 and 120 days per year are frost-free, thus determining the length of the growing season (Thodal 1997; CSLC 1998).

No measurements of microclimatic conditions associated with Tahoe yellow cress have been made. Its decumbent growth form probably takes advantage of elevated sand surface temperatures in early spring, but may be subject to heat stress on sunny, mid-summer days. Light intensities and longwave radiation can be extreme in open, high elevation microsites, with large inputs from reflective or radiating surfaces (e.g. sand surface, sparse clouds). Heat loads absorbed by Tahoe yellow cress leaves (which are hairless and dark in color) would be accentuated by a lack of convective transport across the sand surface boundary layer during periods of little or no wind. Periods with wind, however, could increase evapotranspiration, water stress, and abrasion or burial by sand movement.

The beach sands associated with Tahoe yellow cress are composed of coarse to medium-sized grains of decomposing Sierran granite, occasionally mixed with fine grains of volcanic origin (CSLC 1998). Quartz and plagioclase feldspar usually account for 54 to 62 percent of the minerals present, but "local enrichment" can add unusually large (5 to 48 percent) fractions of mica, sphene, or volcanics (Osborne *et al*. 1985). There are two major natural sources for the sand: Fluvial deposit and cliff-backshore erosion. Fluvial deposition is thought to be the secondary process with respect to beaches at Lake Tahoe, with the Upper Truckee River supplying a maximum of 356 tons (323 metric tons) of coarse-grained sand per year. This is enough to build only 13 ft (4 m) of beach, 3.28 ft (1 m) deep, annually. Cliff-backshore erosion, however, is the most important process for creating sand and beaches (Osborne *et al*. 1985), mining recent lakebeds, ancient moraines, and fluvio-glacial outwash. Storm waves are particularly important in this regard, providing the energy for erosion, terrace cutting, and berm formation. Fluctuating lake levels change the elevations and locations of these activities, suspending and moving deposits from their point of origin. In general, the sands are not transported very far (less than 0.62 to 1.2 mi; 1 to 2 km along the shorezone) or very deep into the lake (less than 40 ft; 12 m). As a result, beach sands are highly "compartmentalized" around the perimeter of the lake, reflecting local sources, sorting, and depositional processes (Osborne *et al*. 1985).

Once deposited above the waterline, beach sands are modified by seasonal flooding and wind erosion. Flooding adds clay and silt from upland erosion, particularly near the mouths of major rivers (e.g. Truckee and Upper Truckee). In some places these fine components are a permanent part of the substrate for Tahoe yellow cress and probably increase water- and nutrient-holding capacity. In other places the fine components are blown away by wind erosion, leaving behind a surface armor layer of coarse grains and cobble. The armor is not chemically cemented, so unlike desert pavement, it remains permeable to rainfall. Prior to extensive surveys in the late 1990s, it was thought that Tahoe yellow cress was associated with, and perhaps dependent upon, this armor layer (CSLC 1994). The layer could retard evaporative moisture loss from below by limiting capillary rise, an effect that would primarily be important to germinules and seedlings. However, closer inspection of many more sites seemed to discount any definitive association (CSLC 2000), and demonstrated that Tahoe yellow cress could be found in a wide variety of lacustrine substrates. These include pure sands, sands mixed with silts and clays, sands mixed with gravels and boulders, and even organic materials such as litter and beach wrack.

Nevertheless, on the scale of the lake's entire perimeter, Tahoe yellow cress has a strong preference for sandy beach habitat. A quantitative 1990 survey indicated that nearly 60 percent of known Tahoe yellow cress occurrences were on substrates composed of greater than 75 percent sand, while only 16 percent were on substrates with less than 50 percent sand (CSLC 1998). The sands tended to be moderately to poorly sorted, indicating a predominance of mixing by wave action, rather than separation by wind erosion. Some of the largest and most persistent Tahoe yellow cress populations (e.g. Taylor Creek, Tallac Creek, and Upper

Truckee East) are associated with sand beaches near the mouths of streams. Such beaches are likely to be large (due to sediment availability), possess a mixture of grain sizes, have well-oxygenated, moisture-laden sediments, and remain in open, early successional stages due to disturbance by stream meandering. Other benefits to Tahoe yellow cress may accrue from natural barriers to human access created by the stream itself and elevated substrate nutrient levels (CSLC 1994).

The association of vigorous Tahoe yellow cress populations with stream mouths (its ancestral habitat) suggests a dependency upon mesic substrate conditions. A shallow water table with wet sands only a few inches below the surface has been postulated as optimal for supporting vigorous growth and flowering (Ferreira 1987). Undisturbed beach at Taylor and Tallac creeks had 2 percent soil moisture at depths of 3 to 6 in (8 to 15 cm) and up to 4 percent at 6 to 9 in (15 and 23 cm) (CSLC 1994). Churning by human foot traffic, however, reduced soil moisture at all depths by more than 50 percent. Alteration of local hydrology by stream channel relocation at Burke Creek apparently decreased the available soil moisture to natural and reintroduced plants at Kahle Beach, contributing to high mortality and invasion by nonnative species (Etra 1994). As previously mentioned, populations along the east shore of the lake would be particularly sensitive to decreased soil moisture availability, but intense human visitation and all stream channel projects (including restoration efforts) have the potential for impacting local Tahoe yellow cress populations in this way. Although prolonged inundation retards growth and flowering (Ferreira 1987; CSLC 1998), high lake levels can also raise beach water tables and stimulate stem growth on sites with available habitat (see Figure 12 and Table 12). The relationship between topographic position, lake level, and Tahoe yellow cress response would be best developed with a water relations study.

The ecological range of Tahoe yellow cress includes at least nine distinctive microhabitats, defined by their geomorphology, elevation, and environmental factors (Table 2). The lowest elevation microhabitat, called "low beach", is available only in years with very low lake levels (e.g. below 6,224 ft; 1,897.08 m LTD). It is gently sloping, composed of sediments and rocks that are usually submerged, and has a very shallow water table. It is rapidly colonized by Tahoe yellow cress and other opportunistic species. At about this same elevation range are sand bars, coarse-grained deposits built by winter wave action. Early in the year they are inundated, but later they provide optimal Tahoe yellow cress habitat as the water recedes. Berms are benches of sand near and parallel to the shoreline, formed by wave run-up, which protect shallow depressions on their inland side from wave impact. Many Tahoe yellow cress occurrences are associated with these protected depressions, including new individuals growing up from the deposited wrack (CSLC 1998). Rock shelters are shorelines dominated by boulders with sand, silt, and gravel deposits that support small enclaves of Tahoe yellow cress. Barrier beaches are formed near the mouths of flooding streams. Sediment loads and fluvial disturbance provide large amounts of open, sandy, and mesic beaches that often support vigorous and persistent Tahoe yellow cress populations. Although flooding and meandering prevent competitive, wetland species from dominating they also can displace or destroy a Tahoe yellow cress population in years with extreme run-off (CSLC 1998). The "high beach" microhabitat is usually beyond the reach of storm waves. It has little or no slope, little topographic variation, and deep sand with a wind-worked surface (sometimes armored). The water table is deep and Tahoe yellow cress populations do not thrive here. Back beach depressions, however, have a shallow water table that supports Tahoe yellow cress as well as other species. In the absence of disturbance, succession will displace Tahoe yellow cress from this habitat as wetland and riparian plants invade. The same is true for meadows, marshes, and wet banks associated with creeks and streams. Finally, wind-blown accumulations of sand, known as dunes, are usually located well above the lake in a few limited locations. As with high beaches, they have a deep water table, wind-eroded surface and provide poor habitat for Tahoe yellow cress.

Although there is no comprehensive vegetation classification system for the plant communities of the Lake Tahoe basin, it is convenient to recognize four assemblages that are associated with Tahoe yellow cress (Table 3). A "shallow water" community hovers just above and below lake level or in areas that are inundated or flooded early in the growing season. Typically it has low beach or sand bar microhabitats and is occupied by few species except when exposed for several years and subsequently invaded. Cover rarely exceeds 2 or 3 percent, but quantitative data are lacking. A few feet higher and extending to the adjacent forest edge is the "high beach" community, composed mostly of herbaceous perennials with sparse cover (less than 5 percent; Gross 2000). Both phacelia (*Phacelia hastata* ssp. *hastata*) (CSLC 1994) and Baltic rush (*Juncus balticus*) (Gross 2000) have been identified as good indicators of Tahoe yellow cress habitat. Sites with a high water table tend to support a "wetland beach" community, dominated by rhizomatous perennials or woody shrubs. Cover is generally higher (roughly 10 to 20 percent; Gross 2000) and succession may lead towards densely vegetated communities (marshes, meadows, riparian scrub) that are unsuitable for Tahoe yellow cress. Finally, many nonnative species can invade all of the above Tahoe yellow cress communities, depending on the degree of natural and anthropogenic disturbance. In some areas the vegetation is dominated by nonnative species, giving rise to a "disturbed" community type. Annual and biennial weeds, especially woolly mullein (*Verbascum thapsus*), may competitively displace Tahoe yellow cress and other natives on drier sites (Etra 1994; Gross 2000), although data are lacking.

Conservation Status

The limited geographic and ecological ranges of Tahoe yellow cress, combined with cursory observations of how the species is affected by lake level dynamics and human impact, led to conservation concerns in the 1970s. The Smithsonian Institution (1974) had determined the species was "threatened" in its comprehensive, pioneering list for the continental United States. Subsequent surveys by Michael Baad (Cal State Sacramento) on USFS lands and Margaret Williams, Lyn Wise, and Arnold Tiehm (Northern Nevada Native Plant Society) on Nevada State Park lands, provided the initial field assessments of occurrence, population size, construction impacts, and recreational pressures. The first local agency to formerly respond was the USFS (under mandate from Chapter 2670 of the Forest Service Manual of January

1980), hiring Charles Knapp to determine the species' status and distribution on public and private lands in the basin. Knapp (1979, 1980a, 1980b) compiled the available information, designed survey methods, conducted extensive field surveys, and summarized his findings. He noted the transient nature of the populations, developed criteria for recognizing Tahoe yellow cress habitat, stressed the importance of long-term monitoring and management, and even suggested actions to enhance and create populations. His work laid the foundation for all subsequent efforts to conserve the species and its habitat.

Jean Ferreira significantly added to our knowledge of Tahoe yellow cress by extending Knapp's surveys and conducting detailed autecological studies during the 1980s (Ferreira 1987). She visited all historic and extant occurrences and provided site-specific narratives that documented inundation, succession, and recreational impacts. Her database of site information and small-scale maps provided the framework for the current database and its summaries (e.g. CSLC 1994, 1998, 2000). She marked plants for measurements of growth and phenology, germinated seeds, and grew plants *ex situ.*

Western Botanical Services, who conducted the first Tahoe yellow cress reintroductions on USFS lands, implemented an equally important conservation effort. With the help of Ferreira, a total of 4,000 seeds were collected from the Upper Truckee East population in 1986 and propagated under greenhouse conditions. Historic localities were chosen based on Knapp's recommendation (Meeks Bay, Taylor Creek, Tallac Creek, and Baldwin Beach), with consideration given to affected components of the physical, biological, and human environment (USFS 1987a, 1987b).

In spring of 1987 and 1988, 2,500 individuals were transplanted to the field. Yearly monitoring was conducted in 1990 and 1991, allowing some determination of survivorship. A similar effort was conducted in 1989 where 1,168 plants were reintroduced to D.L. Bliss State Park by CDPR. These were among the earliest scientific reintroductions of rare plants in North America (Guerrant and Pavlik 1997), and they provided valuable insights for the program we propose in this CS.

Other biologists and agencies have hence contributed to the Tahoe yellow cress database, which may be the most extensive (temporally and spatially) for any rare plant on the planet. The biologists include Coleen Shade and Tricia York (TRPA), Maurya Falkner (CSLC), Janet Bair and Jody Sawasaki (USFWS), Rick Robinson and Beth Gross (CTC), Tatyana Sapozhnikova and other TBI participants, and Anthony Kundert, Sharon Reed, and Annie Barron (USFS). In addition, NNHP (Carson City, NV) and CNDDB (Sacramento, CA) have been instrumental in keeping the status and census data organized and available.

An assessment of the Lake Tahoe basin watershed (Murphy and Knopp 2000) used ecological and cultural criteria to identify Tahoe yellow cress as one of 14 vascular plant "focal species" for monitoring and research. Focal species will be used as indicators of ecosystem conditions for determining trends in the biological integrity of the Lake Tahoe basin (Manley *et al*. 2000).

Table 2. Microhabitat characteristics associated with Tahoe yellow cress. Elevation is relative to 6,225 ft lake level. LL = Low-low water; L = Low water; H = High water; HH = High-high water; ++ = High suitability; + = Suitable; 0 = Marginal; - = Low suitability

Microhabitat (example)	Elevation	Association	Limiting factor(s)	Suitability for Tahoe yellow cress
low beach	LL	low lake levels, inundation, wave action	lake level	++ (Tallac Cr)
bars	L	low lake levels, inundation, wave action	lake level	++ (Cascade)
berms	L	wave run-up, inundation	wave disturbance	+ (Up Truckee E)
rock shelters	L	deposits of silt, clay, litter, boulders	lake level, wave disturbance	0 (Elk Point)
barrier beaches	L	stream mouths, flooding	succession, fluvial erosion	++ (Taylor Creek)
high beach	H	wind erosion	aridity, water table depth	0 (Kings Beach)
back beach depressions	H	local high water	succession	+ (Kahle/Nevada)
meadows and marshes	H	flooding, clay & silt	succession	0 (Agate Beach)
dunes	HH	wind erosion	aridity	- (4-H)

Table 3. Plant community characteristics associated with Tahoe yellow cress. Elevation is relative to mean lake level (6,225 ft). Based upon data presented in CSLC (1998), TRPA (1999), and Gross (2000). * = nonnative taxon.
LL = Low-low water; L = Low water; H = High water

Community type	Elevation	Associated microhabitats	Typical species	
shallow water beach	LL to L	low beach, bars, berms, rock shelters	Tahoe yellow cress	*Rorippa subumbellata*
			Eurasian watermilfoil	*Myriophyllum spicatum**
high beach	L to H	berms, high beach, dunes	Tahoe yellow cress	*Rorippa subumbellata*
			Baltic rush	*Juncus balticus*
			arnica	*Arnica chamissonis*
			bent grass	*Agrostis scabra*
			aster	*Aster occidentalis*
			lupine	*Lupinus lepidus*
			yarrow	*Achillea millefolium*
			phacelia	*Phacelia hastata* var. *hastata*
			rabbitbrush	*Chrysothamnus viscidiflorus*
			peppergrass	*Lepidium virginicum* var. *pubescens*
wetland beach	L	barrier beach, back beach depressions, meadows	Tahoe yellow cress	*Rorippa subumbellata*
			Baltic rush	*Juncus balticus*
			bent grass	*Agrostis scabra*
			Nevada rush	*Juncus nevadensis*
			spike rush	*Eleocharis* sp.
			sedge	*Carex douglasii*
			narrow-leaf willow	*Salix exigua*
			monkeyflower	*Mimulus primuloides*
			mountain alder	*Alnus incana* var. *tenuifolia*
disturbed beach	L to H	high beach, dunes, back-beach depressions	Tahoe yellow cress	*Rorippa subumbellata*
			brome	*Bromus hordeaceus**
			woolly mullein	*Verbascum thapsus**
			spearmint	*Mentha spicata**
			sheep sorrel	*Rumex acetosella**
			curly dock	*R. crispus**
			Kentucky bluegrass	*Poa pratensis**

II.C. CONCEPTUAL MODEL OF METAPOPULATION DYNAMICS

Introduction to Metapopulation Dynamics

Tahoe yellow cress has been found at 51 sites around Lake Tahoe since it was described from Meeks Bay in 1941 (Appendix D). That population was surveyed again in September 2000 along the north end of the crescentic beach, near the same location it was originally found. We do not know how many plants were present when Rollins collected specimens for the herbarium at Stanford University, but we do know that the numbers have fluctuated greatly over the last 20 years (Appendix E). The most stems ever counted at the Meeks Bay site were 290 (1991) and the least was 4 (1988). In some years no stems were found (1982 to 1986), indicating that conditions were unfavorable for perennating rootstocks or seeds that remained present but dormant (disappearance) until they began to grow and emerge again (reappearance). Alternatively, the population may have been lost completely (extirpation), only to be reestablished in 1988 by migrating seeds or rootstocks (recolonization). Over the 1979 to 2000 survey period, Tahoe yellow cress has persisted at Meeks Bay 71 percent of the time, with a 6 year gap in the early 1980s and a 2 year gap in the early 1990s.

Other sites around the lake show similar gaps in occupancy by Tahoe yellow cress, with fluctuations in population size, disappearance/extirpation, and reappearance/recolonization (Figure 1). Sometimes the gap is short (perhaps 1 to 3 years) and sometimes it is long (6 to 11+ years). Short gaps are more likely due to disappearance/reappearance while long gaps more likely due to extirpation/recolonization. Although we often cannot know with certainty which of these mechanisms is responsible for any one gap, observations recorded over the years for many Tahoe yellow cress sites suggest the species exists as a collection of populations that come and go in space and time, linked by processes of vegetative growth, seed production, and propagule (rootstock and seed) migration.

Genetic exchange is also possible if mating occurs between newly arrived propagules and members of an existing population. The species as a whole could be comprised of these interacting populations, each with a unique past, present, future, and rate of change.

Thus, a "successful" species, such as Tahoe yellow cress, can persist over long periods of time because it possesses a population dynamic in which extirpation is countered by colonization. New, unoccupied sites can be colonized, old occupied sites can be recolonized or extirpated, and the timing and probabilities of these events could be influenced by many factors (Table 4). The probability of colonization or recolonization would be determined by attributes of the species (propagule longevity and mobility), of the site itself (location, physiography, microclimate, biological community) and the nature of the migration path (dispersal agents, tortuosity). Similarly, the probability of extirpation would be determined by plant attributes (e.g. propagule longevity *in situ*, plant survivorship and reproductive output, stress tolerance) and site attributes (e.g. disturbance regime, habitat abundance and quality). And obviously, the degree to which a species already occupies the suitable sites will also determine the balance

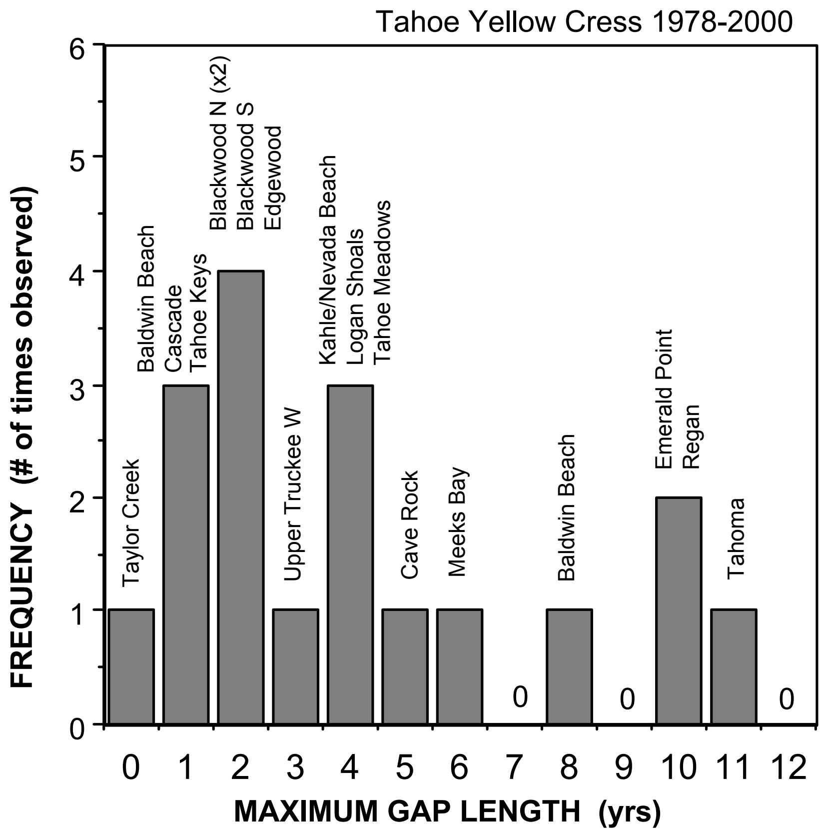


Figure 1. Frequency of maximum gap lengths (in years) derived from analysis of Tahoe yellow cress occurrence/absence data, 1978 to 2000 (Appendix D). Sites are shown above their recorded disappearance (< 6 years) and extirpation ($\geq$ 6 years) events.

between expiration and colonization: If all suitable sites are occupied, then no new colonization can occur.

This population dynamic is refered to as a "metapopulation dynamic." Hanski and Gilpin (1991) defined metapopulation as a "Set of local populations within some larger area, where typically migration from one local population to at least some other patches is possible." The elements of a metapopulation dynamic for Tahoe yellow cress can be summarized by the relationship:

$$dP/dt = CP(1-P) - E(P)$$

Where:

dP/dt the metapopulation dynamic (positive or negative change in occupied sites/unit of time)

P the proportion of occupied sites (i.e. actual habitat)
1 – P the proportion of unoccupied sites (i.e. potentially suitable habitat)
C colonization probability
E extirpation probability (Hanski and Simberloff 1997; Ricklefs 1997)

A positive dynamic (rate of population gain greater than 0) is determined by a high colonization probability, a low extirpation probability, and a medium-high proportion of unoccupied sites (i.e. an abundance of potentially suitable habitat).

Model simulations demonstrate that the magnitude of these values is such that a 9 to 1 ratio of occupied to unoccupied sites (i.e. actual to potentially suitable habitat) can never achieve a positive dynamic even if the C/E ratio is more than 6 to 1 (Figure 2). In other words, no matter how favorable the conditions for colonization, they cannot compensate for a lack of potential sites to colonize. A 1 to 1 ratio of sites requires a C/E probability ratio of at least 2.0 in order to achieve a positive dynamic. Allowing for more unoccupied than occupied sites (e.g. a 1 to 9 ratio) requires a C/E ratio greater than 1. The model allows us to realize that even a 1 to 1 ratio of actual and potentially suitable habitat sites would require a large improvement of colonization probability (or reduction in extirpation probability) that is probably impractical and unachievable. Instead, there must be some ratio of actual to potentially suitable habitat that is less than 1 to 1 in order to restore and maintain a positive metapopulation dynamic.

This model assumes that all sites that actually or potentially support populations of a species have the same probabilities of C and E. This may be true in some cases, but not all. Harrison and Hastings (1996) presented five types of metapopulations that varied depending on the relative size, longevity, and dispersal frequency of component populations (Figure 3). One of those, the “mainland-island” type, may best describe what is observed in Tahoe yellow cress. Certain populations are large and stable, with low probabilities of extirpation and high potential for creating emigrant propagules. These would be considered “mainland” populations occurring at core sites that are the stronghold of the species. Other populations are small and transient, with high probability of extirpation and colonization (depending on location) and low probability of creating emigrant propagules. These would be considered “island” populations occurring at satellite sites with suboptimal characteristics that undermine abundance and persistence. The characteristics of core and satellite sites are not fixed; what is suboptimal now may become optimal in the course of natural environmental variability or with relief from anthropogenic disturbance.

In general, metapopulation dynamics are usually associated with particular kinds of organisms. Such organisms may be short-lived, highly mobile, early seral, habitat specialists whose patterns of distribution and abundance directly reflect spatial patchiness and temporal stochasticity. Some of the best-known examples are found in butterflies (Murphy *et al*. 1990), birds (Verboom *et al*. 1991), and arboreal marsupials (Lindenmayer and Lacy 1995). Among plants, the furbish lousewort (*Pedicularis furbishae*) may be the best-documented case (Menges *et al*. 1986; Menges 1990). This herbaceous perennial colonizes open gravel bars exposed by flooding and channel erosion in the St. John's River (Maine and Canada). Seeds are short-lived (less than 2 years) and dispersed by running water. They germinate and establish among coarse-grained fluvial sediments exposed after high runoff. Depending on the habitat quality of a particular site, a population will have a variable extirpation probability. Sites with little canopy cover by woody vegetation tend to have more persistent populations than sites where succession produces deep shade and root competition. In many ways, furbish lousewort provides a good model for Tahoe yellow cress: Populations are connected by water bodies, they come and go depending on disturbance, they depend on open environments with little or no soil development, and human modification of the habitat threaten the species by limiting the type, frequency, and effects of natural disturbance cycles.

Table 4. Factors that determine colonization probability (C), extirpation probability (E), the proportion of sites occupied (P) and unoccupied (1-P) in Tahoe yellow cress.

C - COLONIZATION PROBABILITY

plant attributes
- seed longevity *in transit*
- rootstock longevity
- propagule mobility
  - buoyancy
  - surface/volume/size

unoccupied site attributes
- distance/direction from source
- beach topography/exposure
- sand type/quality/dynamics
- microclimate/microhydrology
- competitors/predators/diseases

path environment
- wind direction/strength
- current direction/strength
- migration direction/frequency
- tortuosity/connectivity
- predation/disease

P - PROPORTION OF SITES OCCUPIED
- number of occupied sites
- total number of sites
  - occupied
  - unoccupied (potential)

(1- P) - PROPORTION OF SITES UNOCCUPIED
- total number of sites
  - unoccupied (potential)

E - EXTIRPATION PROBABILITY

plant attributes
- seed longevity *in situ*
- root stock longevity *in situ*
- germination response
- survivorship
- opportunistic behavior
  - precocity
  - aseasonal reproduction
- high reproductive output
  - seeds
  - rootstocks
- stress tolerance
- drought
- inundation
- disease resistance
- resprout ability

occupied site attributes
- degree/type of disturbance
  - wind/wave
  - predators/grazers
  - human activity
  - area/distribution/quality
- elevation/lake level
- microclimate/microhydrology

Another good example of metapopulation dynamics in plants is Pitcher's thistle (*Cirsium pitcheri*), a species endemic to the dunes of the western Great Lakes (Bowles *et al*. 1993; McEachern *et al*. 1994). It is an invader of open beach, dune, and interdune troughs that are disturbed by lake level fluctuations, wind, and human activity. Most populations are found in habitat patches with more than 70 percent open sand and moderate amounts of sand movement. Such patches persist for several decades, until succession (in the absence of further disturbance) leads to local extirpation of the thistle. Unlike Tahoe yellow cress, this species is monocarpic (flowers only once during the life of an individual), requires 5 to 8 years before reproduction, and does not spread by rootstocks or rhizomes. Persistence of local populations depends on high phenotypic plasticity (the ability to adjust growth form, reproductive output, and physiology to local conditions), tolerance of sand deposition, and stage-structured populations that buffer against losses from widespread environmental stresses (e.g. drought, outbreaks of seed-feeding insects).

Table 5. Factors that determine C, E, P, and 1-P that are readily manipulated by experiment or management actions.

C - COLONIZATION PROBABILITY

plant attributes
- seed longevity *in transit*
- rootstock longevity
- propagule mobility

unoccupied site attributes
- distance/direction from source
- microclimate/microhydrology
- competitors

path environment
- tortuosity/connectivity
- predation/disease

P - PROPORTION OF SITES OCCUPIED
- number of occupied sites
- total number of sites
  - occupied
  - unoccupied (potential)

(1- P) - PROPORTION OF SITES UNOCCUPIED
- total number of sites
  - unoccupied (potential)

E - EXTIRPATION PROBABILITY

plant attributes
- survivorship
- high reproductive output
  - seeds
  - rootstocks

occupied site attributes
- degree/type of disturbance
  - wind/wave
  - predators/grazers
  - human activity
  - area/distribution/quality
  - elevation/lake level
- microhydrology

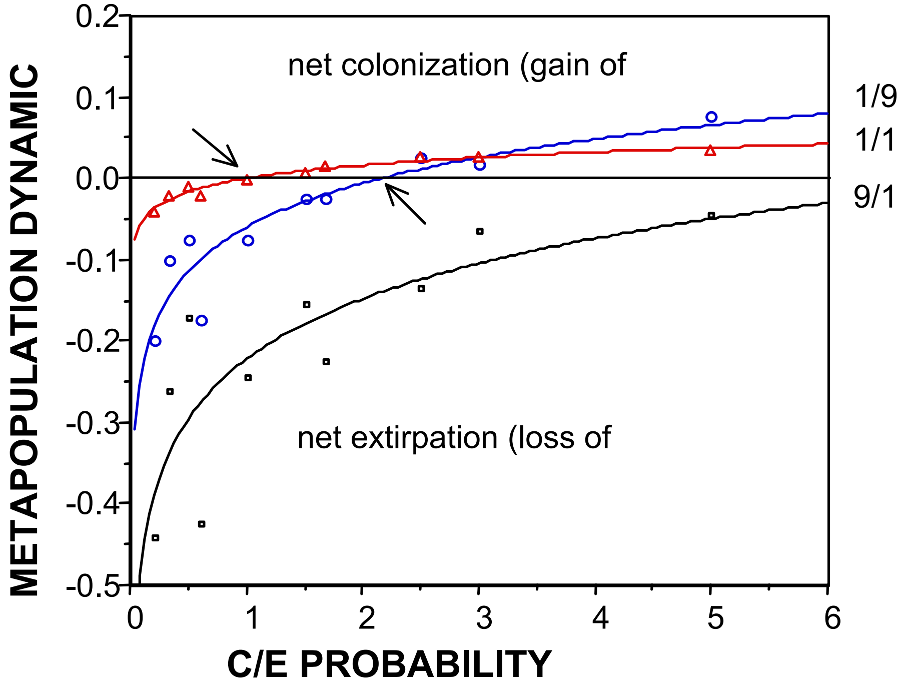


Figure 2. Effect of colonization and extirpation probabilities (expressed as a ratio) and the relative proportion of occupied to unoccupied sites (1:9, 1:1, 9:1) on the calculated metapopulation dynamic. A negative dP/dt indicates net loss of populations, a positive value indicates net gain. Arrows show the no net change points for the 1:9 and 1:1 ratios.

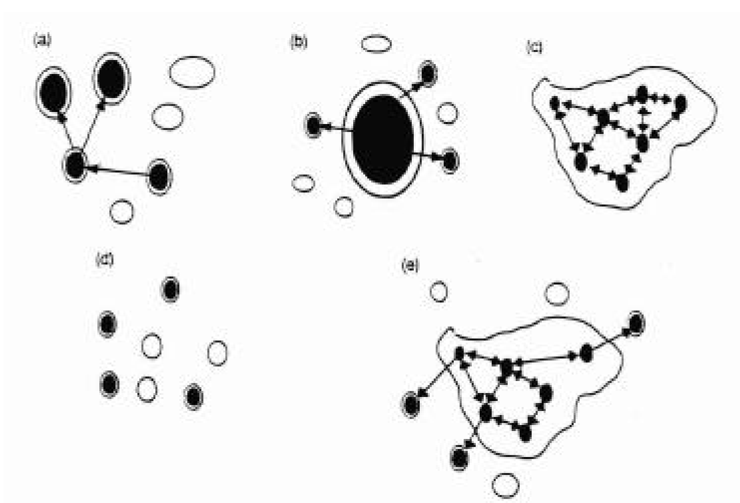


Figure 3. Alternative forms of metapopulation structures: a) Classical, with each population having a similar probability of persistence; b) mainland-island, with a persistent "core population" and more transient satellites; c) patchy, populations interconnected by frequent dispersal events that make extirpations unlikely; d) non-equilibrium, with populations linked by infrequent dispersal so that all have a high probability of extirpation; and e) complex, combining the features of a through d. Filled circles = occupied habitat, unfilled = vacant (potential) habitat, arrows = dispersal (the thicker the more frequent), outer line = boundaries of population or species. Adapted from Harrison and Hastings (1996).

Evidence for Metapopulation Dynamics in Tahoe Yellow Cress

Several indirect lines of evidence support the hypothesis that Tahoe yellow cress exists as a complex of metapopulations. First, local extirpation and colonization have been observed over the 22-year history of Tahoe yellow cress monitoring along the shores of Lake Tahoe. If we analyze the occurrence and absence record (Appendix D) and the site narratives (CSLC 1998, 2000) we can establish with confidence there were 24 documented extirpations (absence gap greater than 6 years), with 4 events appearing to be very long-term (gap greater than 15 years, Table 6). This would give an estimate of E = 0.027/yr (24 extirpations/40 sites with a high quality record/22 years). In some cases the cause of extirpation was clearly known (e.g. bank construction at El Dorado Beach in 1979), in other cases it was not (e.g. Agate Bay and D.L. Bliss). Colonization of new sites (often close to known occurrences) has also been observed, but much less frequently. In fact, none of the most recent field biologists to work with Tahoe yellow cress have witnessed the establishment of a new colony (J. Etra, Western Botanical Services, pers. comm. 2000; M. Falkner, pers. comm. 2001; J. Sawasaki, USFWS, pers. comm. 2001). Recolonization of formerly occupied sites can be inferred from analysis of the gap record if we assume that reappearance from rootstocks is unlikely after 5 or 6 years of inundation and continuous absence. The data record and available narratives provide evidence for 4 colonization events and 4 recolonization events (Table 7) over the 22-year period and, therefore, an estimate of C = 0.0091/yr. This allows a rough estimate for the C/E ratio of 0.34, indicating that extirpation has been about three times as common as colonization and recolonization over the monitoring period.

The second line of evidence for metapopulation dynamics is that seedlings of Tahoe yellow cress are often observed in the "bathtub" ring of organic matter that is deposited on berms, in beach depressions, and on foredune areas by rising lake levels, tides, wind, and storm waves (Ferreira 1988; CSLC 1998; M. Falkner, pers. comm. 2000). They are most abundant in late spring and early summer, after the ebb of winter storms and freezing daytime temperatures. It remains unclear if the new plants are the product of seed or rootstock dispersal, the former subsequently germinating and the latter simply sprouting and growing vegetatively. The source and sink relationships among the populations are also unknown, so there is no way of knowing how far or how long the propagules can travel.

Finally, the apparent lack of genetic variation among surveyed Tahoe yellow cress populations is consistent with the idea of migratory exchange of alleles in a highly mobile, outbreeding species. This was also found to be the case in other plants possessing metapopulation dynamics, including furbish lousewort (Waller *et al*. 1988) and Pitcher's thistle (Loveless and Hamrick 1988). Widely separated populations tend to be the most dissimilar, reinforcing the notion that local, rather than long-distance dispersal, governs the composition and dynamics of these gene pools. Harrison and Hastings (1996) point out that most natural metapopulation systems with high rates of turnover (extirpation-recolonization-colonization) have low genetic differentiation of subpopulations because they have high rates of dispersal and gene flow. They specifically reviewed the genetic consequences of possessing a mainland-island type of metapopulation dynamic and concluded that the potential for

Table 6. Documented extirpation events for Tahoe yellow cress and their likely causes. Only high quality site records are included, those with less than 12 percent NS years with contiguous survey record (years, in parentheses). Gap length in years. * = contiguous record is short and confined to either the 1979 to 1990 or 1990 to 2000 period.

Site (record yrs)	Last seen - gap	Attributed to	References
Long-term Extirpations (> 15 years)			
Agate Bay (12)	1950s ? - 50	inundation (6,229 ft) + rec	CSLC 1998
D.L. Bliss (16)	1963 ? - 37	recreation + raking	Stuckey 1972; Ferreira 1987
El Dorado (16)	1979 - 21	bank stabilization	CSLC 1998
Sand Harbor (12)	1979 - 21	recreation	Ferreira 1987; CSLC 1998
Short-term Extirpations (6-15 years)			
Sunnyside (12)	1993 - 7	unknown	
Ward Creek (15)	1994 -6	inundation (6,227 ft)	
Cherry Street* (9)	1994 - 6	inundation (6,227 ft)	
McKinney Creek* (9)	1994 - 6	inundation (6,227 ft)	
Tahoma (16)	1982 - 11	inundation (6,228 ft)	Ferreira 1987
	1994 - 6	inundation (6,227 ft)	
Emerald Point (16)	1994 - 6	inundation (6,227 ft)	infer from Ferreira 1987
Eagle Point* (9)	1994 - 6	inundation (6,227 ft)	
Baldwin Beach (18)	1981 - 8	inundation (6,228 ft)	Ferreira 1987
Pope/Kiva (16)	1994 - 6	inundation + shading	CSLC 1998
Regan/Al Tahoe (16)	1979 - 10	inundation (6,226 ft)	Ferreira 1987
	1994 - 6	inundation (6,227 ft)	infer from Ferreira 1987
Timbercove (15)	1990 - 10	altered hydrology	CSLC 1998
4-H (16)	1993 - 7	altered hydrology	CSLC 1998
Zephyr Cove* (12)	1994 - 6	inundation (6,227 ft)	
Skunk Harbor* (9)	1990 - 10	unknown	
Secret Harbor* (10)	1990 - 10	unknown	
Crystal Point W* (7)	1994 - 6	inundation (6,227 ft)	
Kings Beach* (9)	1991 - 9	unknown	
Dollar Point* (8)	1994 - 6	inundation (6,227 ft)	

divergence of island populations only exists if mainland populations are initially variable. This would allow variant founders to determine the characteristics of local gene pools, especially if accompanied by changing ecological conditions. Otherwise, random emigration of propagules from genetically fixed, homogeneous mainland populations would simply lead to similar satellites. This may be the case with Tahoe yellow cress: Mainland populations experience episodic bottlenecks as high lake levels return, removing or reducing any accumulated genetic variation. Satellite populations thus reflect the depauperate nature of their mainland sources.

Table 7. Documented colonization, recolonization, and reappearance events for Tahoe yellow cress. Only high quality site records are included, those with less than 12 percent NS years with contiguous survey record (years, in parentheses). Gap length in years. * = contiguous record is short and confined to either the 1979 to 1990 or 1990 to 2000 period.

Site (record yrs)	First seen	Population attributes	References
Colonizations of New Sites			
McKinney* Creek (9)	1989	19 stems (1990), gone 1994	NNHP 2001 (eo 928)
Cascade Creek (13)	1990	170 stems (1990)	NNHP 2001 (eo 930)
Baldwin Beach (18)	1990	1 stem (1990)	CSLC 1998
Tahoe Meadows (13)	1998		CSLC 2000
Recolonizations of Formerly Occupied Sites			
Tahoma (16)	1994	p. 1979-81, gone 1982-93	Ferreira 1987; CSLC 1998
Emerald Point (16)	1990	p. 1979, gone 1980-89	CSLC 1998
Baldwin Beach (18)	1990	p. 1980-81, gone 1982-89	CSLC 1998
Regan/Al Tahoe (16)	1990	p. 1979, gone 1980-1989	CSLC 1998
Reappearance after Inundation			
Meeks Bay (17)	1986?	inundated 1982, p. 1988	CSLC 1998
Taylor Creek (18)	1988?	inundated 1982, p. 1988	CSLC 1998
Logan Shoals* (13)	1984?	inundated 1982, p. 1986	Ferreira 1987

Direct observation of dispersal and colonization processes would be an additional line of evidence that could support the application of a metapopulation model to Tahoe yellow cress. Simple observational experiments could determine: 1) How far and how long Tahoe yellow cress propagules can disperse; 2) predominant directions for dispersal from different points around the lake; and 3) the composition of beach wrack at different locations and times of the year.

Relation of Metapopulation Model to Recovery

How can a metapopulation model be applied to the recovery of Tahoe yellow cress? Not enough monitoring data are available to actually simulate changes in the species over the last 20 years. Records of which sites were occupied exist, but no scientific inventory of unoccupied sites with appropriate habitat has been conducted. Extirpation probabilities can only be estimated if we arbitrarily assume that occupancy gaps greater than 5 years cannot be reinvaded from dormant rootstocks already present in the sand (i.e. they are unlikely to be the result of disappearance and reappearance). The estimated colonization probability suffers from the bias than many hundreds of potentially suitable habitat sites were not surveyed during the monitoring period. The strict application of this equation is not possible without robust, independent estimates of values for all four of its variables. Nevertheless, the expression can be used to help us understand: 1) The relative magnitude of estimated C and E values indicates that recovery activities must increase C relative to E by a factor of five or more; 2) both actual and potentially suitable habitat must be conserved for a species with metapopulation dynamics; 3) the existing ratio of actual to potentially suitable habitat sites is much less than 1 to 1 and closer to 1 to 9; 4) the cryptic processes of dispersal and genetic exchange must be restored or maintained; and 5) we can organize and prioritize our thinking about the recovery process and to identify critical attributes and processes for restoration. Recovery actions must, therefore, increase colonization probability, decrease extinction probability, and maintain occupied and unoccupied sites in sufficient number and distribution as to allow crucial exchange processes that favor overall persistence. In essence, the goal of the recovery process is to promote conditions that reestablish a positive metapopulation dynamic in Tahoe yellow cress so that the species will maintain itself into the indefinite future.

Recovery of the Metapopulation Dynamic

A large number of biological and physical factors influence the metapopulation dynamic of Tahoe yellow cress (Table 4). Persistence of single populations depends on plant vigor, the number and distribution of individuals, habitat quality, disturbance, beach topography, and lake level. These and other factors all determine the probability of extirpation at a given site, but only some may be manipulated for purposes of recovery (Table 5). This subset of manageable and measurable factors constitutes the universe from which recovery actions must be drawn.

In their work with Pitcher's thistle, McEachern *et al*. (1994) emphasized that recovery and restoration must be approached at both the local and landscape levels. Manipulation of manageable and measurable factors within single populations (local level) was designed to increase population size and growth rate, while dampening between-year variances in demographic characteristics. These included outplanting seeds, watering and fertilizing established adults, treating inflorescences with insecticides, fencing to exclude grazers, and constructing a trail system to guide recreational visitors away from Pitcher's thistle locations. Manipulations involving multiple populations (landscape level) were designed to ensure that pollen and seed dispersal between habitat patches were not impaired. These included transporting and outplanting seeds from genetically dissimilar populations to remnant plants left isolated by development and recreational use. Land acquisition and subsequent restoration were also recommended to reestablish habitat linkages across a highly fragmented, heavily used landscape. They made it clear, however, that all such manipulations should be installed as experiments and monitored to evaluate their impacts, relative costs, and efficiencies.

Recovery of Tahoe yellow cress will depend on restoration of its metapopulation dynamics at local and landscape levels. Such a program must increase the number and size of Tahoe yellow cress occurrences and work towards reestablishing the vital processes of dispersal, genetic exchange, population growth, and colonization. Our knowledge of the species and its habitat is incomplete, as is our ability to restore and manage natural ecosystems. Therefore, the program for Tahoe yellow cress must be designed as a series of management-oriented experiments that provide essential information and techniques that lead directly to species recovery and ecosystem enhancement (Pavlik 1996). An ongoing monitoring program is required to evaluate those experiments (Pavlik 1994) and to detect the impacts of restoration efforts on metapopulation dynamics.

II.D. ANALYSIS OF EXISTING DATA

Patterns of Persistence and Presence

The 22-year occurrence and absence monitoring data (Appendix D) provides a foundation for understanding the dynamics of Tahoe yellow cress populations on a landscape level. A large number of sites were included (range of 2 (1978) to 43 (1994)), with some having as many as 19 years on record during the 1978 to 2000 period. Documentation for many of the historic locations is extensive (e.g. Baad 1978, 1979; Knapp 1979, 1980; Reed 1982; Ferreira 1987, 1988; CSLC 1998; Appendix D), and includes a plethora of observations and measurements that have not yet been fully explored. Herein we focus on what the available record can tell us about metapopulation dynamics and factors affecting population persistence, and the implications of those dynamics and factors for Tahoe yellow cress conservation.

Although the occurrence/absence data have been collected by many different individuals, each with their own perspective and level of training, there are relatively few complications that would undermine the analysis performed. This is because occurrence/absence data, unlike population size estimates, demographic studies, modeling exercises, and microspatial analysis, simply require an ability to recognize the species and to accurately record its occurrence or absence after a competent survey has been conducted. Knapp set the standards for those surveys early on, specifying which sites, how they were to be searched, demographics (e.g. phenological state), site characteristics (e.g. lake level, beach morphology), and ancillary data (property ownership) to be collected (Knapp 1979, 1980). Subsequent efforts (Ferreira 1987; staff from CSLC, TRPA, and TBI-CTC) have built upon Knapp's framework, making some attempt to promote consistent methodologies (CSLC 1998). Despite missed survey years, incomplete surveys, and inevitable deviations from protocol, the site records can be evaluated and ranked for quality and successfully linked to other parameters using correlative analyses (see Appendix G for methods).

This analysis will draw a distinction between persistence and presence (Appendix G). Persistence is defined as the ability of a Tahoe yellow cress population to maintain itself through time at a given site. It is calculated by determining the number of years observed at a given location ("X" marks) and dividing by the number of record years (sum of "X" and "0" marks) for that site (e.g. at Sunnyside this is 1/12 or 8.3 percent, Appendix D). Therefore, persistence measures temporal variation in occurrence. Presence is defined as the ability of Tahoe yellow cress populations to occupy multiple sites in a given year. It is calculated by determining the number of sites where the species was observed in a given year ("sum X" in Appendix D) and dividing by the number of sites surveyed ("sum X+0") in that particular year (e.g. in 1979 it was 72 percent for the non-miscellaneous records). Therefore, presence measures spatial variation in occurrence and is synonymous with geographical frequency.

The occurrence and absence data provide evidence for temporal and spatial gaps that suggest the occurrence of fundamental metapopulation events (e.g. local extirpation, colonization, and recolonization), especially when coupled to anecdotal observations contained in the narrative record (e.g. Ferreira 1988; CSLC 1998). Temporal gaps at a single site are present as a series of "0s" in the table (Appendix D), preferably bracketed by "Xs". Gaps are thus confirmed absences from a particular location, and can vary from 0 to 11 years in length. A frequency diagram for maximum gap lengths (assuming continued absence in missed survey years (e.g. 1984 and 1985), but not "not surveyed" (NS) years) is weakly bimodal, with a large peak around 2 years and a small peak around 10 years (Figure 1). The median value falls between 2 and 3 years, with no gap years (0) and 11-year gaps being equally unusual.

What do these temporal gaps represent? In some cases Tahoe yellow cress can be apparently absent from a site because of inundation by the lake. This has been documented at Meeks Bay, when a population was covered by rising waters in 1982 and remained submerged for at least 4 years (Table 7). It reappeared in exactly the same location after waters receded. Similar observations have been made at Taylor Creek and Logan Shoals over shorter periods of time (CSLC 1998). Given that the inundated sands are waterlogged and anoxic, and that there does not appear to be specialized, oxygen-transporting tissues in Tahoe yellow cress rootstocks, tolerance to flooding in this species must be metabolically based and relatively limited in its potential duration. However, the ability of Tahoe yellow cress rootstocks to endure some adverse conditions means that short-term gaps cannot be regarded as extirpations: Rather, they are most likely "disappearance/reappearance events" with respect to the above-ground habitat of a site. Long-term gaps are more likely to represent authentic extirpation and recolonization events as part of a metapopulation dynamic. Although a robust distinction is difficult, if not impossible to make, we have no evidence to suggest that a disappearance/reappearance gap has exceeded 6 years. Extirpation/recolonization gaps are, therefore, those that equal or exceed 6 years.

Have extirpation and subsequent recolonization been witnessed and documented for Tahoe yellow cress? Ferreira (1987) describes attempts to relocate the species at its type locality in Meeks Bay. She notes that Stuckey could not find any plants during his 1963 survey, nor could Baad in 1978. Knapp, however, found a small colony there in 1979 that grew each year to 91 plants before being inundated in 1982. Although we cannot be sure whether or not plants existed at Meeks Bay between 1964 and 1977, the 1979 event had features of a recolonization event (Knapp 1979). Recolonization took place again in 1988 after a 6 or 7-year absence. Similar observations have been made at Tahoma, where Tahoe yellow cress was confirmed absent by censuses conducted between 1982 and 1993 (Appendix D). The 11-year period began with true, inundation-caused extirpation (Ferreira 1987) because lake recession during the 7 drought years of 1987 to 1993 was not accompanied by a reappearance. Not until 1993 did a survey find a small colony that only persisted for 2 years. This kind of authentic extirpation-recolonization gap has also been documented at Regan/Al Tahoe, Emerald Point, and Baldwin Beach (Table 7).

Extirpation without recolonization is more readily observed. As previously referred to in this report, the analysis of the occurrence and absence data reveals a total of 25 extirpation events over the 22-year history of monitoring (Table 6). Long-term extirpations (15 or more consecutive years absent) are few in number but appear to be permanent because none have ever been naturally recolonized. The Agate Bay population has been gone almost 50 years. Short-term extirpations (6 to 15 consecutive years absent) are more common and mostly a feature of the mid-to-late 1990s. Some of the extirpations have been attributed to direct impacts from construction, recreation, beach raking, and the alteration of site hydrology. In at least one case, shading by native willows may be a contributing factor. The great majority of extirpations, however, have been linked to inundation during periods of high lake levels (mostly equal to or exceeding 6,227 ft; 1,897.98 m LTD). In some cases, field researchers actually observed plants and/or habitat being submerged, in other cases the extirpation was only correlated with high lake levels with no record of reappearance. It is possible that lake recession after 2000 might demonstrate that some of these apparent extirpations are only temporary, and Tahoe yellow cress rootstocks are capable of producing new shoots after 6 years of inundation.

Colonization of new locations is a particularly rare event because it is difficult to observe. It is unknown *a priori* which unoccupied sites could produce plants in any given year. Ideally, all suitable habitat would be systematically surveyed in any given year, whether plants were present in the past or not. With a perimeter as long and inaccessible as that of Lake Tahoe, this approach is very impractical. Therefore, detection of colonization is simply by chance, perhaps improved by the availability of suitable habitat or proximity to other known locations. There must also be some previous survey records available that establish the absence of the plant for some length of time prior to "discovery". This would, of course, increase confidence in the conclusion but it does not guarantee a clear distinction between colonization and recolonization.

Consequently, the occurrence and absence data (Appendix D), combined with narrative records (Etra 1986; Ferreira 1987; CSLC 1998, 2000; NNHP 2001) provide evidence for only 4 colonizations over the 22-year monitoring period, three of which were associated (by 1 year or less) with lake levels at or below 6,224 ft (1,897.08 m) LTD. At Baldwin Beach, a single plant was found behind a public restroom, too far away from the known population to have been the result of rootstock growth (CSLC 1998). This was a clear case of dispersal by seed, although humans may have been the agent. At Cascade a large number of stems (170) were observed in 1990 on a low sand bar only 1 foot above lake level after having been surveyed without success in 1979, 1981, 1983, and 1986. A new population at McKinney Creek was found in 1989. There were 19 stems counted during the 1990 survey, but these had disappeared by 1994. Tahoe yellow cress was not known from here in 1979 or 1981, and has not returned in recent years. Finally, a new, high water population was observed during a 1998 lakewide survey along the southeast stretch of beach at Tahoe Meadows (CSLC 2000). Other records may also represent colonizations (e.g. Kaspian Camp 1991 to 1992, Valhalla Beach 1991 to 1992, Roundhill 1991 to 1993, and Chimney Rock 1991 to 1992), but sufficient data are lacking.

There were also a few populations whose extirpation has never been witnessed (Appendix D). Upper Truckee East and Taylor Creek have not experienced a gap of any length, so within the limits of the occurrence/absence data set, they have a persistence (Pr) of 100 percent (14 and 16 year records, respectively). Blackwood South and Edgewood have 88 percent persistence with 16-year records each. Perhaps all four represent "mainland" populations occupying "core" sites in a "mainland-island" type of metapopulation dynamic (Harrison and Hastings 1996). On the other extreme are island populations at satellite sites, such as Tahoma (Pr = 31%, 16 year record) and Skunk Harbor (Pr = 11%, 9 year record). These two satellite sites are known for habitat that is available only in low lake level years (e.g. 1990), while the mainland sites have back beaches, back beach depressions, and/or sand at a variety of elevations that provide refuge in high water years (see Table 12; site narratives in Ferreira 1987 and CSLC 1998). It may also be important that most mainland sites are associated with gently sloping basin margins along the south shore (50 or less, Gardner *et al*. 2000). These margins are extensive (up to 2.2 mi; 3.5 km wide), sediment-laden, and away from the landslide/tsunami-prone fault zones (with the exception of Blackwood Creek) that could have provided ample, sandy, and stable habitat in the distant past.

How can the patterns of persistence among Tahoe yellow cress sites be summarized and what do they tell us about long-term trends? Although a true trend analysis for Tahoe yellow cress should be based on rigorous statistical inference from population size and structure data (Pavlik 1994), we can classify patterns across the 22-year monitoring period into 8 basic types within 3 persistence categories (Figure 4). The first category, continuous (over the 1978 to 2000 period), includes populations with gaps of 0 to 4 years. As previously discussed, such gaps probably represent above-ground disappearance due to temporary, poor conditions and subsequent reappearance after perennating rootstocks were able to produce more shoots. Within this category are three general trends: 1) Persistent (present during the beginning, middle, and end of the record period); 2) decreasing (present at the beginning but not the end); and 3) increasing (present at the end but not the beginning). At least nine Tahoe yellow cress sites exhibit the continuous-persistent type of trend while another four have the continuous-decreasing trend. No sites were classified as continuous-increasing, perhaps because recent lake levels have been relatively high and low elevation habitat has been unavailable for Tahoe yellow cress colonization.

The second category, intermittent, includes populations with 4 to 6 year gaps that probably represent true extirpation-recolonization events. Four sites were intermediate-persistent (perhaps due to high recolonization rates) while 15 were intermediate-decreasing. No sites in this category had a trend towards increasing persistence.

Finally, the ephemeral category includes populations with gaps greater than 6 years that certainly represent true extirpations. The observed recolonization at D.L. Bliss State Park was due to a newly founded population from reintroduction efforts. Otherwise, most of these ephemeral satellite sites remained devoid of Tahoe yellow cress as the result of long-term extirpation and a lack of recolonization. Overall, 13 populations demonstrated a persistent trend, 19 a decreasing trend, 0 an increasing trend, and 8 a long-term extirpation trend. For the species as a whole, more than twice as many sites have populations with negative trends toward decreasing persistence or extirpation (19+8) as compared to sites with positive trends toward increasing persistence (9+4).

This analysis of persistence trends is strongly influenced by the fact that lake levels have equaled or exceeded 6,227 ft (1,897.99 m) LTD during the past 6 years (1995 to 2000). Low water populations have been inundated and disappeared (but not necessarily extirpated), resulting in the aforementioned prevalence of negative trends. However, presence in this species appears to be cyclical (Figures 5 and 6), with positive trends associated with climatic drought and subsequent low lake levels (e.g. 1978 to 1979 and 1988 to 1994), regardless of who owns or manages the property (i.e. USFS, State and County governments, or private entities). Variation in presence is also cyclical, with smaller standard errors associated with low lake years and larger errors with high lake years (means are for sites grouped by ownership). Consequently, there is a very strong relationship ($r^2 = 0.75$, $P < 0.001$, Figure 7) between lake level (mean annual, data from U.S. Geological Survey 2000) and Tahoe yellow cress presence (yearly mean for 31 sites, $n = 16$ record years). Mean lake elevations above 6,226 ft (1,897.68 m) LTD reduce Tahoe yellow cress presence below 60 percent, the lowest values in the range of 21 to 31 percent. The greater scatter of points at highest lake levels is probably due to variations in site topography and beach morphology (i.e. sites with high water habitat retain their Tahoe yellow cress populations even during periods of rising lake levels).

Although Tahoe yellow cress presence appears to be cyclical and mostly related to lake level fluctuations, there may be small variations due to property ownership and management. During the 1980s, sites managed by the USFS had much lower presence than did sites managed by State and County governments and private entities (Figure 6). This observation was reversed during the mid-late 1990s, perhaps because of greater efforts to construct enclosures and take proactive conservation measures by the USFS in the late 1980s (the presence record does not include reintroduced populations). State and County-managed sites fared the worst, with Tahoe yellow cress disappearing completely from all eight properties during 1994 and 1995 (the reintroduced population at D.L. Bliss State Park has been excluded from the analysis). The populations on these sites appeared to be more sensitive to lake level fluctuations (Figure 8), but the underlying reasons may not solely be a function of management (e.g. beach topography and morphology).

Tahoe yellow cress sites differ greatly in their level of recreational visitation. Data are not available for privately owned sites, but presumably the levels would be lower than on public sites. Visitation at 5 Nevada State Parks ranges between 750,000 and 1,000,000 visitors per year (1989 to 2000), with similar levels at California State Parks and USFS lands in the Lake Tahoe basin. Activities that encourage foot traffic along heavily visited beaches have the most impact on Tahoe yellow cress, and there are many observations to this effect in the available literature (Knapp 1980; Reed 1982; Ferreira 1987; CSLC 1998, 2000; TRPA 1999; NNHP 2001). Even as early as 1963, when visitation was much lower than today, Stuckey (1972)

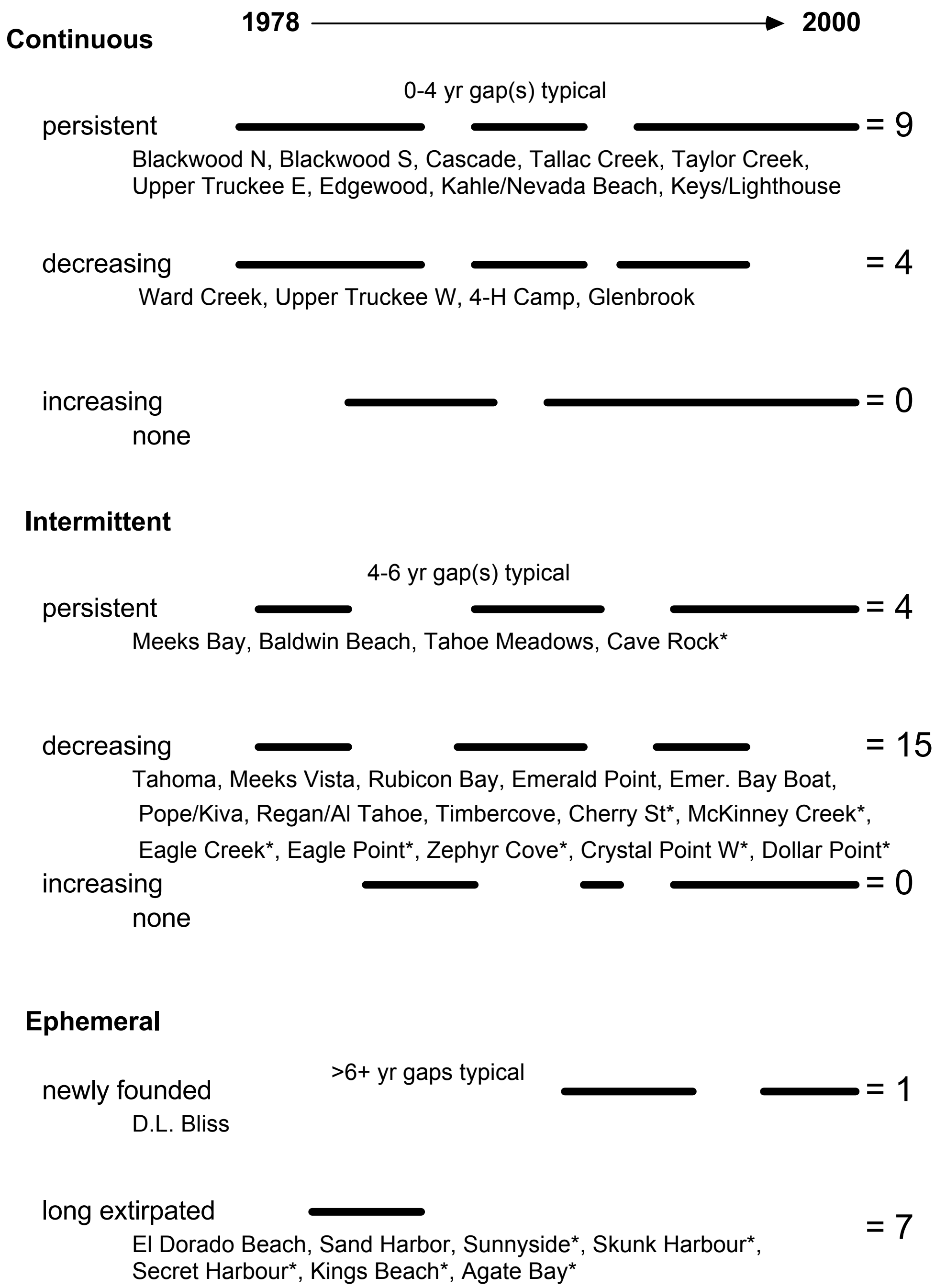


Figure 4. Patterns of Tahoe yellow cress persistence at 40 sites (high quality records only), 1978 to 2000. Typical gap lengths determine type of pattern (continuous, intermittent or ephemeral). * = short-term record, spanning either the 1980s or 1990s.

noted that the plant endured "much abuse from the trampling feet of swimmers and sun bathers". Unfortunately, increased visitation is also associated with high lake level years, when beach areas are most reduced in area and Tahoe yellow cress is less likely to be present (Table 8). Over the last decade, visitors to California and Nevada state parks increased by about 10 percent between low lake (1989 to 1994) and high lake level years (1995 to 2000). Available habitat declined by 87 percent due to the geometry of the filling basin so that the concentration of human activity on unsubmerged habitat increased by nearly 800 percent. Habitat conditions during any single year deteriorate over the summer and fall as human activities follow the water's edge and spread the disturbance into downslope Tahoe yellow cress habitat (TRPA 1999). Tahoe yellow cress presence precipitously declines, with recreational impacts effectively reducing abundance and distribution. At these times the persistence of populations depends on the availability of microhabitat refuges. For Tahoe yellow cress, these refuges are less accessible areas, enclosures, or adjacent parcels that are often sub-optimal as habitat (Reed 1982), but provide the only relief from anthropogenic disturbance.

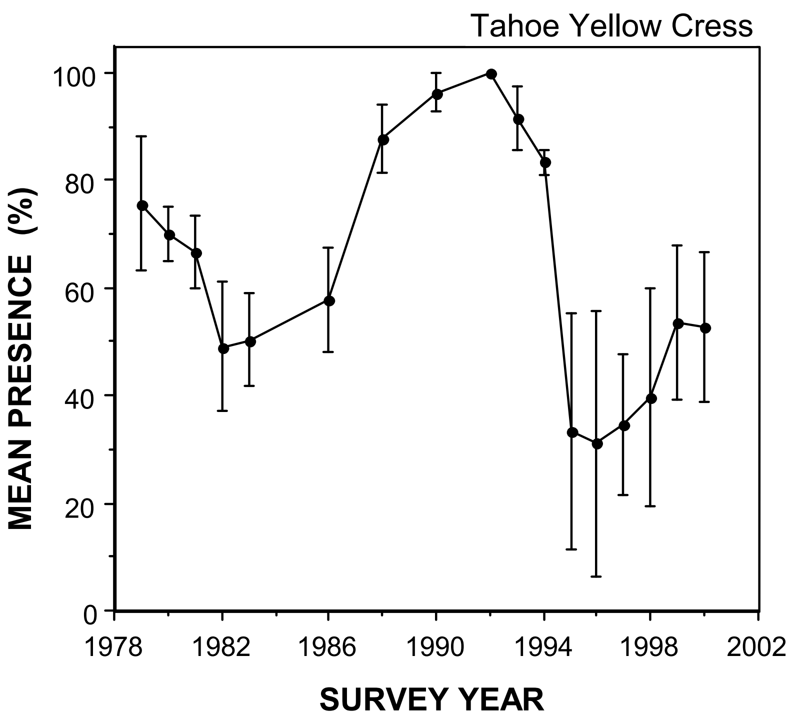


Figure 5. Mean presence + SE (n = 3 ownership categories, 31 total sites with long-term, high quality records) for Tahoe yellow cress, 1979 to 2000.

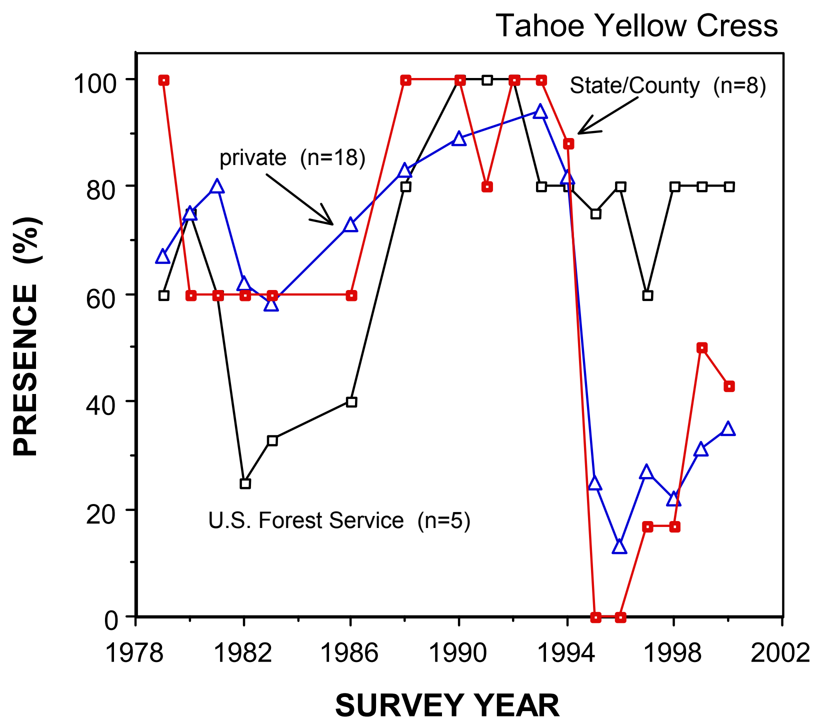


Figure 6. Presence by ownership categories (n = number of sites in each category with long-term, high quality records) for Tahoe yellow cress, 1979 to 2000.

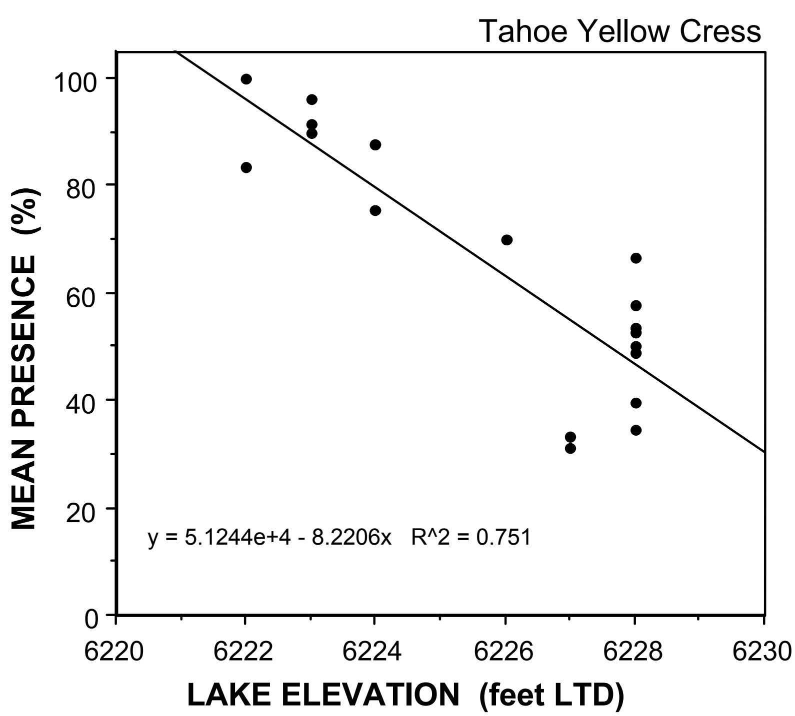


Figure 7. Relationship of mean presence as a linear function of mean lake elevation for Tahoe yellow cress, 1979 to 2000.

Table 8. Recreational visitation and Tahoe yellow cress presence during drought and wet years, 1989 to 2000. Means ± SD shown, along with relative change (% of initial), t-statistic (unpaired), and probability of type II error (P). Lake level data from USGS 2000; Nevada visitation data from Howard (pers. comm. 2000); California data from Michaely (pers. comm. 2000); Tahoe yellow cress habitat acreage from Bair (1996); and presence data from Figure 5.

	Drought years 1989 to 1994	Wet years 1995 to 2000	%	t	P
Lake level (ft > msl)	6,222.8 ± 0.75 ft	6,227.7 ± 0.52 ft	+0.01	13.0	<0.001
# visitors @ NV Parks/yr	862,895± 29,936	913,786 ± 104,540[1]	+5.9	1.2	<0.278
# visitors @ CA parks/yr	733,485 ± 74,125	842,517 ± 84,068	+14.9	2.5	<0.082
Tahoe yellow cress habitat (acres)	1,863	233	-87		
Visitor density[2] (# visitors/acre)	857	7,538	+780		
Tahoe yellow cress presence (% of sites)	89.0 ± 5.7	32.8 ± 9.8	-63.1	10.2	<0.001

1. This mean becomes 946,004 ± 76,652 if the low value from 1998 (752,693) is excluded, thus indicating a 9.6 percent increase in visitation to Nevada State Parks between the dry and wet periods (t = 2.46, P = 0.036). This would be justified in this extreme El Nino year, when the long rainy winter and spring reduced overall visitation to the Lake Tahoe basin.

2. Calculated by dividing the sum of CA and NV means by the habitat acreage. It is an inexact statistic and should be used for illustrative purposes only because the visitation numerator does not include visitors to private and USFS lands and because the acreage does include habitat on private and USFS lands.

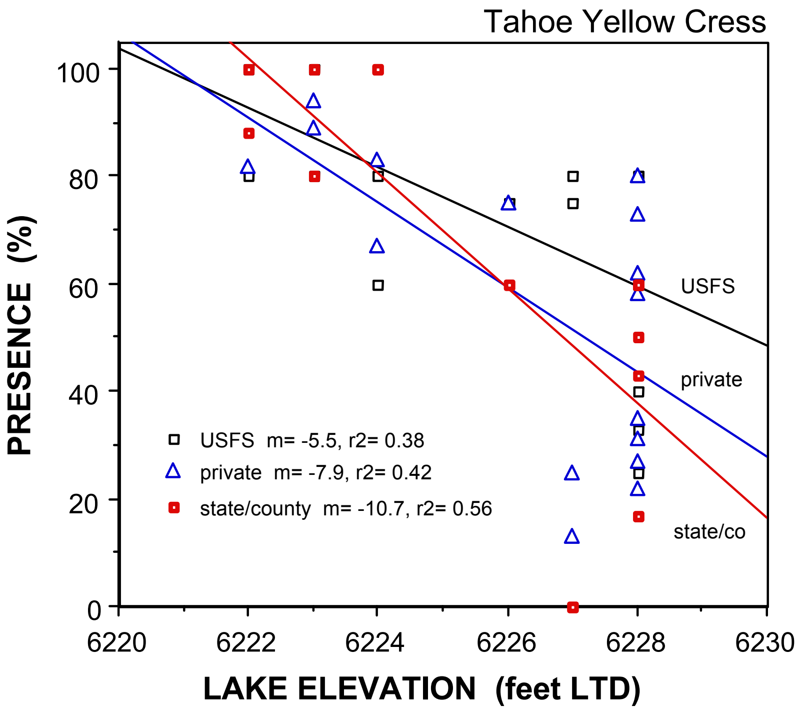


Figure 8. Relationship of presence by ownership as a linear function of mean lake elevation for Tahoe yellow cress, 1979 to 2000.

The Number and Size of Populations

The highest number of extant, natural Tahoe yellow cress populations recorded during a single year was 35 after surveys were conducted in 1993 at 44 sites (Appendix D). Their distribution by lake area quartiles was highest along the northwest, southwest, and southeast sectors, with over 83 percent of all known populations represented in each (Figure 9). The northeast sector had the fewest known populations (5), of which only one was present in that year (20 percent). The fewest number of extant, natural populations was 7 after surveys were conducted in 1996 at 39 sites. The northwest and northeast sectors had 0 populations out of the 11 that were known from those areas, while the southwest and southeast sectors maintained 30 and 19 percent of their known populations, respectively. Therefore, the number of extant, natural Tahoe yellow cress populations can vary by a factor of five, with the southwest and southeast sectors of the lake accounting for the most during optimal times (29 maximum) and the most likely to persist during suboptimal times (7).

The absolute number of populations (i.e. occupied sites) cyclically fluctuated as did presence, with more populations observed in dry years with low lake levels, and fewer in wet years with high lake levels (Figure 10). The regression of lake level on number of populations is highly significant ($r^2 = 0.724$, $P < 0.001$) and indicates a loss of seven populations for every 2-ft

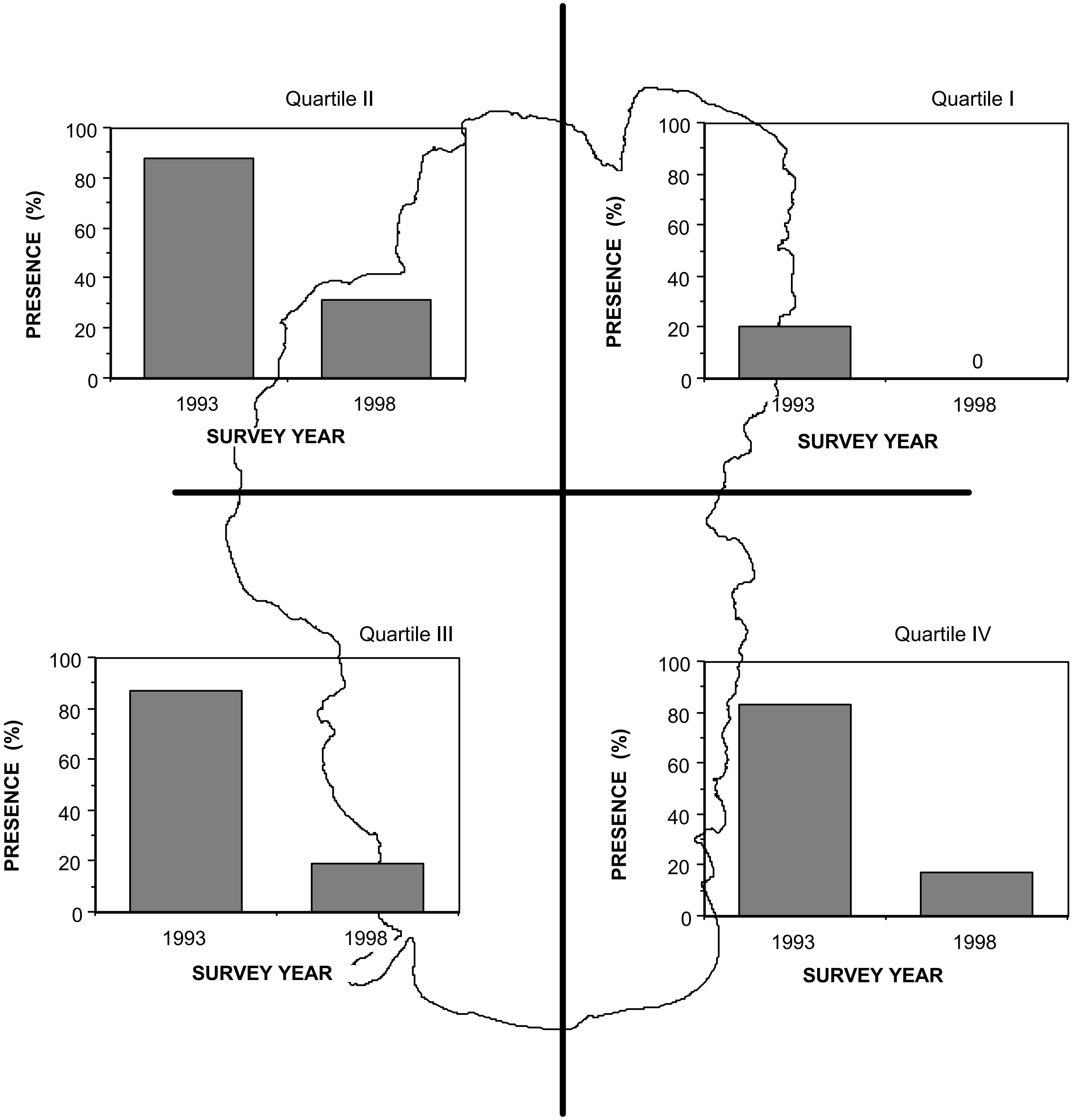


Figure 9. Presence of Tahoe yellow cress by quartiles around Lake Tahoe in low lake level (1993) and high lake level (1998) years.

rise in water (Figure 11). As previously discussed, changes in lake level are correlated with changes in human activity (e.g. visitor density, management regime, raking) which could also be responsible for the reduction in number of populations.

The mean number of stems per population (roughly an indicator of "typical" population size among sites) also fluctuated over time, but the pattern is not readily explained by lake level fluctuations. During the 1980s, the mean number of stems per population increased from a low of 53 (1979, a dry year with lower than average lake levels) to 404 (in 1986, a wet year with high lake levels) and on to an all-time high of 463 (in 1990, a dry year with low lake level) (Figure 10). This decreased again during the 1990s, but began increasing in 2000. When plotted against lake level, stem count per population was high at the dry and wet extremes (below 6,224 ft; 1,897.04 m and above 6,227 ft; 1,897.99 m LTD) and low in between (Figure 12). This complex relationship may be an artifact of limited data sets or represent a physiological sensitivity to hydrological changes that accompany lake level fluctuations. With respect to the latter, dry years may expose large amounts of habitat with an accessible, shallow water table that allows the establishment of plants (CSLC 2000). Wet years benefit upslope populations that survive inundation because remaining individuals take advantage of saturated soils, expanded floodplains and near-surface water tables. Thus, there is an apparent double benefit to low lake levels in the form of more populations with greater stem counts while there is but a single benefit to high lake levels in the form of greater stem counts (but in fewer, more ecologically restricted populations).

In general, the number of stems (or individuals) in a population determines much about the responses of the population to environmental change. Large populations have greater amounts of genetic variation, more microhabitat diversity, less susceptibility to random events and catastrophe, higher reproductive output, and, therefore, a higher probability of persisting into the future than do smaller populations. This is a central paradigm in conservation biology: Population size by itself is one of the best predictors of the extirpation rate of isolated populations (MacArthur and Wilson 1967; Pimm *et al*. 1988; Primack 1998). It also appears to be true for Tahoe yellow cress (Figure 13). There is a strong, logarithmic relationship ($r^2 = 0.63$, $P < 0.001$) between mean stem count per population (site) and the persistence of the population. Differences in habitat quality between sites are probably reflected in the residuals, with high quality sites lying above the line and low quality sites below. Virtually the same relationship is obtained when plotting mean maximum stem count against persistence (Figure 14).

The relationship shown in Figure 13 can be used to estimate values for the minimum stem count per site (population size) required for varying probabilities of persistence (Table 9). In some ways these represent demographically based minimum viable population (MVP) estimates widely used in conservation biology (Shaeffer 1981), with the following caveats: 1) These estimates were obtained retrospectively from field data, rather than as projections from population models; 2) they apply to the 20-year monitoring period, not to the 100, 500, or 1000 year timeframe simulated by modeling. The period included, however, two full drought-wet cycles and high levels of human activity within the habitat range of the species; 3) there is an unknown relationship between stem count and number of individuals, so population size has not been truly accessed; and 4) the ability to reproduce from rootstocks probably dampens changes in true population size over time so that lower persistence probabilities (e.g. 90 percent) could be accepted in lieu of the standard 95 or 99 percent. These qualifications do not detract from the utility of the MVP estimates in this CS. The estimates can define the target sizes of native, created and managed populations and thus provide indicators of biological and project success (Pavlik 1996).

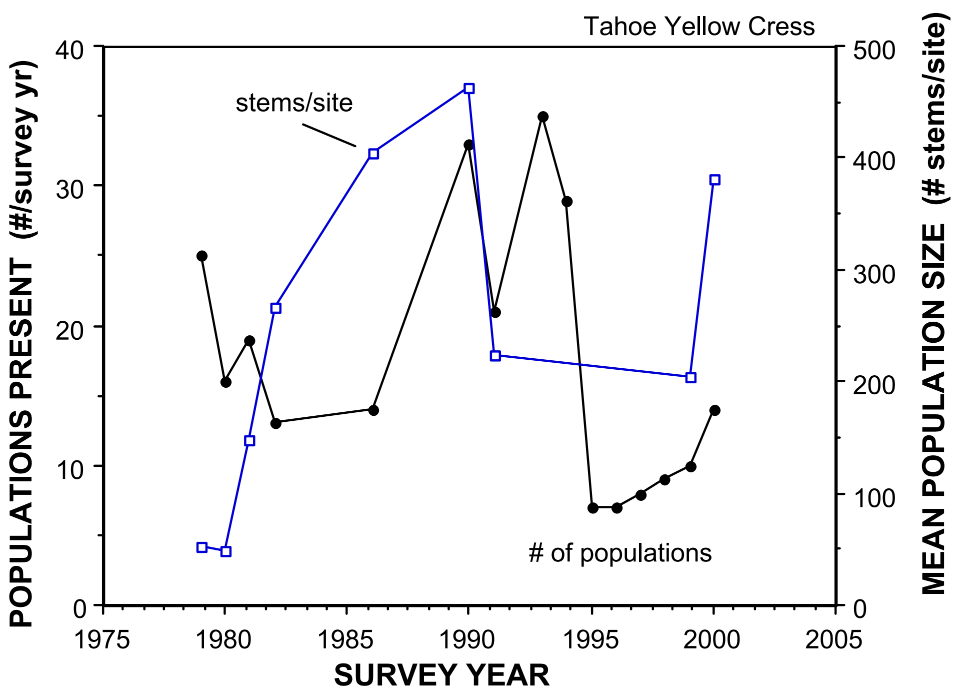


Figure 10. Changes in absolute number of extant Tahoe yellow cress populations (sites with Tahoe yellow cress, Appendix D) and mean population size (mean stem count per site), 1979 to 2000.

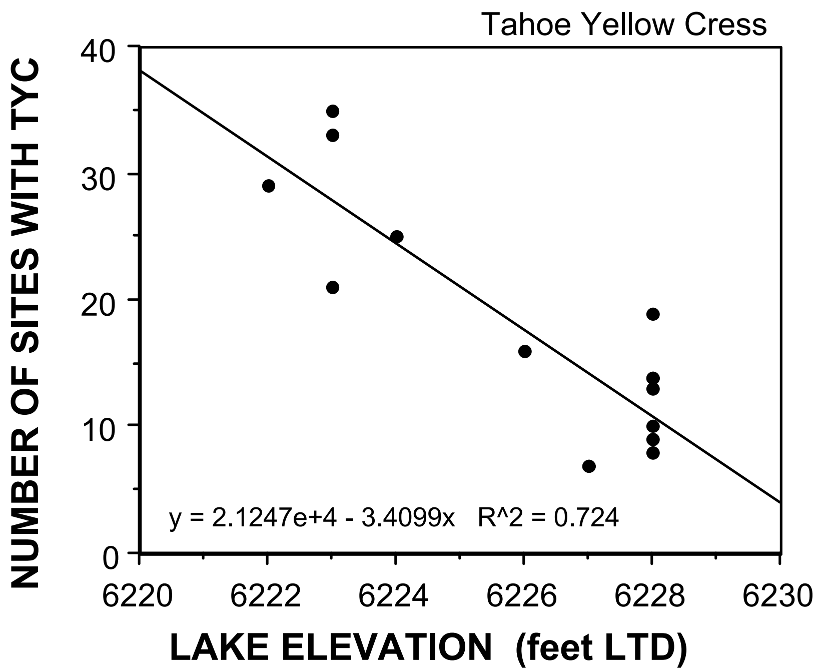


Figure 11. Relationship between absolute number of extant Tahoe yellow cress populations (sites with Tahoe yellow cress, Appendix D) and mean lake elevation, 1979 to 2000.

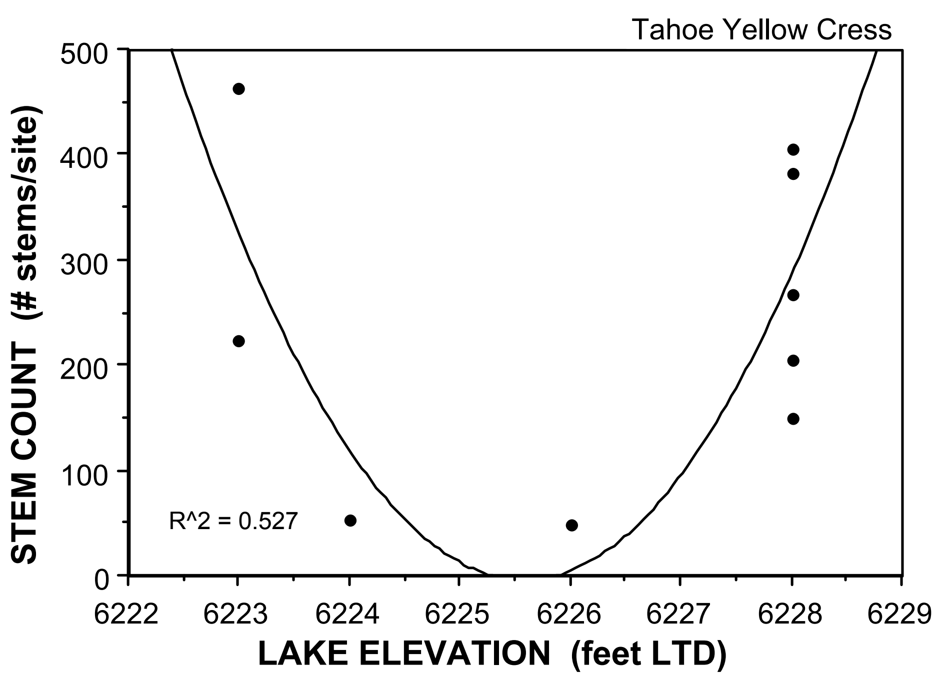


Figure 12. Relationship between mean stem count (mean for a given lake elevation) and lake elevation for Tahoe yellow cress, 1979 to 2000.

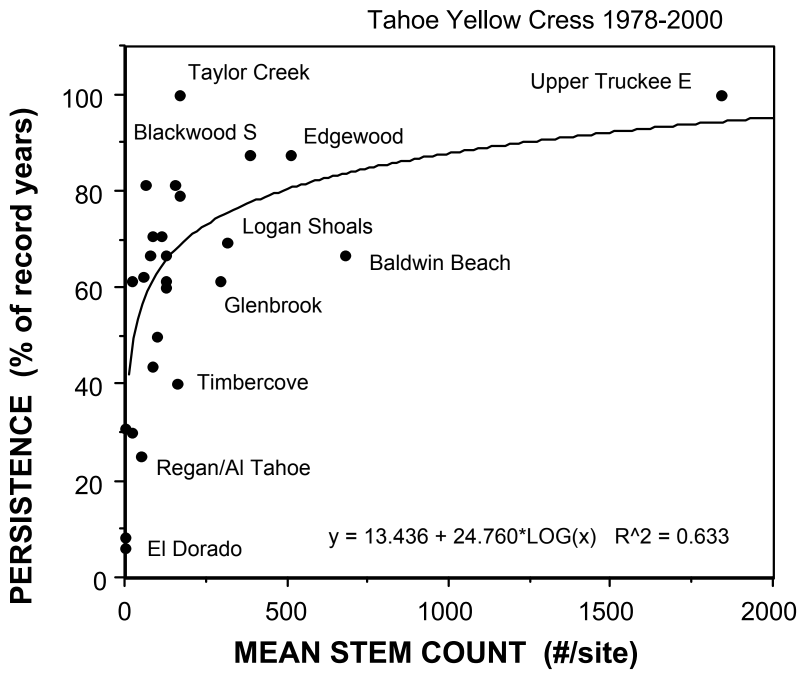


Figure 13. Relationship between mean stem count (mean for a site in all record years, Appendix E) and persistence (for a site, Appendices A and D) for Tahoe yellow cress, 1978 to 2000.

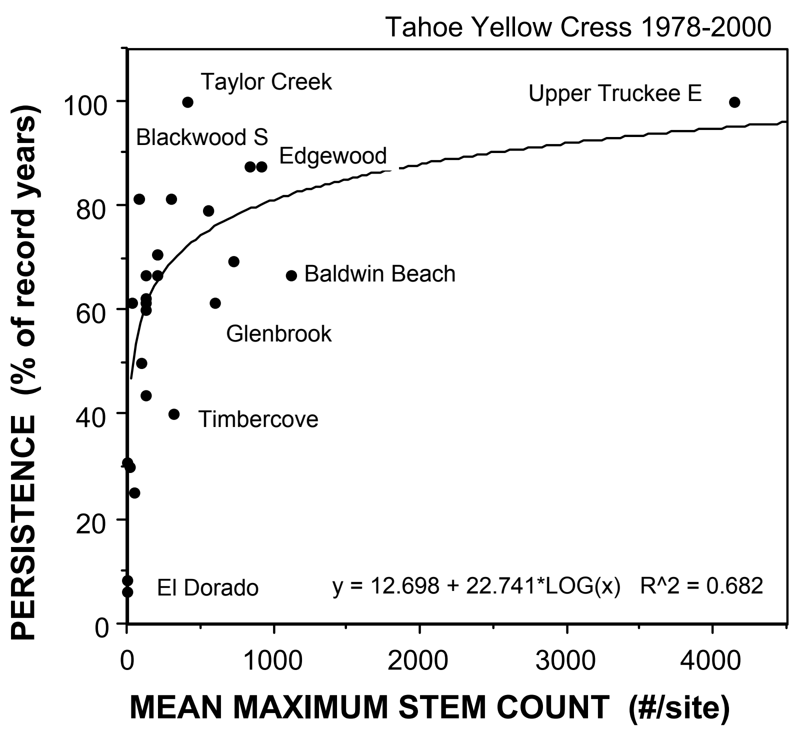


Figure 14. Relationship between mean maximum stem count (mean of three highest values for a site in all record years, Appendix E) and persistence (for a site, Appendices A and D) for Tahoe yellow cress, 1978 to 2000.

Table 9. Calculated values of minimum viable population size (minimum mean stem count/site) for Tahoe yellow cress with different probabilities of persistence after 20 years. Data collected from 29 sites between 1978 and 2000. See Figure 13 for relationship.

Probability of persistence after 20 years (%)	Minimum mean stem count/site
99	2800
95	1900
90	1200
75	300
50	30

Evaluation of Known Tahoe Yellow Cress Sites for Conservation and Restoration

The persistence and stem count data can be used to evaluate known Tahoe yellow cress sites for purposes of conservation and restoration. Sites that support relatively large, invariant and persistent populations are of highest conservation value because they consistently provide favorable conditions for the species. These will be designated as "core" sites for conservation and they will play an important role in both maintaining the species and in developing management prescriptions from restoration experiments. Sites with smaller, fluctuating and intermittent populations may be less favorable due to natural and anthropogenic factors. Nevertheless, they have proven to be quite suitable for Tahoe yellow cress and will be designated as "high priority restoration" sites. Sites with very small, highly variable populations with significant gaps still provide habitat under some conditions and will be designated as "medium priority restoration" sites (see Figure 16 and 17 for mapped locations of core, high, and medium priority sites). Finally, sites with small, ephemeral populations that are commonly characterized by extirpation will be "low priority restoration" sites that are important for maintaining the metapopulation dynamic but will not support thriving populations under present conditions.

Thus, it is possible to rank sites that have sufficient data based only on the biological character of the Tahoe yellow cress populations they support. An index of viability was calculated for each site based upon three components:

Index = Ra + -1(CoVar) + Pr

Where:	Ra	the relative abundance (mean stem count at a site/sum of mean stem counts of all sites X100
	-1(CoVar)	the negative coefficient of variance (-1 X the coefficient of variance of mean maximum stem count at a site multiplied by 100)
	Pr	persistence (number of occurrences at a site/record years multiplied by 100

Sites that support relative large, invariant, and persistent populations will have a high, positive index value while those with small, variant, and ephemeral populations will have a low, possibly negative value (if the CoVar term is large). Sites with low quality occurrence/absence data or that lack stem count data could not be assigned an index and were simply designated as "unranked" (Appendix G, Table 11).

A total of 29 sites had calculated index values that ranged between 97 (Taylor Creek) and -77 (Regan/Al Tahoe). If arranged as a linear ordination, there were 4 convenient clusters each separated by at least 10 index points (Figure 15, Table 10), although the range within the clusters could be as much as 50 points. The high cluster, designated as that of the core sites, had the widest range and was only weakly distinguished from the next cluster of high priority restoration sites.

Core sites had high persistence (mean of 87 percent), very different abundances (101 to 103), but these did not vary much at a given site. Designation of Blackwood N and as a core site, rather than high priority restoration sites, was based upon its high persistence (greater than 70 percent) combined with moderate abundance and low variance in stem counts (less than 35 percent). Kahle/Nevada Beach was initially designated a core site; however, a stream restoration project constructed near the population inadvertently modified the hydrology and other habitat characteristics of the site, which now supports upland vegetation. Kahle/Nevada Beach was therefore reclassified as a high priority restoration site. High priority sites were a more tightly clustered group characterized by moderate persistence (mean of 63 percent), with moderate abundance (101 to 102) and moderate variance. Sites in the medium priority restoration cluster were separated from each other by small increments and were characterized by moderate persistence (mean of 56 percent) but extremely variable stem counts. Finally, the low priority restoration sites had low persistence (mean of 24 percent), low stem counts (100 to 101), and very high variance.

Table 10. Ranked Tahoe yellow cress sites and their characteristics. Viability index is the sum of three components (Ra = relative abundance, CoV= coefficient of variation of mean max stem count, P = persistence). Rel Dev = relative amount of site development, Rec Impact = relative amount of recreational impact. ++ = most favorable, - = least favorable, + and 0 in between. (See Appendix G for details, Figures 16 and 17 for mapped locations. See Table 13 for the adopted ranking of known Tahoe yellow cress sites.)

		Components					
	Index	Ra	CoV	P	Owner/Mgr	Rel Dev	Rec Impact
Core Sites							
Taylor Creek	97	+	++	++	USFS	light	light-mod
Upper Truckee E	78	++	0	++	Private	light	light
Tallac Creek	75	0	++	+	USFS	light	mod-heavy
Edgewood	65	++	0	+	Private	mod	light
Blackwood S	65	+	0	+	Placer Co	light	light-mod
Blackwood N	49	+	+	0	Private	light	light
Kahle/Nevada Beach	47	+	0	+	USFS	light-mod	mod-heavy
High Priority Restoration Sites							
Glenbrook	37	+	0	0	Private	light-mod	mod-heavy
Eagle Creek	35	+	+	0	California	light	moderate
Ward	31	+	0	0	Private	light	light
Meeks Bay	31	0	0	0	USFS	mod-heavy	mod-heavy
Cascade	31	+	0	0	Private	light	light
Medium Priority Restoration Sites							
Upper Truckee W	18	+	-	+	CTC	light	mod-heavy
Rubicon Bay	16	0	-	0	Private	light	mod-heavy
Emerald Point	10	++	0	-	California	light	mod-heavy
Zephyr Cove	5	0	0	0	USFS	moderate	moderate
4-H	2	0	-	0	U Nevada	light	heavy
Baldwin Beach	-7	++	-	0	USFS	moderate	heavy
Timbercove	-9	+	-	-	Private	heavy	heavy
Logan Shoals	-11	+	-	0	Private	moderate	light-mod
Eagle Point	-15	0	-	-		light	light-mod
Tahoma	-15	-	0	-	Private	moderate	heavy
Tahoe Keys/Lighthouse	-15	+	-	0	Private	heavy	light-mod
Tahoe Meadows	-19	0	-	0	Private	heavy	light-heavy
Low Priority Restoration Sites							
Pope/Kiva	-37	0	-	0	USFS	light	mod-heavy
Sand Harbor	-38	-	0	-	Nevada	moderate	heavy
El Dorado Beach	-40	-	0	-	City SLT	moderate	heavy
Secret Harbor	-62	-	-	-	USFS	moderate	mod
Regan/Al Tahoe	-77	0	-	0	Private	moderate	heavy

Table 11. Unranked Tahoe yellow cress sites and their characteristics. These sites lack sufficient data to calculate the viability index or its components. (Ra = relative abundance, CoV = coefficient of variation of mean max stem count, P = persistence). Rel Dev = relative amount of site development, Rec Impact = relative amount of recreational impact. na = not available. ++ = most favorable, - = least favorable. (See Appendix G for methods and scalars). These sites will be ranked by the TAG by April 1, 2002.

		Components					
	Index	Ra	CoV	P	Owner/Mgr	Rel Dev	Rec Impact
Sunnyside	na	na	na	-	Private	heavy	mod-heavy
Kaspian Camp	na	na	na	na			
Cherry Street	na	na	na	-			mod-heavy
McKinney Creek	na	na	na	-	Private	light-mod	heavy
Meeks Vista	na	na	na	na			
D.L. Bliss	na	na	na	-	California	light	mod-heavy
Emerald Bay Avalanche	na	na	na	na	California	light	light
Emerald Bay Boat Ramp	na	na	na	-	California	mod	mod-heavy
Elk Point	na	na	na	na			
Skyland	na	na	na	na			
Cave Rock	na	na	na	-	Nevada	moderate	mod-heavy
Skunk Harbor	na	na	na	-	USFS		
Crystal Point W	na	na	na	-			
Kings Beach	na	na	na	-	California		heavy
Agate Bay	na	na	na	-	Private		mod-heavy
Dollar Point	na	na	na	-			

What are the characteristics of the habitat that result in differential performance of Tahoe yellow cress populations and thereby distinguish core, high priority, medium priority, and low priority restoration sites? Unfortunately, there is no site-specific set of independent measures (e.g. beach topography, water table depth, wind and wave intensity, visitor impacts) that could be correlated with the viability index or its components. With respect to human disturbance (Table 10), core sites tend to be lightly developed (i.e. no permanent structures on the beach or significant alterations in drainage) and receive mostly light to moderate levels of recreational impact (based on Ferreira 1987; CSLC 1998, 2000). Relative levels of development and recreational impact progressively increase at high priority, medium priority, and low priority restoration sites, with permanent structures, channels, walls, boat storage, marinas, high visitation, and high soil disturbance becoming dominant site features. Ownership and/or management, per se, appear to be less important than degree of development and use because all ownership/management categories are represented in each of the ranked site clusters.

There is very little evidence to suggest that successional processes significantly or permanently alter habitat conditions to the detriment of Tahoe yellow cress. Invasion of wetter areas by grasses (Blackwood N), rushes (Tallac Creek, Upper Truckee W, and Edgewood), alders (Cascade), and willows (Pope Beach) has been noted, as well some invasion of drier areas by nonnative species (e.g. woolly mullein at Taylor Creek) (Ferreira 1987; CSLC 1998). It is likely that Tahoe yellow cress is displaced by wetland species, especially when high lake levels are sustained and back beach depressions become densely vegetated swales (Ferreira 1987). However, the cyclic return to low lake levels retards and probably reverses the wetland progression, and Tahoe yellow cress is capable of reclaiming such sites if other conditions are favorable. Nonnative species, however, may represent a long-term threat if they continue to advance into Tahoe yellow cress habitat, stabilizing the sand and altering important ecosystem characteristics (by raising sand organic matter and nutrient content, decreasing sand mobility, and altering the physical environment around seedlings).

Topographic diversity at a site may be the single most important feature determining Tahoe yellow cress population performance over long periods of time. Ferreira (1987) noted that during high water years, occupied sites were those with large beach areas above 6,229 ft (1,898.60 m) LTD that could not be invaded by wetland species. In low water years, sites with back beach depressions and low elevation sand bars become available and are often colonized rapidly and extensively by Tahoe yellow cress (e.g. the sand bar exposed in 1990 at Cascade; CSLC 1998). Therefore, we would predict that core and high priority sites, those with the highest persistence and ability to produce and maintain stems through time, would be those that provided habitat in low and high lake level years. A site-specific analysis of persistence during one low level period (1990 to 1994, mean level -2.5 to -3.5 ft; -0.7 to -1 m below 6,225 ft; 1,897.38 m LTD) and two high level periods (1982 to 1986 and 1996 to 2000, means +2 to +3 ft; 0.6 to 0.9 m above 6,225 ft; 1,897.38 m LTD) provides evidence to that effect (Table 12). All core sites and all but one high priority site had Tahoe yellow cress in all three periods, as well as during one or more transition periods (years with mean levels within -1 to + 1.5 ft; -0.3 to 0.5 m of 6,225 ft; 1,897.38 m LTD). Conversely, medium priority and low priority restoration sites with low indices and unranked sites in general, tended to provide habitat in either low water or high water years, sometimes during transition years as well. Even though a site may provide habitat in both low and high lake level years, its ability to support Tahoe yellow cress may vary under different rainfall and hydrological conditions. Meeks Bay, Baldwin Beach, Upper Truckee West and East, and Logan Shoals had peak stem counts in low-level years, by factors of at least four to five (Appendix E). Timbercove, 4-H Camp, Kahle/Nevada Beach, and Glenbrook had peak stem counts in high-level years, by factors of two to three minimally. Four sites, all designated as core, did not peak at all but instead had produced large numbers of stems (greater than 102) consistently throughout both low and high level periods. These patterns probably reflect differences in site microtopography, water table depth, and levels of disturbance that vary in the magnitude of their short-term effects but have little long-term impact at a site as lake level and climate cyclically change.

Finally, it should be noted that no evaluation of unoccupied sites is possible at this time. The 1993-94 inventory of shorezone parcels found hundreds of parcels lacking Tahoe yellow cress but possessing a beach with at least 30 percent coverage by sand. Given the lack of correlative data linking population performance to habitat characteristics, we have no way to determine how many of these unoccupied sites could support the species and to what degree. Nevertheless, their numerical abundance, distribution and availability are essential for maintaining a positive metapopulation dynamic (Figure 2) and they must not be thoughtlessly degraded. They may represent optimal, but temporarily abandoned sites awaiting re-colonization or incipient refuges that will become more suitable for occupation when environmental conditions inevitably change.

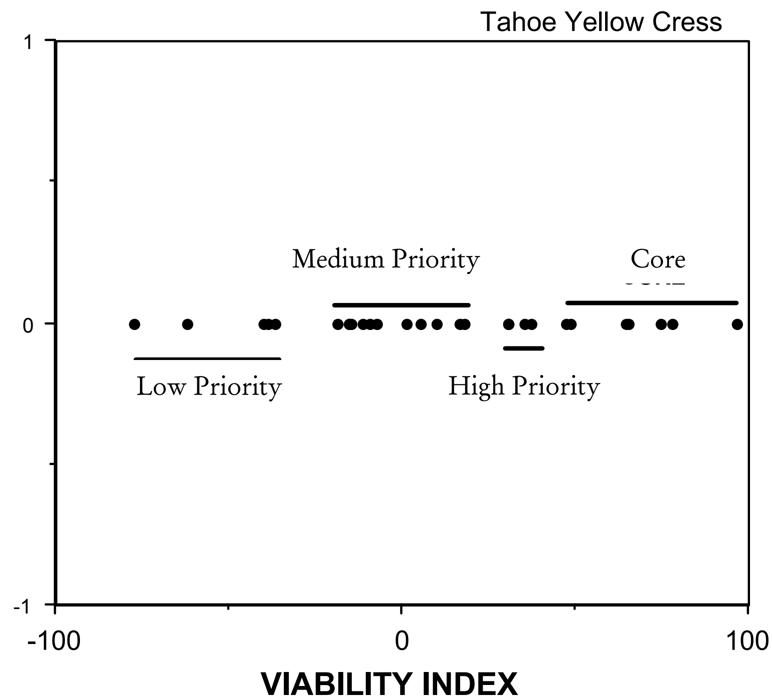


Figure 15. Linear ordination by viability index for all ranked sites of Tahoe yellow cress. See Table 10 for additional information.

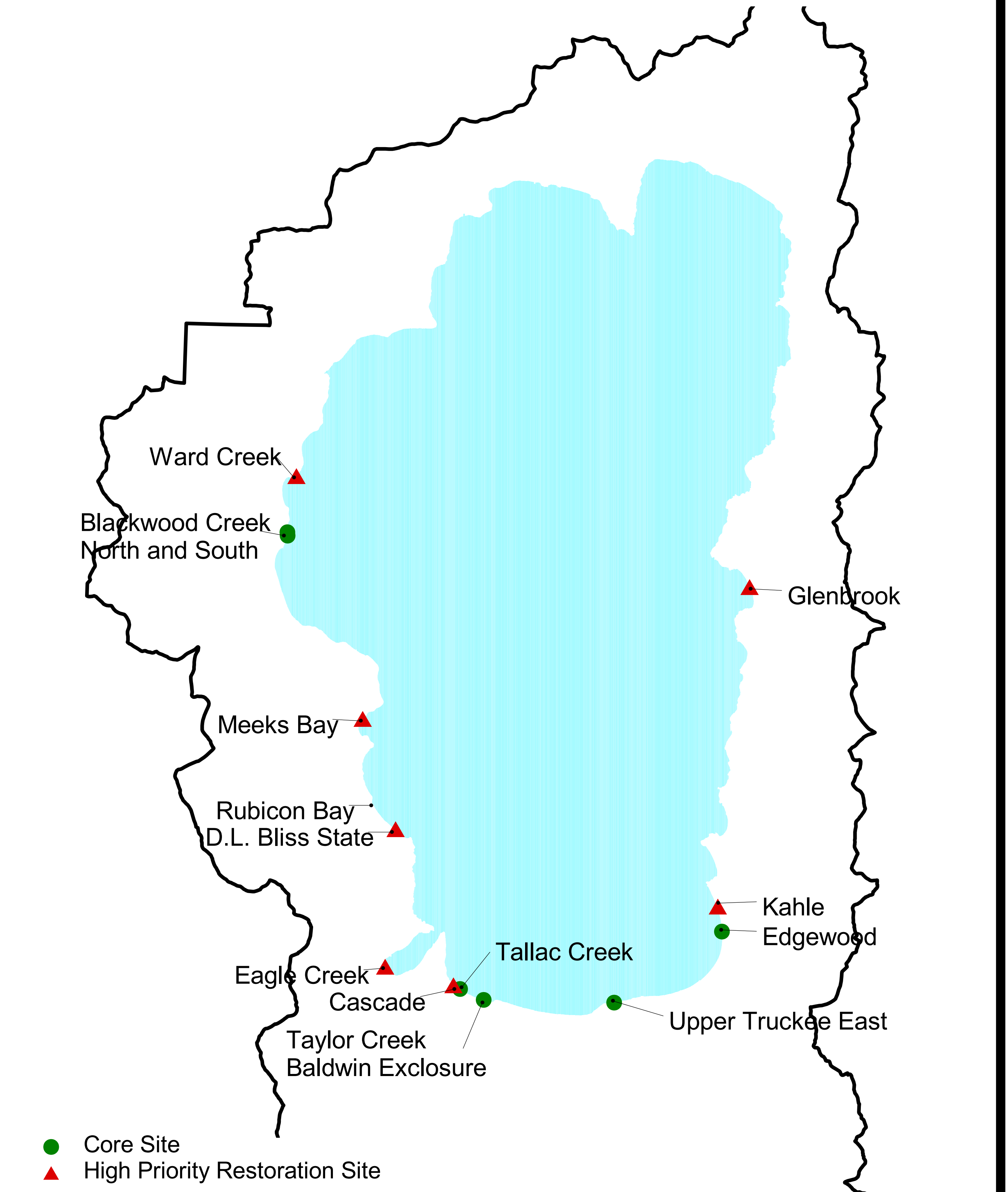
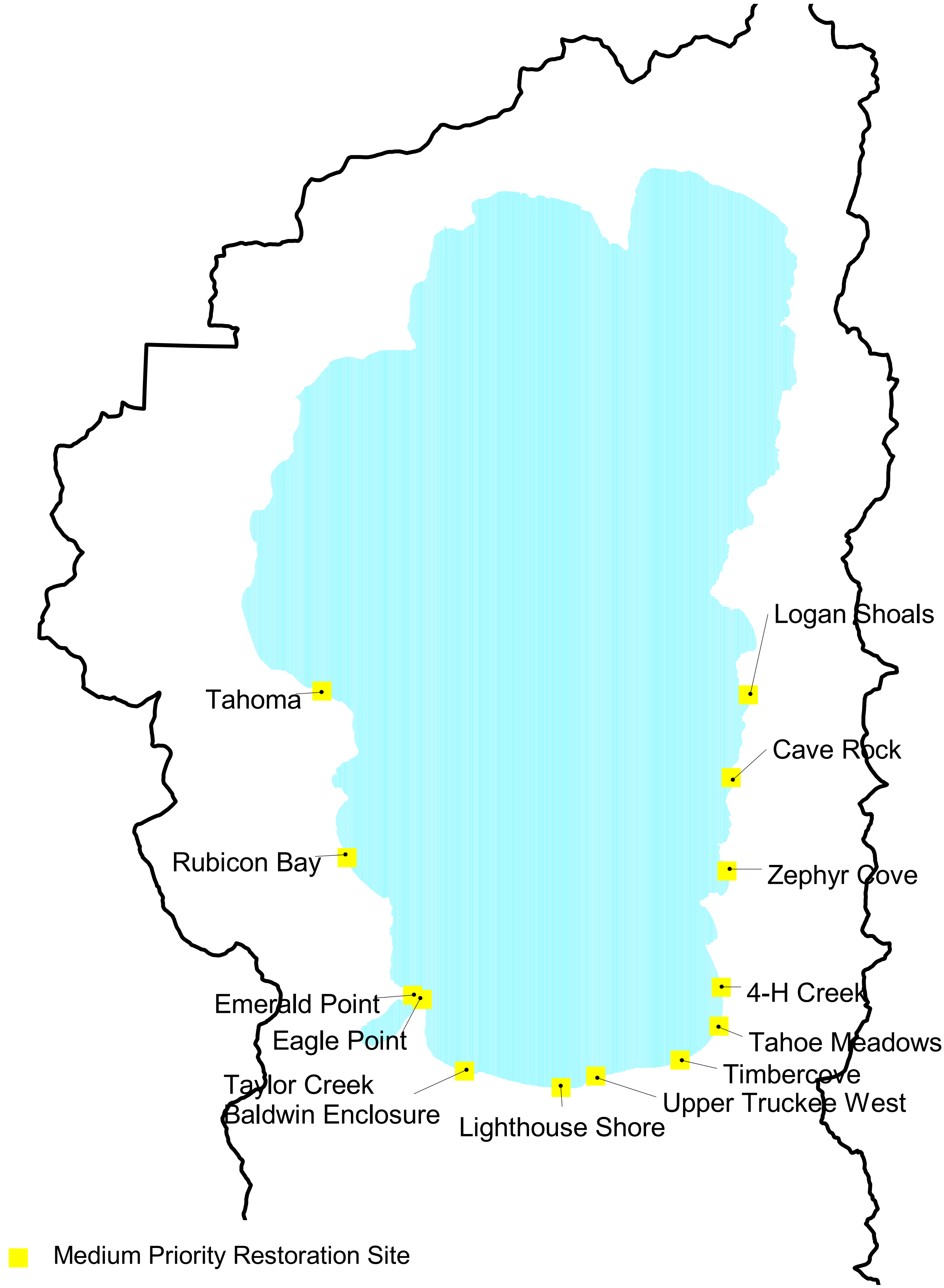


Figure 16
Core and High Priority Restoration Sites



TAHOE REGIONAL PLANNING AGENCY

Figure 17
Medium Priority Restoration Sites

N

Table 12. Habitat availability in low lake level (less than 6,225 ft) and high lake level (greater than 6,225 ft) years for Tahoe yellow cress. Determinations made from analysis of occurrence/absence and stem count data 1978 to 2000 (Appendices A and B). Low years = 1990 to 1994 (mean level -2.5 to -3.5 ft below 6,225 ft), High years = 1982 to 1986 and 1996 to 2000 (+2 to +3 ft above 6,225 ft) and transition years (t) all others (mean level -1 to +1.5 ft). Low quality records were excluded. **Bold** = site with constant stem counts in low and high years, [lp] = stem count peak in low level years, [hp] = stem count peak in high level years.

low + high + t	low + high	high + t	high only	low + t	low only	t only
Ward Creek	Cave Rock	Timbercove[hp]	Kings Beach	Tahoma	Sunnyside	El Dorado
Blackwood N				Meeks Vista	Cherry Street	Sand Harbor
Blackwood S				Emerald Point	McKinney Creek	
Meeks Bay[lp]				Emerald Bay Boat	Eagle Creek	
Rubicon Bay				Regan/Al Tahoe	Eagle Point	
Cascade				Pope/Kiva	Skunk Harbor	
Tallac Creek				Elk Point	Secret Harbor	
Baldwin Beach[lp]					Crystal Point W	
Taylor Creek					Dollar Point	
Keys/Lighthouse						
Upper Truckee W[lp]						
Upper Truckee E[lp]						
Tahoe Meadows						
Edgewood						
4-H Camp[hp]						
Kahle/Nevada Beach[hp]						
Zephyr Cove						
Logan Shoals[lp]						
Glenbrook[hp]						

II. E. Conservation On Public And Private Lands

Fundamentally, the conservation of Tahoe yellow cress relies on our understanding of the metapopulation biology of this species (Section II.C). The key aspects of the biology of this plant are the colonization rate, the extirpation rate, the number of occupied sites, and the number of unoccupied sites. Table 5 lists the elements that are readily manipulated by resource management that may affect these aspects of the plant's biology. These elements are the focus of the CS in general and the primary focus of public and private land management.

The difference in conservation focus on public verses private lands is based on affecting different aspects within the metapopulation model: $dP/dt = CP(1-P) - E(P)$. However, the types of impacts and the ability of resource managers to influence those impacts are variable. Attempting to implement identical conservation and management practices on public and private lands may have vastly different results. The different approaches are articulated below, and are designed to be the most effective given the biological, regulatory, and social constraints.

Private Lands

This species, regardless of the actions of public agencies, cannot be protected without stewardship by private landowners. Only two-thirds of the core and high priority sites and half of the medium priority sites are under public management (Table 13). In addition to the ownership/management of populations, colonization of potentially suitable habitat is critical to this species, and private landowners manage a majority of potential habitat within the basin. To meet the ecological requirements of this species, which exhibits a metapopulation dynamic, both public and private lands are necessary for successful conservation. Engaging private landowners and encouraging their support of a stewardship program will be the central challenge of this CS.

There are a number of barriers to a private landowner stewardship program. The primary barrier is the concern that having Tahoe yellow cress on one's property will prevent a landowner from developing their land. Projects with Tahoe yellow cress on-site may require design modifications and/or mitigation of impacts. The stewardship program is being developed to work with and guide landowners in drafting a site-specific management plan before the project is submitted. This will help the private landowner both to conserve Tahoe yellow cress and to allow their proposed project to move forward.

Another barrier to stewardship is a lack of awareness about Tahoe yellow cress. Some impacts to this species and its habitat occur unknowingly. Many landowners do not know what Tahoe yellow cress looks like or if it occurs on their property. In addition to the stewardship program, an education program will be developed to help inform private landowners about Tahoe yellow cress. The program will help landowners understand how beach use, such as raking, affects the species and its habitat. In many cases, if Tahoe yellow cress is known to be on-site, landowners could simply avoid the species and still fully enjoy their beach access.

Another barrier to the Tahoe yellow cress stewardship program is the timing of the project review process by regulatory agencies. Because the survey period for the species is from June 15th to September 30th, permit applications may be delayed until the next survey period. There have been three changes to the TRPA project review process to streamline applications (Appendix I). First, the database generated from the results of the 1993-1994 shorezone survey, as modified by survey work, will be used as a first cut to determine if field surveys are required. Second, surveys may be conducted the season prior to submittal of the application, and third, a TRPA approved botanist may conduct the surveys.

The ongoing adaptive management program will be the vehicle to address future changes in the regulatory protection process. If conservation efforts in the future are successful, it is conceivable that regulatory protection could be decreased. In addition, the stewardship, public education, and outreach programs are designed to aid landowners with both conservation activities and the permit application process (Section II.J).

Public Lands

Conservation of Tahoe yellow cress and its habitat on public land is directed by the policies and guidelines of the responsible agencies (Appendix H). In general, most public agencies are mandated to protect Tahoe yellow cress as well as other sensitive species and habitats. Appendix J identifies the proposed conservation actions for core and high priority restoration sites managed by public agencies. However, there are three primary barriers to conservation on public lands: 1) Balancing stewardship with development and use of recreational facilities and access; 2) balancing stewardship with other land use; and 3) funding and resource allocation.

The use and potential development of public lands is frequently part of the mission of a multiple-use agency. However, public land management agencies whose lands support listed and/or sensitive species and their habitats are required to consider potential conflicts between species conservation and human use. In the case of Tahoe yellow cress, this conflict can be quite evident. Public beaches are limited in the Tahoe basin, and the shorezone provides the only habitat for this species. Although Tahoe yellow cress is legally protected, it is difficult to shift resources to this species in light of the short supply of public beach recreational opportunities. This fundamental conflict will not be completely resolved through the implementation of the CS; however, this effort represents another concrete step in increasing resources to conserve this species.

The public agencies in the basin are committed to the adaptive management process, and will manage populations occurring on lands under their purview in concert with the other public agencies. Subsequent to the annual lake-wide survey, the TAG will develop a list of desired conservation and management activities for the upcoming year. The TAG and executive committee will then determine priorities and potential funding mechanisms. This process will be further refined through the adaptive management process. The majority of the funding for research, restoration, and recovery activities will come from the public agencies.

At this time it is unclear how the different public agencies will limit use of the publicly managed lands that support Tahoe yellow cress and its habitat. However, all projects conducted within the shorezone on public land will be reviewed by TRPA (or addressed under Memoranda of Understanding (MOU) agreements) and other responsible agencies, to ensure that Tahoe yellow cress will not be negatively affected. The executive committee and/or the TAG may be asked to consult, if requested, on a project-by-project basis.

II.F. CONSERVATION GOALS, OBJECTIVES, AND ASSOCIATED ACTIONS

The following conservation goals, objectives, and associated actions shall guide and be the target for conservation and management actions for Tahoe yellow cress. Successful implementation of the CS may preclude the need to federally list the species as well as provide grounds for changing the legal status of this species at the California and Nevada state levels. The contents of the CS are not intended to alter the current regulatory requirements of each agency, nor is the protection afforded this species through existing policies and guidelines negatively affected by this CS. These goals and objectives are intended to provide additional direction to successfully conserve Tahoe yellow cress.

Associated with each objective is a set of actions intended to achieve the goals. The actions described are general in nature. Site-specific actions for core sites and high priority restoration sites are listed in Appendix J. Additional actions not related to specific sites are listed in Table 14.

It is important to note that while historic sites have been classified into core sites, high priority restoration sites, medium priority restoration sites, low priority restoration sites, and unranked sites (Table 13), regulatory protection of existing populations is not based on this ranking. All sites are afforded equal protection. However, the true value of this ranking is the ability to prioritize and expend conservation resources as effectively as possible. For the purposes of this section and the CS in general, Table 13 shall be maintained to reflect the current adopted ranking of the known sites based on the best available information.

The adaptive management process will serve as the mechanism by which these goals and objectives may be refined. Results of future research and monitoring of the species may reveal that the initial target number of individuals and populations should be revised based on newly obtained information.

GOAL 1: PROTECT OCCUPIED HABITAT AND POTENTIALLY SUITABLE HABITAT THAT DOES/COULD SUPPORT NATURAL POPULATIONS

Protection of the habitat where extant populations occur is critical to the conservation of this species. In addition, protection of unoccupied habitat that can be colonized is also necessary to maintain the species metapopulation life history traits. Until refined by further research, "potentially suitable habitat" shall be defined as any parcel identified as containing 30 percent sand and defined as potentially suitable habitat in the TRPA 1993-1994 shorezone study (Appendix I).

Objective 1.A: Protect core sites.

Actions: Implement restrictions, appropriate fencing, visitor education and control, enforcement and oversight by the appropriate landowner or land management agency, and habitat management to encourage a positive metapopulation dynamic (Section II.C).

1) Implement appropriate restrictions on shorezone projects (defined in Chapter 3 of the TRPA Code), alteration of perishore topography, alteration of hydrology, and structures that promote intensive visitor impacts (e.g. boat mooring, storage, or launching facilities).
2) Appropriate fencing may include permanent, durable, and effective barriers that do not significantly obstruct beach geomorphic processes or plant and wildlife movement. These barriers must be monitored and maintained and should have a minimal effect on scenic quality.
3) Visitor education and control includes signage, designated paths and boardwalks, available information and interpretation, and the ability to restrict public access when the likelihood of an imminent extinction event becomes apparent.
4) Compliance with permit condition will be handled by the appropriate permitting agency.
5) Protection of core sites on public land will include enforcement and oversight by the use of security patrols, local law enforcement agencies, violation reporting mechanisms, and adjacent landowner watch programs.
6) Protection of core sites on private lands will focus on a stewardship and educational approach.
7) Habitat management includes, but is not limited to, no mechanical debris removal, beach raking according to approved guidelines, and no introduction of nonnative plant species.
8) Stewardship assistance should be provided for privately owned core sites to assist private landowners in developing site-specific management/action plans for Tahoe yellow cress on their property.
9) Ranked sites that become extirpated should retain the protections and monitoring of their rank until their conservation importance or restoration potential can be ascertained.
10) Site-specific management plans will be developed for each core site. A partial list of conservation activities planned for the next two fiscal years can be found in Appendix J.

Objective 1.B: Protect high priority restoration sites.

Actions: Implement restrictions, appropriate fencing, visitor education and control, enforcement and oversight by the appropriate landowner or land management agency, and habitat management to encourage a positive metapopulation dynamic (Section II.C).

Specific actions for high priority restoration sites are equivalent to those identified under Objective 1.A for core sites.

Objective 1.C: Protect medium priority restoration sites.

Actions: Implement restrictions, appropriate fencing, visitor education and control, enforcement and oversight by the appropriate landowner or land management agency, and habitat management to encourage a positive metapopulation dynamic (Section II.C).

1) Implement appropriate restrictions on shorezone projects (defined in Chapter 3 of the TRPA Code), alteration of perishore topography, alteration of hydrology, and structures that promote intensive visitor impacts (e.g. boat mooring, storage, or launching facilities).
2) Appropriate fencing may include permanent, durable, and effective barriers that do not significantly obstruct beach geomorphic processes or plant and wildlife movement. These barriers must be monitored and maintained and should have a minimal effect on scenic quality.
3) Visitor education and control includes signage, designated paths and boardwalks, available information and interpretation, and the ability to restrict public access when the likelihood of an imminent extinction event becomes apparent.
4) Compliance with permit condition will be handled by the appropriate permitting agency.
5) Protection of medium priority sites on public land will include enforcement and oversight by the use of security patrols, local law enforcement agencies, violation reporting mechanisms, and adjacent landowner watch programs.
6) Protection of medium priority sites on private lands will focus on a stewardship and educational approach.
7) Habitat management includes, but is not limited to, no mechanical debris removal, beach raking according to approved guidelines, and no introduction of nonnative plant species.

8) Stewardship assistance should be provided for privately owned medium priority sites to assist private landowners in developing site-specific management/action plans for Tahoe yellow cress on their property.

9) Ranked sites that become extirpated should retain the protections and monitoring of their rank until their conservation importance or restoration potential can be ascertained.

10) Site-specific management plans will be developed for each medium priority site. A partial list of conservation activities planned for the next two fiscal years can be found in Appendix J.

Objective 1.D: Protect low priority restoration sites and unranked sites.

Actions: All low priority restoration sites (Table 10) and unranked sites (Table 11) will be provided with appropriate development review, visitor education and control, enforcement and oversight by the appropriate landowner or land management agency, and habitat management in years when Tahoe yellow cress plants are present. Tahoe yellow cress habitat should not be destroyed in years when it is absent.

1) Unranked sites that become extirpated will be surveyed and protected as low priority restoration sites until their conservation importance can be ascertained.

Objective 1.E: Protect newly colonized populations.

Actions: Newly colonized sites should be surveyed and treated as low priority restoration sites until their conservation importance can be ascertained.

Objective 1.F. Protect potentially suitable habitat to promote colonization.

Actions: Encourage stewardship on private lands such that newly established plants can persist.

Enforce beach raking guidelines (Appendix L).

Develop educational material that encourages visitors to not harm the species.

Through the review of projects consider the impact of permanent removal or impact of potentially suitable habitat. A process for making these determinations will be developed through the adaptive management process.

GOAL 2: IMPROVE TAHOE YELLOW CRESS POPULATIONS

In order to conserve this species the known populations must support an increased number of individuals, and in some cases, due to habitat degradation, restoration may be required. Management actions to improve existing Tahoe yellow cress populations will be focused on the core and high priority restoration sites. These are the sites the analysis in Section II.D identified as critical for the conservation of the species and therefore should be enhanced.

Objective 2.A: Core sites must be managed and restored to ensure 90 percent persistence for at least 20 years. Mean counts must exceed 1,200 reproductive stems for 6 individual years over a 10-year period (a period long enough to include a full high-low lake level cycle) (Figure 5, Table 9). Efforts should be made so that stems are distributed across the local environmental gradient, including elevation above lake level, slope, soil moisture, and microhabitat (Tables 2 and 3).

Actions: Population management should include: Control of invasive, nonnative plants early in their invasions and succession by native plants if they significantly reduce Tahoe yellow cress habitat; and preservation of appropriate beach geomorphic processes, wrack deposition, and armor development.

Population restoration should include: Reintroduction of propagated plants and/or seeds to appropriate habitats based upon an experimental program that increases the chance of project success (see Goal 4); and protection and monitoring of reintroduced populations to ascertain their conservation significance.

Objective 2.B: High priority restoration sites must be managed and restored to ensure 75 percent persistence for at least 20 years. Mean counts must exceed 300 reproductive stems for 6 individual years over a 10-year period (a period long enough to include a full high-low lake level cycle) (Figures 5 and 13, Table 9). Efforts should be made so that stems are distributed across the local environmental gradient, including elevation above lake level, slope, soil moisture, and microhabitat (Tables 2 and 3).

Actions: Actions are equivalent to those identified under Objective 2.A.

Objective 2.C: Medium priority restoration sites must be managed and restored to ensure 50 percent persistence for at least 20 years. Mean counts must exceed 30 reproductive stems for 6 individual years over a 10-year period (a period long enough to include a full high-low lake level cycle) (Figures 5 and 13, Table 9).

Actions: Actions are equivalent to those identified under Objectives 2.A and 2.B.

GOAL 3: PROMOTE CONDITIONS THAT FAVOR A POSITIVE METAPOPULATION DYNAMIC

For the foreseeable future, conservation efforts will focus on increasing the population of Tahoe yellow cress by affecting the factors that positively influence the metapopulation dynamic of this species (Table 5). Section II.C discusses the biological understanding of the metapopulation dynamics as it relates to species recovery.

Objective 3: Colonization should be observed at 10 sites where colonization has not been observed before. These additional colonization events will indicate that efforts to encourage a positive metapopulation dynamic are successful (Section II.C).

Actions: Complete a thorough, GIS-based inventory of potential Tahoe yellow cress habitat in the shorezone.

Map potentially suitable habitat that is adjacent to core and high priority restoration sites. Public landowners will consider managing these areas to promote colonization. Private landowners adjacent to these areas will be contacted by the stewardship group to explore if the landowner is interested in participation in the stewardship program.

Conduct surveys in potentially suitable habitat adjacent to large natural or large restored populations in order to detect and determine the factors governing colonization events.

Manage and protect actual and potentially suitable habitat to increase the probability of colonization (Figure 2, Tables 6 and 7).

Use monitoring data to demonstrate a significant increase in the colonization/extirpation ratio during a 10-year period (Figure 2).

GOAL 4: CONDUCT RESEARCH THAT DIRECTLY SUPPORTS MANAGEMENT AND RESTORATION

The ability to successfully manage Tahoe yellow cress is limited by our understanding of the biology of the species. Reintroduction experiments present the greatest opportunity for increasing our knowledge of Tahoe yellow cress. At each step during seed collection, propagation, and outplanting of Tahoe yellow cress knowledge can be gained if adequate forethought is given to methods and sampling design. A discussion of research needs can be found in Section II.L.

Objective 4: Implement a program of experimental reintroductions of Tahoe yellow cress to appropriate core and high priority restoration sites in order to determine the techniques, habitat conditions, and logistical factors that will optimize the chances for successful restoration.

Actions: Experiments should test management-oriented hypotheses (Pavlik 1996) regarding critical variables (e.g. soil moisture, visitor impacts, microhabitat, Table 2).

A framework comprised of goals and objectives should be established for each experimental population (Pavlik 1996) and optimizing features (e.g. hardened founders) must be built into the design of the reintroductions.

Demographic and physiological monitoring (Pavlik 1994, 1996) should be conducted to provide the data for hypothesis testing and the formulation of restoration prescriptions.

Continue the experimental program and its monitoring components for at least 8 years to allow exposure of the reintroduced populations to a full range of environmental variation (Figure 5).

Develop restoration prescriptions that are based upon the experimental reintroductions and apply them to high and medium priority restoration sites (Goal 3).

Make restoration prescriptions and materials available to all landowners and managers, public and private.

GOAL 5: REVISE AND CONTINUE THE MONITORING PROGRAM FOR TAHOE YELLOW CRESS

Past monitoring efforts have been critical to understanding how to manage this species. The annual monitoring effort should continue to evaluate whether or not the conservation strategy is being successfully implemented.

Objective 5A: Revise the existing monitoring program to improve its accuracy, efficiency, and utility.

Actions: Utilize datasheets (Appendix N) that accommodate GPS-defined sites and population locations, and that better define the monitoring procedures and effort.

Link monitoring effort (e.g. proportion of sites surveyed per year) to average lake level: The higher the lake level (e.g. height at or above 6,226 ft; 1,897.68 m LTD) the greater the proportion of sites surveyed. Sound statistical guidelines should be adopted.

Maintain continuity of the longest data records by emphasizing those sites designated as primary monitoring sites.

Keep monitoring records for natural and experimental populations separate.

Utilize the data storage and analysis formats established in this CS (Appendices C, D, E, F and G and the figures and tables presented herein).

Objective 5B: Develop a separate database of metapopulation events, especially those related to conservation and restoration activities.

Actions: New datasheets for recent colonizations should prompt a record-keeping mechanism that tracks new populations and describes their circumstances (Table 7, Goal 4).

Sites with recent extirpations must also be tracked to detect recolonizations and to better understand the demographic significance of gaps (Figures 1 and 4).

GOAL 6: IMPLEMENT AN INTERAGENCY ADAPTIVE MANAGEMENT FRAMEWORK

The future of conservation efforts cannot be fully described at the present time. New knowledge and new techniques will become available as we move forward with the monitoring and research programs. Coordinated efforts and evaluation of those efforts will be the foundation for an adaptive management framework that will enhance our ability to more successfully manage and protect this species.

Objective 6: Effectively carry out the adaptive management scheme outlined in Section II.H by producing 6 years of annual reports.

Actions: Establish an adaptive management framework (Figure 18) for promoting the flow of information between the elements of management, monitoring and research, and between the major public and private stakeholders.

Produce an annual report described in the MOU/CA.

Establish the AMWG to integrate Tahoe yellow cress conservation actions into the basin-wide restoration and planning efforts.

Develop a standard set of policies, procedures, and funding sources that secure Tahoe yellow cress populations from effects of lake level changes and direct, human-induced habitat disturbances, maintain ecological processes in the shorezone, and provide for the necessary research, monitoring, and restoration programs. The executive committee will complete this with advice from the TAG. The executive committee will work within the authorities of the Region's entities and follow procedures to recommend, approve, or make administrative decisions within each governmental structure. Utilize data from the monitoring program to aid in decision-making relative to Tahoe yellow cress conservation, restoration, and recovery.

II.G. DESCRIPTION OF MANAGEMENT ACTIONS

Essential components of the CS for Tahoe yellow cress include protection, restoration, monitoring, research, and ongoing adaptive management. These efforts will be designed to secure current populations against extirpation and to increase their numbers; to expand the current distribution of populations to new and historic sites; to sustain existing and newly established populations over the long-term; and direct future management action though adaptive responses informed by monitoring and research. The following actions provide the necessary support for the Tahoe yellow cress CS and its goals and objectives.

Protect priority ranked sites that support persistent natural populations

Six core sites (Taylor Creek, Upper Truckee East, Tallac Creek, Edgewood, Blackwood South, and Blackwood North), 6 high priority restoration sites (Glenbrook, Eagle Creek, Ward Creek, Meeks Bay, Cascade, and Kahle/Nevada Beach), and 12 medium priority sites (see Tables 10 and 11) will be protected to reduce impacts from human visitors and environmental disturbances that can compromise habitat conditions that support Tahoe yellow cress. Areas subject to chronically high visitation may require boardwalks or well-marked trail systems to direct traffic away from plant populations. Permanent fences will only be necessary in areas of greatest sensitivity on public lands where previous protections have failed. Temporary fencing may be required at all sites during years with high lake levels to reduce accidental trampling and redirect traffic. Additional conservation responses may be necessary in years during which average lake level exceeds 6,226 ft (1,897.68 m) LTD, when human activities are concentrated into very limited beach and back dune areas.

Enforcement and legal responses of each agency under its given authority will be vital to the success of this conservation strategy. The outreach program will provide information to the public regarding violations that may occur and whom to contact in the event any violations are observed (Appendix K). A concerted effort between public and private entities will enable lands supporting Tahoe yellow cress to be protected.

In response to information needs and to initiate recovery of Tahoe yellow cress across its historical distribution, experimental reintroduction efforts will be implemented. Experimental populations will be secured by fencing and posted with informational signs prior to installation. Introduced plants will be segregated from natural populations to provide a clear distinction between experimental and natural populations.

Develop site-specific management/action plans for core and high priority restoration sites

A fundamental element of coordinating the conservation effort for Tahoe yellow cress is collectively planning for the future. Each entity will lend its expertise to assist other partners in formulating plans for core and high priority restoration sites. It is envisioned that each site-specific management/action plan will take a 3 to 5 year look into the future and discuss conservation actions in general terms. These plans will include site-specific ecology, potential protection measures and access control, if necessary; appropriate reintroduction efforts; monitoring efforts; and research needs. Because of the uncertainty in management and environmental conditions, detailed plans are not necessary or desirable. These plans will change as more knowledge is gained about conservation needs and management techniques. A preliminary list of actions is provided in Appendix J.

The development of these plans will also serve as part of the consultative process between agencies. By working together to develop and revise the plans, all participating entities will remain fully apprised of the actions of other agencies. This process will not only help increase the effectiveness of conservation efforts but will result in the streamlining of projects. The TAG will provide technical assistance for each site plan, and in the spirit of collaboration each public agency will implement projects consistent with their authorities and available resources.

Through the stewardship program (Section II.J), assistance will be available to private landowners whose properties support core and high priority restoration sites. Guidance will be provided, if requested, on the development of site-specific plans, and TAG members from regulatory agencies will assist with the any regulatory requirements for landowners participating in the stewardship program.

Manage all sites that currently support Tahoe yellow cress

All currently ranked and unranked sites that are occupied or have been occupied by Tahoe yellow cress will be managed to protect the species.

On public lands, unoccupied potentially suitable habitat will be surveyed at least once every 2 years to identify new colonization events. Any newly colonized habitat would then be managed as occupied habitat (see above). In addition, the following rule set applies for unoccupied potentially suitable habitat:

- No alteration of shoreline, beach, or other perishore land features or hydrology without project review and protection of potentially suitable habitat;
- Consider management actions that encourage colonization; and
- No introduction of nonnative plants and control of these species, if present.

On private lands, the focus of management will be to encourage stewardship of this species. A stewardship program will be developed to assist private landowners (Section II.J). Ideally private landowners will protect this species on a voluntary basis. The TAG will be available to provide assistance to private landowners whose properties support core and high priority restoration sites.

Based on the analysis of existing data (Section II.D), management targets (Table 9; Goal 2) for Tahoe yellow cress populations have initially been set at more than 1,200 individuals (stems) at core sites, a level that should allow population persistence for 20 years with 90 percent assurance. Interim target population sizes for high priority sites should be greater than 300 stems, which would provide 75 percent likelihood of persistence for the same period, and, greater than 30 stems should be the interim target population size goal at medium priority sites, giving a 50 percent chance of persistence. Further research and adaptive management will enable us to appropriately adjust these targets.

Carry out experimental reintroduction efforts

Reintroduction efforts should be undertaken at all high priority and medium priority restoration sites once additional information on the genetic make-up has been obtained. This component of the overall CS will require establishment and maintenance of laboratory stock or stocks including seeds and plants in different stages of maturity. More than one laboratory or greenhouse facility will be used for propagation of captive stock and seed storage. Reintroduction efforts will be carried out in an experimental framework with clearly articulated restoration, population, and research objectives. Experimental reintroduction attempts will strive to identify the range of hydrological and topographic circumstances that sustain individual Tahoe yellow cress populations through variations in lake level and weather. Experiments will investigate optimization strategies in outplanting, by using multiple plantings with individuals of varying ages. Contingency measures will be developed for each reintroduction site in the event of an unsuccessful experiment.

As populations are established they should be subject to standardized monitoring employing archival and annual survey data sheets (in addition to focused tracking associated with experimental design). All data and reports will be submitted to the TAG regardless of which entity conducts the reintroduction.

Monitor natural and reintroduced populations

All extant and reintroduced populations will be subject to an initial (archival) assessment of physical and biotic circumstances, and the site and population boundaries will be documented using GPS technology. Photographs of the actual habitat supporting the species will be taken along the cardinal compass directions. Thereafter annual monitoring of stems (for population census) will occur in all years with lake level in excess of 6,226 ft (1,897.68 m) LTD at all ranked and unranked sites. At lake levels below 6,226 ft (1,897.68 m) LTD, and with concurrence from the TAG, monitoring may be reduced to a subsample of the 24 primary (ranked) and additional secondary (unranked) population sites. Monitoring efforts must be standardized on archival (initial or baseline) and annual survey forms (Appendix N). Data will be entered into an appropriate spatially explicit data storage system and subject to annual review and appropriate analysis.

To better understand Tahoe yellow cress metapopulation dynamics, potentially suitable habitat in areas surrounding both established and reintroduced populations will be monitored annually to ensure colonization/recolonization events are documented. For standardization purposes this search will be limited to a predetermined number of person hours per year and limited to the areas identified in Figure 20. If possible, intensive visual surveys should extend from occupied sites in both directions to the streambank of the next adjacent watercourses entering the lake, or until unsuitable habitat is encountered. Newly established populations (or individuals) should be recorded on an archival survey sheet and subsequently monitored annually. Environmental characteristics (the physical and biotic circumstances) associated with such successful colonization events should also be documented on the appropriate data sheet.

Develop an interagency low population fencing and management permit

The time required to acquire the necessary permits to place protective measures in the shorezone could present a hindrance to the protection of Tahoe yellow cress. Regulatory agencies will work to develop a master permit for protective fencing and projects that could be activated during low population numbers (Section II.I). This permit for conservation action could be tied to the management/action plans developed for specific sites.

Maintain a site ranking for every site

Table 13 shows the initial adopted ranking of known Tahoe yellow cress sites. This table was derived from data and analysis in Section II.D (Table 10). This table, and any subsequent modifications, will serve as the adopted site ranking for purposes of the goals, objectives, and actions addressed in Sections II.F and II.G. This table relies entirely on the ranking outlined in Section II.D (Table 10); however, it has been modified to reflect the changed hydrologic conditions at Kahle/Nevada Beach. The TAG will develop ranking criteria and rank all currently unranked sites (Table 11). The TAG will also rank newly colonized sites.

Table 13. Adopted ranking of known Tahoe yellow cress sites. Unranked sites will be ranked and new sites will be ranked as found.

Core Sites	**Medium Priority Restoration Sites**	**Low Priority Restoration Sites**
Taylor Creek (USFS)	Upper Truckee W (CTC)	Pope/Kiva (USFS)
Upper Truckee E (CTC)	Rubicon Bay (Private)	Sand Harbor (Nevada)
Tallac Creek (USFS)	Emerald Point (California)	El Dorado Beach (City SLT)
Edgewood (Private)	Zephyr Cove (USFS)	Secret Harbor (USFS)
Blackwood S (Placer Co)	4-H (U Nevada)	Regan/Al Tahoe (Private)
Blackwood N (Private)	Baldwin Beach (USFS)	
High Priority Restoration Sites	Timbercove (Private)	
Kahle/Nevada Beach (USFS)	Logan Shoals (Private)	
Glenbrook (Private)	Eagle Point (CDPR)	
Eagle Creek (CDPR)	Tahoma (Private)	
Ward (Private)	Tahoe Keys/Lighthouse (Private)	
Meeks Bay (USFS)	Tahoe Meadows (Private)	
Cascade (Private)		

Initial management and monitoring responsibilities

The signatories have developed a list of initial management and monitoring responsibilities (Table 14). Different entities have agreed to perform specific conservation actions. Some of these actions are clearly the responsibility of one or two entities, and some of the actions require consideration by the TAG and executive committee. This list represents commitments by the assigned to these actions within the confines of funding by the appropriate legislative authority.

Consider revisions to existing TRPA MOUs

TRPA will initiate discussions with its MOU partners to revise existing agreements to enable and facilitate the implementation of the CS by participating agencies. Because Tahoe yellow cress occurs in the shorezone of Lake Tahoe and a significant amount of TRPA regulation is focused in the shorezone, modifications to the existing agreements may be complex.

Consider development of a "Safe Harbor" program

The USFWS, TRPA, NDF, and CDFG will work with participating entities to consider and possibly develop a policy, which provides incentives for private and other non-federal property owners to restore enhance, or maintain habitat for Tahoe yellow cress. Federal land managers are required to conserve Tahoe yellow cress, but because this species and its habitat occur largely on non-federal lands, the involvement of non-federal property in the conservation and recovery of Tahoe yellow cress is integral to the eventual success of this effort. Under the policy, to the extent feasible with the constraints of existing protective regulations (i.e., CESA, NRS 527-260 *et seq*., and TRPA code), the USFWS, TRPA, NDF, and CDFG will work to find an acceptable policy that provides future protection to non-federal landowners involved in a stewardship program. Consideration of a policy will be developed through the adaptive management process once the necessary research has confirmed and refined the minimum viable population size for Tahoe yellow cress. The TAG will make recommendations to the executive committee about such a policy, and the executive committee will decide how to provide. This policy could provide the assurances necessary to successfully engage property owners in the conservation of Tahoe yellow cress.

Recommendations from the Tahoe Yellow Cress Stewardship Group (TYCSG)

As described in Section II.J, the TYCSG will play an integral role in the protection of Tahoe yellow cress on private lands. The TAG will solicit input and recommendations from this group for its annual reports. Members of the TYCSG as well as other private landowners will also be encouraged to participate in annual surveys.

Address water level management within Lake Tahoe

Although water levels are one of the critical factors in the population dynamics of Tahoe yellow cress, there is no clear method to address water level management. The water level in Lake Tahoe is controlled by water rights and prior court decrees, i.e., 1914 General Electric Decree, 1935 Truckee River Agreement, which was incorporated into the 1944 Orr Ditch Decree. The Truckee River Operating Agreement (TROA) being developed at the present time will address the operation of the water supply in the Truckee River system. According to the latest TROA models, it is anticipated that TROA will only minimally affect lake/reservoir levels. Members of the TAG may work through the pending TROA environmental review process to explore reduction or mitigation of any potential impacts of TROA on Tahoe yellow cress habitats.

Consideration of upland environmental improvement projects

In the immediate future a large number of upland environmental improvement projects, some of which are essential to improve water quality from existing developed areas, and other projects will be occurring within the Lake Tahoe watershed. Some of these projects may have impacts at the mouth of watershed outfalls where Tahoe yellow cress populations/habitat may exist. The TAG had first hand experience of this situation in consideration of the Park Avenue and Rocky Point projects. The anticipated key issues involved in these projects are how to analyze/assess the short- and long-term environmental effects and their level of significance from: 1) Changes in hydrology and hydraulic conditions, 2) changes in nutrient levels from the watershed; and 3) changes to the beach morphology. These types of projects need a process to analyze potential impacts to Tahoe yellow cress.

Identifying parameters that will enable projects to move forward while protecting Tahoe yellow cress is essential. Implementation of such projects should consider research opportunities so that answers to management-oriented hypotheses can be obtained as a result of the project, while protecting Tahoe yellow cress.

As more information regarding environmental effects is obtained, the threshold of significance may require adjustment. The TAG will forward a draft list of analysis methods and levels of significance to the executive committee by January 2003, and will review these levels and methods every year as part of the adaptive management program. Some of the key management questions for the adaptive management strategy will focus on the issue of project analysis.

The TAG will also forward to the executive committee a strategy for consideration of impacts to Tahoe yellow cress when information is unclear or the impacts to Tahoe yellow cress are uncertain. This strategy will include timelines and information required to provide the tools for an appropriate environmental analysis. The TAG will allow for discussion of upland environmental improvement projects at its meetings in order to assist jurisdictions planning projects.

Table 14. Five Year Plan for Management and Monitoring Responsibilites

Conservation Actions	Entity to Implement	Estimated Total Costs
Assist in development of a conservation/management strategy/agreement	All Parties	$80,000
Develop and implement an adaptive management strategy	All Parties	$10,000/yr[1]
Assist with funding for conservation plan/agreement	All Parties	Staff Time
Assist in development of site-specific conservation recommendations for occupied sites		
– Upon completion of annual surveys, appropriate measures will be developed for each observed site	All Parties	Adaptive Mgnt[2]
--Develop Mgnt Plans for all Core and High Priority Sites	All Parties	$5,000/site[1]
--Develop Mgnt Plans for all Low Priority Sites and unranked sites	All Parties	$5,000/site[1]
– Determine when physical barriers to access are necessary at special events	All Parties	Staff Time
Develop generalized restoration/reintroduction methods	TAG	$10,000
Provide technical assistance to other partners		
– Make qualified personnel available to conduct surveys, serve as biological monitors for projects, interface with the public for outreach efforts, etc.	All Parties	Staff Time
Assist in development and implementation of annual survey and monitoring program		
– Standardize survey and monitoring data collection sheets for use by all agencies	TAG	Adaptive Mgnt[2]
– Develop standardized data dictionary for GPS/GIS	TRPA	Staff Time
– Conduct presence/absence surveys of all known and suitable sites	All Parties	$10,000
– Conduct site specific monitoring for specific issues.	All Parties	$5,000
– Prepare annual survey and monitoring reports	All Parties	$1,500
– As part of the adaptive management effort assess survey and monitoring program and revise as necessary	All Parties	Adaptive Mgnt[2]
--Develop brochure on sensitive shorezone species, including TYC	TRPA/USFS/ USFWS/NVSL	Done
Assist in development and implementation of outreach/education program		

Table 14. Five Year Plan for Management and Monitoring Responsibilites

Conservation Actions	Entity to Implement	Estimated Total Costs
– Develop brochures and posters that will be available through the agencies, hotels and other visitor facilities (including printing)	TYCSG/TAG	$6,000
– Include articles in local newspapers	TYCSG/TAG	Staff Time
– Develop news stories for radio play	TYCSG/TAG	Staff Time
-- Conduct annual "marine contractor" education event.	TYCSG/TAG	Staff Time
-- Conduct annual "enforcement" personnel education event.	TYCSG/TAG	Staff Time
-- Conduct annual landscapers education event.	TYCSG/TAG	Staff Time
-- Conduct annual Public Utility District education event.	TYCSG/TAG	Staff Time
– Develop website specific to TYC with link to agency sites (website will ultimately focus on the sensitive resource issues in the Tahoe Basin)	TYCSG/TAG	Staff Time
– Develop educational packages for teachers	TYCSG/TAG	$2,000
– Develop informational packages for local entities (i.e., homeowners associations, PUDs, etc.)	TYCSG/TAG	$2,000
– Develop interpretive presentations for campfire gatherings, etc.	USFS/CDPR/NVSP	$2,000[3]
– Initiate landowner contacts to identify those willing to sell or exchange	TYCSG/TAG	Staff Time
– Update all information used for outreach and educational purposes	TYCSG/TAG	Staff Time
Forward all survey and monitoring results to NNHP and CNDDB on the appropriate data sheets	All Parties	Staff Time
Information Distribution		
– Develop mechanism to receive and distribute information from various entities, including the public (i.e., via website)	TRPA	TIIMS[4]
-- Develop mechanism to distribute example conservation mgnt plans.	TRPA	TIIMS[4]
Coordinate enforcement activities with NDF and CDFG		
– Assist in development of a notification process to ensure appropriate levels of enforcement and compliance	All Parties	CS[5]
– Promptly notify NDF or CDFG of any possible violations of state laws protecting TYC	All Parties	CS[5]
– Document violation thoroughly when observed	All Parties	CS[5]

Table 14. Five Year Plan for Management and Monitoring Responsibilites

Conservation Actions	Entity to Implement	Estimated Total Costs
--Increase compliance inspections	All Parties	Unknown
– Pursue enforcement actions as needed	All Parties	Unknown
– Require biological monitors on construction projects	All Parties	$500/site
Identify and implement research needs		$200,000
– Seed harvest/stockpile	TAG	
– Propagation	TAG	
– Germination	TAG	
– Pollination	TAG	
– Environmental Conditions	TAG	
– Genetic diversity	TAG	
– Life history	TAG	
– Outplanting success	TAG	
Assist with outplanting, propagation, nursery/greenhouse research activities	All Parties	Adaptive Mgnt[2]
Redesign and reconstruct existing enclosures	USFS	
– Maintain enclosures at Baldwin Beach (Taylor Creek and Cascade)	USFS	Done
– Monitor habitat/population changes within enclosures using protocol	USFS	
– Redesign, produce, and install signs for enclosures	USFS	$40/sign
– Conduct necessary maintenance on enclosures and signs	USFS	$1,000/yr
– Redesign, reconstruct enclosures at Meeks Bay and Nevada Beach	USFS	Done
Locate and construct additional enclosures		
– Investigate historic locations and determine potential for restoration and construction of enclosures	USFS	
– Construct new enclosures and conduct outplanting	USFS	
– Monitor habitat/population changes	USFS	
Create position to be dedicated to botanical resource issues	USFS	Done
Identify privately-held occupied and potentially suitable habitat for possible acquisition by appropriate agencies from willing sellers.	TAG	Staff Time
Investigate limiting recreational use at beaches supporting TYC		
– Consider beach use limitations guidelines	TAG	Adaptive Mgnt[2]
– Tallac Creek Marsh Restoration Feasibility Study	USFS	$5,000
Increase patrolling of beaches to ensure no trespass into enclosures	USFS/CDPR/NVSP/ CTC	Unknown

Table 14. Five Year Plan for Management and Monitoring Responsibilites

Conservation Actions	Entity to Implement	Estimated Total Costs
Review management plans, survey and status reports, provide technical assistance	USFWS	Adaptive Mgnt[2]
Support outreach, research, and seed bank efforts through section 6 or other funding mechanisms	USFWS	Staff Time
Review, revise and implement construction and access guidelines to provide more protection to TYC sites	TAG/Exec Committee	Adaptive Mgnt[2]
Assist with enclosure reconstruction	CTC	
– Assist agencies with construction of exclosures	CTC	Unknown
– Assist USFS with reconstruction at Baldwin Beach and implementation of monitoring program to study the effects of the fence modification and exclosure expansion; report available October 2000	CTC	Done
Provide staff and resources to assist with TYC surveys, including GPS and other equipment and GIS support	All Parties	
Broaden existing stewardship program to include TYC	TYCSG	
– Stewardship agreements	TYCSG	
– Public education	TYCSG	
– Planning and site improvement grants for establishment of TYC preserves and introductions	TYCSG	
– Acquisitions of conservation easements	TYCSG	
--Identify owners and managers of private parcels containing TYC for outreach purposes	CDFG/NDF	$1,500
– Develop and distribute informational letter outlining TYC situation, conservation efforts, and legal permitting requirements on private lands	CDFG/TAG	$3,000
Develop and implement conservation strategy for Barton site to ensure TYC protection	CTC	
Reconstruct portions of D.L. Bliss exclosure	CDPR	
Identify suitable habitat where exclosures could be constructed	CDPR	
– Construct new exclosures and conduct outplanting	CDPR	
Conduct necessary maintenance on exclosures and signs	CDPR	
Provide GPS/GIS support	TRPA	$1,500

Table 14. Five Year Plan for Management and Monitoring Responsibilites

Conservation Actions	Entity to Implement	Estimated Total Costs
Incorporate TYC database into real-time data management system	TRPA	TIIMS[4]
Update range-wide TYC databases with new survey and monitoring data as received and ensure these data are available to all interested entities	NNHP/TRPA	Adaptive Mgnt[2]
Assist with outplanting, propagation, nursery/greenhouse research activities	All Parties	Adaptive Mgnt[2]
Assist with re-introduction projects	NVSP	Unknown
Develop and implement conservation strategies for TYC sites affected by public access issues	Public Utility Districts	Unknown
Assist with outreach and stewardship programs	TLOA	
– Encourage participation in annual surveys and monitoring efforts	TLOA	N/A
– Include information on TYC in newsletters	TLOA	$2,000
– Work with agencies to coordinate workshops and informational meetings for interested parties	TLOA	$2,000
-- Develop the TYC Stewardship Group	TLOA	Unknown
– Facilitate contact with other private entities and associations not affiliated with TLOA	TLOA	N/A

1. Does not include environmental documentation if needed.

2. Items listed as "Adaptive Management" will be covered in the annual activities of the TAG, and mainly includes staff time.

3. Completed by CTC and USFS.

4. TIIMS (Tahoe Intergrated Information Management System) is being developed by regional agencens under specrate contract.

5. Indicated that this action has been completed as part of the Conservation Strategy (CS).

II.H. ADAPTIVE MANAGEMENT FRAMEWORK

The Tahoe yellow cress CS depends upon the successful implementation of an adaptive management framework designed to bring new information immediately into new management direction. A step-down outline of the framework is presented in Figure 18. It briefly describes the key steps in acquisition, transfer, storage, analysis, and assessment of data from monitoring and research. It is important to recognize that agencies that have committed to implement the CS may choose to add further responsibilities or dissect described steps to better articulate intended tasks. Each of the steps presented in Figure 18 are requisite to ensure the success of the CS. It is critical that the signatories provide the resources necessary to ensure successful implementation of the adaptive management framework. Resources to implement the framework will be reconsidered by the TAG, AMWG, and executive committee for the forth year and beyond. Until an AMWG is established, the TAG will report to the executive committee. The AMWG will serve to further develop the salient details of the adaptive management framework. It should also be noted that each entity within the Region has additional governmental structures and limitations of their authority. The authority granted to each agency limits the actions of that agency. In addition, a number of agencies have governing boards that ultimately set policies and allocate funding. Figure 18 does not show these additional structures.

The adaptive management framework largely describes the movement of information. Several boxes require expanded and explicit descriptions of responsibilities, authorities, and action plans that will need to be customized by each agency and amended both between and within years. Lines of responsibility and authority for each agency with Tahoe yellow cress conservation obligations will be described and filed for each site and each year with the data manager.

The following descriptions by box number describe the adaptive management framework. The associated gantt chart identifies calendar dates for completion of the annual activity cycle (Figure 19).

Box 1: Until an AMWG is formed, the executive committee shall integrate Tahoe yellow cress conservation actions into basin-wide restoration efforts. Tahoe yellow cress conservation actions will be carried out so as to be compatible with forest management, biodiversity-related conservation actions, watershed management, and recreation planning. The AMWG will review TAG recommendations to integrate them into a program of basin-wide priority actions and expenditures, in turn making recommendations to executives as part of basin-wide resource planning activities.

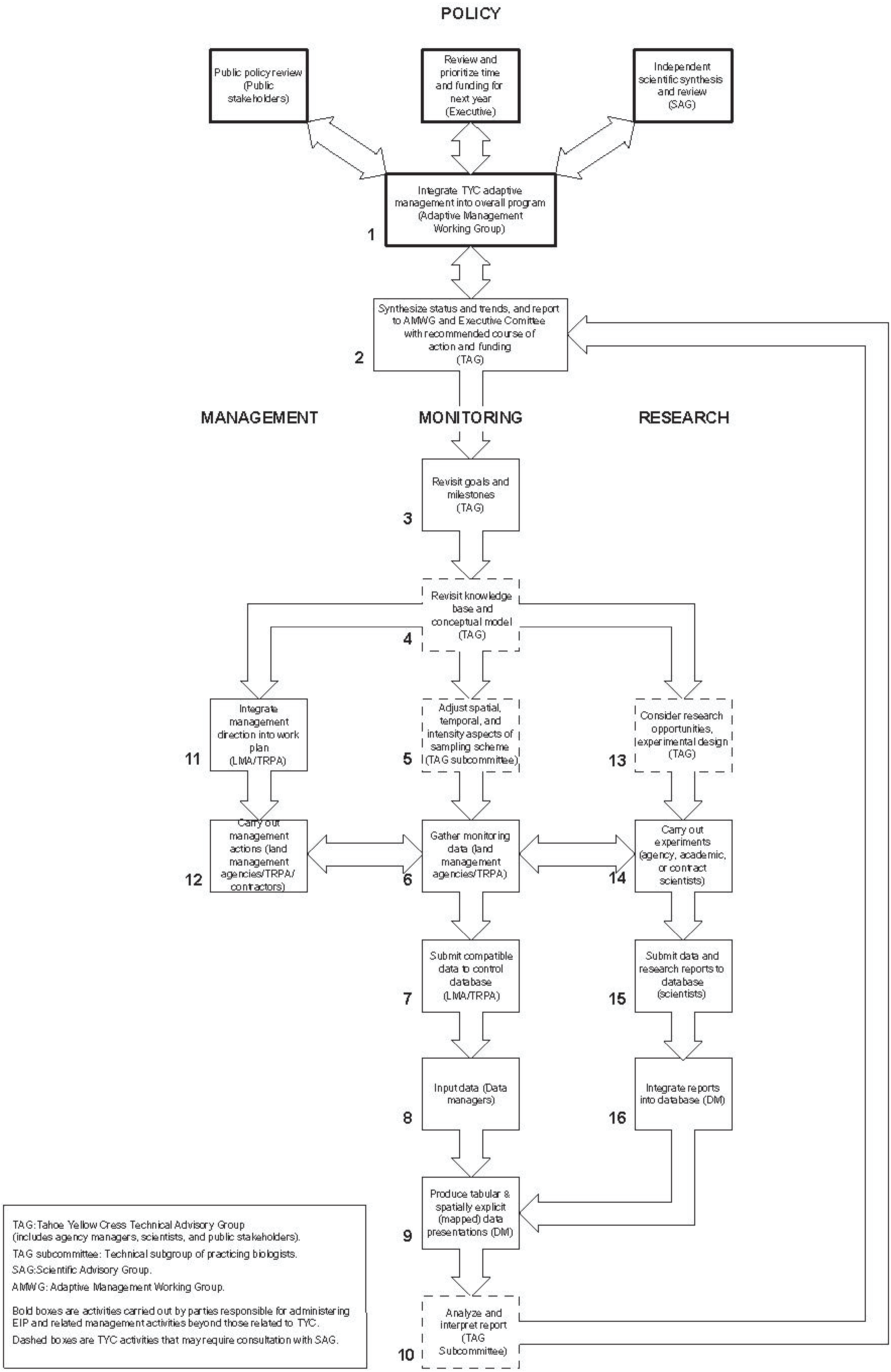


Figure 18. Adaptive managment framework and assignments

		March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
1	Integrate TYC adaptive management into overall program.	■	■	■	■	■	■	■	■	■	■	■	■
2	Synthesize status and trends, and report to AMWG and executive committee with recommended course of action and funding												■
3	Revisit goals, objective and milestones.									■	■		
4	Revisit knowledge base and conceptual model.									■	■		
5	Adjust spatial, temporal and intensity aspects of sampling scheme.									■	■		
6	Gather monitoring data.				■	■	■	■					
7	Submit compatible data to control database.							■					
8	Input data.							■	■				
9	Produce tabular and spatially explicit (mapped) data presentations.								■				
10	Analyze and interpret report.									■			
11	Integrate management direction into work plan.	■	■	■									
12	Carry out management actions.				■	■	■	■					
13	Consider research opportunities, experimental design.	■	■	■	■	■	■	■	■	■	■	■	■
14	Carry out experiments.				■	■	■	■					
15	Submit data and research reports to database.							■					
16	Integrate reports into database.								■	■			

Figure 19. Timeline describing annual cycle of adaptive management actions

Boxes 2 and 3: The TAG will synthesize and interpret data on Tahoe yellow cress status and trends (with evidence from its technical subcommittee); identify and periodically reassess conservation planning goals for the species; reassess the site rankings (Table 10); establish monitoring targets, intensity, and frequency compatible with the goals, to ensure that data collected appropriately measure progress toward program goals; and oversee data management efforts and production of data products, including reports, maps, and other graphical representations of species information.

Boxes 4 and 5: The TAG will update the Tahoe yellow cress knowledge base. Spatial and temporal aspects of monitoring will be adjusted through time as the information base builds in time series (some previously acquired data may prove less valuable than others and collection may be terminated; newly recognized conservation applications may require new or differently resolved monitoring data). This review will be done in consultation with appropriate members of the Scientific Advisory Group (SAG) and/or other independent experts.

Box 6: Each land management agency will gather annual monitoring data using the standardized survey protocol and forms (Appendix N, as amended) in collaboration with other agencies or individuals party to the conservation agreement.

Boxes 7, 8, and 9: Data so gathered will be submitted to the NNHP for incorporation into the database. Display products that require specific GIS capacities may be produced by NNHP in collaboration with TRPA. Data resulting from ongoing research projects will be submitted in the form of final reports and spatially explicit products compatible with the NNHP Tahoe yellow cress database. A report with updated maps and tabular data will be provided to the TAG.

Box 10: Updated map information, newly filed research reports, and other available information will be reviewed by the TAG technical subcommittee. Results of these deliberations will be communicated to the TAG so that annual conservation planning actions, including prioritization of actions and funding requirements, can be identified.

Boxes 11 and 12: Management planning, as noted above, will be carried out by each land management agency whose lands support Tahoe yellow cress or its habitat. Management planning on private lands shall be carried out in cooperation with amenable private landowners or their representatives, TRPA, and applicable state agencies. The TAG members representing each agency will coordinate to maximize information transfer between those facilitating the advancement of the CS and those implementing management actions. The TAG members will assist in developing and reviewing all management, restoration, or other activities that may affect Tahoe yellow cress individuals, its habitat, or areas identified as potential reintroduction sites.

Box 13: The TAG, in collaboration with the SAG and appropriate independent scientists, will periodically consider research opportunities and experimental responses to management information needs. Request for proposals will be solicited based on the results of those deliberations and availability of funds.

Boxes 14 and 15: Research scientists contracted to carryout experimental manipulations of Tahoe yellow cress populations (or individual plants) in the field or laboratory will coordinate with and report to the TAG. Submission of research reports and data obtained by researchers will be via the TAG and will be a mandatory condition of grants or funding.

Box 16: Data managers, NNHP and TRPA, will integrate new data into the database.

II.I. IMMINENT EXTINCTION CONTINGENCY PLAN

A necessary component of any conservation strategy and/or adaptive management framework is to define the types and degree of actions to be taken when the number of populations and/or the sizes of populations become critically low. This kind of pre-planning for future action is necessary for the following three reasons:

1. There may be insufficient time between the identification of an imperiled population and need to take action;
2. the description of possible actions to be taken to save the species will be known to all stakeholders in advance; and
3. the level of effort and resource commitment is acknowledged by all agencies and stakeholders.

Any and all of these actions described below will be recommended by the TAG and reviewed by the executive committee. The executive committee will operate within the given authorities and procedures of their respective agencies.

Level 1:

When there are 6 core populations and a total of 15 (inclusive of the core populations) total populations (each with greater than 30 reproductive stems), or greater than 60% presence; the AMWG and TAG will recommend a course of action to the executive committee as part of the normal operation of the adaptive management framework. Existing guidelines and policies will remain in effect for protection of existing occurrences and potentially suitable habitat.

Level 2:

When there are 6 core populations and less than 15 (inclusive of the core populations) total populations (each with greater than 30 reproductive stems each) or 6 core populations and less than 60 percent presence:

1. New shorezone structures or shorezone alteration will only be permitted if a detailed survey has been conducted between June 15 and September 30, and the parcel in question is not listed as occupied or potentially suitable habitat in the 1993 shorezone survey;
2. all known core and high priority restoration sites will be fenced to restrict access. (All required permits will be obtained in a timely manner.);
3. all core sites on public lands that do not support Tahoe yellow cress at such time will be fenced to allow for recolonization;
4. propagation and reintroduction efforts will be expanded and outplanted areas will be protected; and

5. the extent of area for each population will be defined in the development of the site-specific management plans, or without such a plan, the area will be defined as the beach from meanlow water level to the backshore, and 50 ft (15.24 m) on each side of the population as measured from the most remote individuals.

Level 3:

When there are 5 or fewer core populations or less than 10 (inclusive of the core populations) total populations (each with greater than 30 reproductive stems) or less than 50 percent presence:

1. No new shorezone structures or shorezone alteration will be permitted in areas of occupied or potentially suitable habitat without a Tahoe yellow cress protection and management plan;
2. all known populations will be fenced to restrict access. (All required permits will be obtained in a timely manner.);
3. all core sites on public lands that do not support Tahoe yellow cress at such time will be fenced to allow for recolonization;
4. propagation and reintroduction efforts will be expanded and outplanted areas will be protected;
5. as a deterrent, any harm to existing plants will be fully investigated and prosecuted;
6. the USFWS will consider emergency listing the species;
7. the USFWS will approach the Federal water master, if high lake levels are believed to be contributing to the decline of the species;
8. the extent of area for each population will be defined in the development of the site-specific management plans, or without such a plan, the area will be defined as the beach from meanlow water level to the backshore, and 50 ft (15.24 m) on each side of the population as measured from the most remote individuals; and
9. regulatory agencies will develop a lake-wide fencing permit to protect Tahoe yellow cress and its habitat.

Level 4:

When there are 3 or fewer core populations or less than 7 (inclusive of the core populations) total populations (each with greater than 30 reproductive stems) or less than 40 percent presence:

1. No beach raking will be allowed;
2. no new shorezone structures or shorezone alteration will be permitted in areas of occupied or potentially suitable habitat;
3. all known populations on public lands will be fenced to restrict access;
4. all core sites on public lands that do not support Tahoe yellow cress at such time will be fenced to allow for recolonization;

5. propagation and reintroduction efforts will be expanded and outplanted areas will be protected;
6. any harm to existing plants will be fully investigated and prosecuted including, but not limited to, a fine of up to $5,000.00 per stem of damaged plant imposed by TRPA; investigation and prosecution by CDFG; and investigation and/or prosecution by USFWS if a knowing violation of State or Federal law has occurred; and
7. the extent of area for each population will be defined in the development of the site-specific management plans, or without such a plan, the area will be defined as the beach from meanlow water level to the backshore, and 50 ft (15.24 m) on each side of the population as measured from the most remote.

II.J. STEWARDSHIP PROGRAM, PUBLIC EDUCATION, AND OUTREACH

Stewardship program

Successful implementation of the CS will include the development of a stewardship program in which private landowners and public agencies may participate. The stewardship program will be designed to be a cooperative educational effort that encourages landowners and non-governmental entities to manage for the conservation of Tahoe yellow cress and, if possible, generate site-specific management plans. The TLOA has volunteered to organize the TYCSG, which will be a non-profit group whose mission will be to encourage the conservation of Tahoe yellow cress on private lands. Although this group has yet to be formed, TLOA plays an integral role in communicating to those it represents the importance of conserving Tahoe yellow cress on private lands. Establishing this foundation will assist in the promotion of the stewardship program.

Coordination with TYCSG will be through a stewardship subcommittee assigned by the executive committee. The subcommittee may attend TYCSG meetings, and provide technical assistance to the group. The subcommittee may also provide advice and assistance in the development of stewardship plans for private landowners. The Tahoe yellow cress monitoring efforts and analysis will be a helpful tool in measuring the effectiveness of the stewardship program. Upon completion and analysis of annual and archival monitoring efforts, the TAG will develop appropriate site-specific management recommendations. These recommendations may be used to assist landowners and non-governmental entities in development of their site-specific management plans. The TAG will be responsible for establishing overall objectives, and the stewardship subcommittee will work with the landowners and non-governmental entities to incorporate these objectives and recommendations into the site plans.

Working cooperatively with and providing education to landowners is essential to an effective, successful CS. Interfacing through the stewardship subcommittee, the TAG and the TYCSG may organize public presentations, and generate brochures and newsletters for distribution to lake front owners and non-governmental entities to inform them of the stewardship program process. In addition, informational signs may be designed specifically for private landowners interested in participating in the program (Appendix M).

To encourage cooperation and promote the importance of land and resource stewardship, the TAG will publish examples of successful partnerships with landowners choosing to participate in the program. In addition to these outreach efforts, the program will include a component that recognizes private landowners for their contributions to Tahoe yellow cress conservation. Forms of recognition may include awards for participation and cooperation, providing specialized signs for Tahoe yellow cress populations on private lands, and public ceremonies. The stewardship subcommittee will determine the nature and feasibility of such incentives.

To determine the effectiveness of stewardship actions taken, it is essential to conduct monitoring on private lands that support Tahoe yellow cress populations. While this monitoring does not have to be conducted by TAG members or other agencies, it is essential monitoring does occur. The subcommittee will provide requested assistance to private landowners with recognizing the species, implementing the monitoring protocols, filling out data sheets, and any reporting requirements.

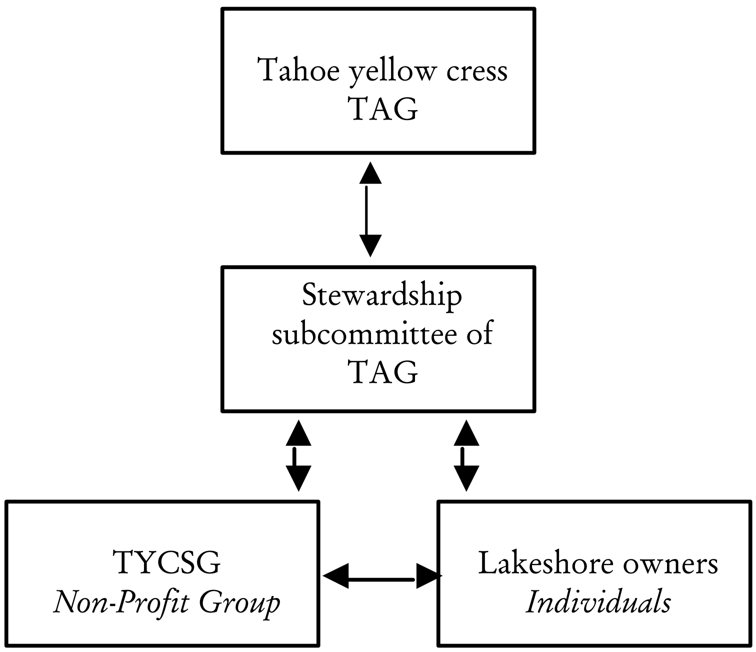


Figure 20. Organization of Tahoe yellow cress stewardship program.

Public education and outreach plan

A public education and outreach program is an important component of the stewardship program. The overall focus of education and outreach will be directed towards reducing the amount and severity of human activities that degrade Tahoe yellow cress and its habitat. Various outreach methods can be utilized to guide the public in the implementation of their site-specific management plans. The goals of this outreach plan will include communicating the following:

- Tahoe yellow cress is endemic to the shores of Lake Tahoe and grows nowhere else in the world;

- Tahoe yellow cress occurs in the shorezone which is heavily impacted by human activities in the Lake Tahoe basin;
- the biology of Tahoe yellow cress, including habitat needs, its imperiled status, and its response to human disturbance;
- the significance of preserving the species and other sensitive resources; and
- what must be done to protect Tahoe yellow cress and its habitat and how the public can assist in the conservation effort.

II.K. MONITORING, SCIENCE, AND RESEARCH AGENDA

Monitoring

An effective survey protocol will be implemented that includes a reliable census of known populations and systematic searches of unoccupied but potentially suitable habitat areas. In addition, physical and biotic conditions that are thought to determine Tahoe yellow cress presence and abundance will be assessed in order to develop a more complete understanding of the environmental correlates of habitat suitability. This knowledge will then be used to guide future management actions, especially to provide early warnings of imminent species declines.

The monitoring program outlined here will expand upon past efforts to incorporate the collection of data specific to measures of habitat condition and associated variables that should provide a more comprehensive, correlative explanation for the distribution and abundance of Tahoe yellow cress. The monitoring program will utilize appropriate data sheets (Appendix N) and will be capable of detecting shifts in the status of Tahoe yellow cress at all occupied locations and identify changes in key environmental variables that are correlated with those shifts, thus providing decision makers with guidance to take corrective management actions where necessary.

Changes in species abundance resulting from factors intrinsic to natural systems, such as stochastic variation, successional trends after natural disturbances, and cyclic variation, are integral to the metapopulation dynamic model and will be accounted for in monitoring activities and data analyses. However, because Tahoe yellow cress exists in so few locations and in such limited numbers, management intervention may be necessary even where change is not human. Indeed, the analyses of past data indicate that Tahoe yellow cress is responding to environmental variation of a cyclic character, with numbers of populations and (potentially) their sizes increasing with receding lake levels and diminishing with higher levels. Those observations suggest that management should be intensified at higher lake levels to reduce the possibility of extirpation events resulting from either human activities or stochastic environmental causes. Furthermore, monitoring should be intensified at high lake levels as well. At lake level 6,226 ft (1,897.68 m) LTD and above, population analysis should be carried out each year. Below 6,226 ft (1,897.68 m) LTD, surveys may be less frequent (every other year is advised).

The monitoring program will include use of the archival and annual data sheets (Appendix N). The archival survey sheet is designed to record key physical and biotic environmental data that include habitat characteristics that are not likely to vary significantly during future conservation planning efforts. Vegetation variables would be collected to serve as baselines for comparison with future data. Archival data should be obtained in the field at 5-year intervals. The annual survey sheet is for population census and assessment of dynamic local habitat variables (such as invasion by nonnative plant species) that may compromise habitat suitability for Tahoe yellow cress. Not all data necessary to assess environmental conditions that affect Tahoe yellow cress will be recorded on the survey forms. Macroenvironmental variables such as year-to-year variation in weather and lake level elevation will be housed in a centralized database and linked to the Tahoe yellow cress database.

The data sheets are compatible with the existing database to allow extension of ongoing analyses. This preserves the current, long-term record and allows further testing of hypotheses related to metapopulation dynamics and effects of population size on long-term persistence. Monitoring will be conducted according to established protocols identified in Appendix N.

A number of reductions, analyses, and presentations of the annual monitoring data will be performed, including: 1) Entry of data into an occurrence/absence spreadsheet (Appendix D) to allow calculation of persistence and presence parameters; 2) entry of stem count (estimates) data into a spreadsheet (Appendix E) to allow for recalculation of mean stem count at each site; 3) presentation of data from reintroduced populations in a separate spreadsheet; and 4) development a survey form for and database of recreational disturbance from all surveyed sites.

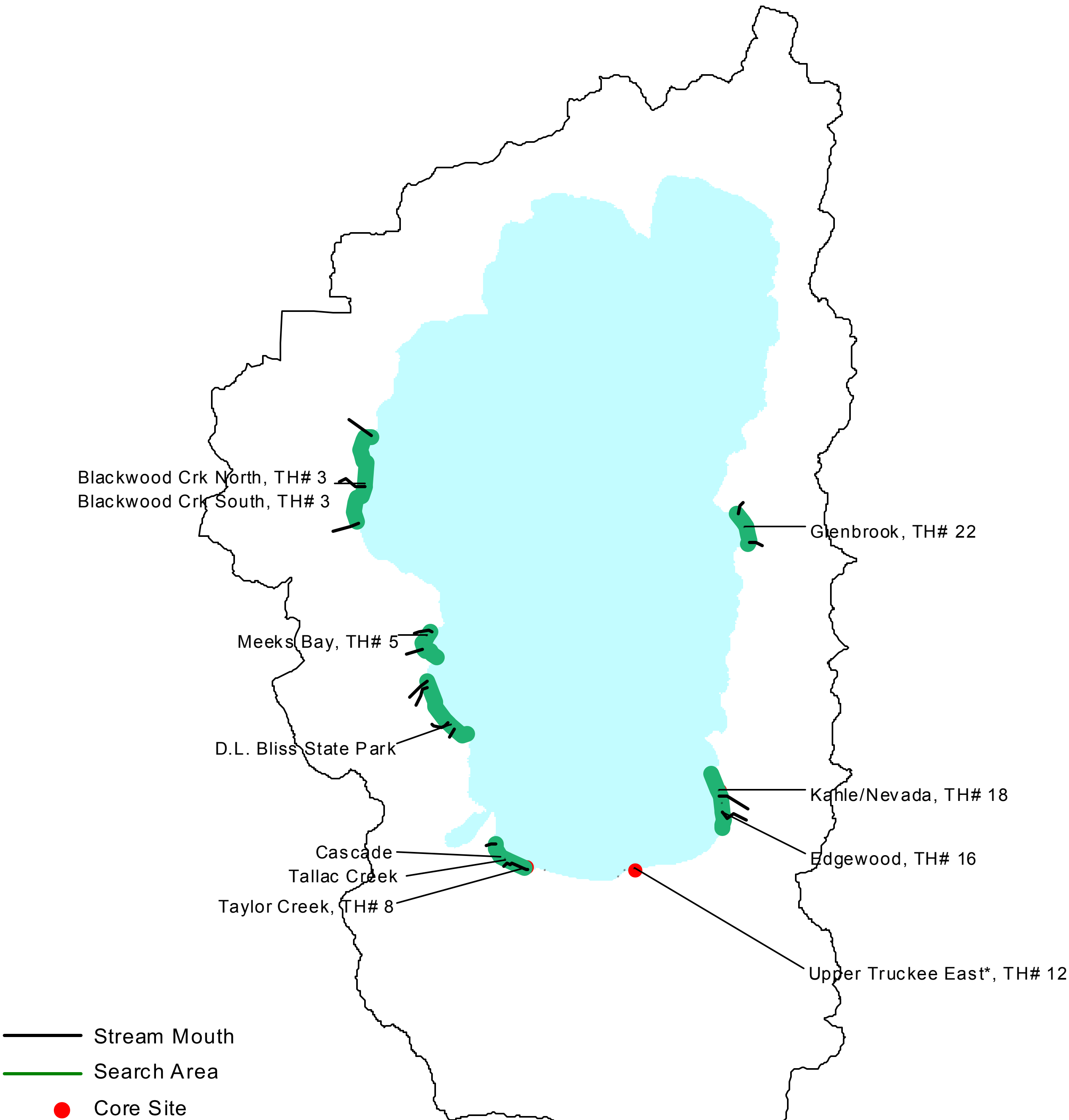
In addition, new populations, including satellite occurrences adjacent to current populations, will require that a new archival data sheet and subsequent annual data sheets be completed. Additional monitoring programs or amendments to current monitoring procedures will be developed to test the efficiency of site protections, management efforts, public education and outreach programs, and staff training procedures.

Research

The implementation of intensive and systematic monitoring protocols in addition to focused research will assist conservation planners to resolve data gaps essential to the overall, long-term CS. Pursuing additional information on the taxonomic status of the species, its life history, and many aspects of its community ecology is valuable in a broad scientific context, and may assist in providing necessary guidelines for Tahoe yellow cress conservation and restoration. Critical information on metapopulation structure and dynamics will be best gathered from experimental translocation/restoration efforts and tracking of resulting populations through time, as noted below.

The executive committee will annually review potential funding and allocate funds for research. The TAG, if so directed, will explore other funding opportunities for research on Tahoe yellow cress.

Figure 21



Public land should be searched every year for TYC. Private land should only be searched with the permission of the landowner.

TAHOE REGIONAL PLANNING AGENCY

Search Areas for New Colonizations

N

The TAG technical subcommittee will review design of experimental approaches, and both experimental research and monitoring protocols designed to support the CS will be reviewed periodically and adjusted to meet changing program needs. The following information needs are proposed in rough order of immediacy.

Presence, persistence, and population size

- Researchers need to test the hypothesis that the presence of Tahoe yellow cress populations is cyclical and largely determined by fluctuations in lake level. Data to test this hypothesis will come from well-designed monitoring protocols that produce occurrence/absence data from known occupied and historical sites as long time series.

- Further data from monitoring should be used to test the hypothesis that the size of Tahoe yellow cress populations are also cyclical and a function of lake level. Because population size responses are likely to be determined by complex environmental factors beyond lake level, experimental design must be multi-factorial and well controlled to differentiate among alternative hypotheses.

- Data from monitoring should be used to test the hypothesis that the persistence of Tahoe yellow cress populations is a function of stem numbers (the surrogate measure of population size). This effort will require exact and ongoing stem counts at all occupied sites in long time series.

- Data from population monitoring should be used to examine which measure of annual lake level (e.g. mean, maximum, minimum, or some other measure) is the most relevant in predicting Tahoe yellow cress presence, persistence, and population size. Importantly does the use of any one specific measure affect subsequent correlations?

Metapopulation dynamics

- Data from intensive monitoring should be used to determine the spatial and temporal scales of metapopulation dynamics. Specially monitoring data should be used to:

- Identify the maximum length of Tahoe yellow cress appearance gaps at individual sites due to inundation or other environmental factors. Previously occupied sites should be tracked after lake recession to establish how long submerged individuals may survive.

- By expanding the monitored footprint outward from individual occupied sites to adjacent stream mouths, evidence of new colonizations and recolonizations can be documented. Examination of beach wrack, floating debris, and adjacent habitat areas for seedling establishment is necessary, especially near larger extant populations.

- Researchers should use current and future data sets to develop strict criteria upon which colonization, recolonization, and extirpation events are defined for purposes of refining calculation of colonization/extirpation probability ratios to be used to measure management program success.

- Tests should be made of the relevance and fit of the “mainland-island” metapopulaiton model for use in conservation planning for Tahoe yellow cress.

Habitat features and other environmental correlates of habitat suitability

- Identification and quantification of the physical and biotic habitat features that determine the distribution, abundance, and persistence of Tahoe yellow cress will be necessary to evaluate sites for reintroduction, introduction, and management actions.

- Intensive assessment of microhabitat and plant community characteristics associated with Tahoe yellow cress should be undertaken, including quantitative description of physical circumstances (substrate beach morphology, presence of bars, berms, barriers, rock shelters, depressions, or dunes); limiting disturbance factors (lake level, wave disturbance, water table, fluvial processes or aridity); and plant community characteristics (species composition, nonnative species invasion, and successional phenomena).

- A water relations study should be conducted to identify the hydrological and topographic features of habitat and potentially suitable habitats that serve to maximize Tahoe yellow cress vital rates, including survivorship, growth, and reproduction. This effort can be carried out within a reintroduction experiment with multifactorial outplanting design.

Restoration research

- A number of restoration research questions can be answered using monitoring data and translocation experiments.

- Attempts should be made to reintroduce populations across physically diverse sites to test for differential success response to key environmental variables.

- Experimental reintroduction should be carried out at currently occupied sites and target restoration efforts should have different goals, objectives, and evaluation criteria, possibly conforming the mainland-island model for Tahoe yellow cress.

- Determine if restoration efforts exhibit differential responses to lake level (i.e., if restoration at high lake levels tends to fail more often than at low levels).

- Add to monitoring programs data collection requirements designed to assess human responses to site protections, specific management actions, public education efforts, and training programs.

Understanding key Tahoe yellow cress life history characteristics

- Perform an analysis of those factors that limit seed production by examining inflorescences, infructescences, ovaries, and fruits from plants distributed across sites and across physical (topographic, edaphic, and hydrological) gradients.

- Determine the breeding biology of Tahoe yellow cress to establish levels of inbreeding and outbreeding by simple bagging and pollen transfer experiments under field and greenhouse conditions.

- Measure vegetative features (including number of branches, rosette diameter) that are likely to correlate with fecundity and precocity.

- Assess pollination systems by observing floral visitation and collecting visitors for pollen analysis.

Genetic analyses

- Patterns of genetic variation that may be important to future Tahoe yellow cress conservation planning efforts are largely unknown. Several studies may shed useful light on conservation genetics.

- Efforts should be made to supplement the current genetic database with selective sampling across the geographic range of Tahoe yellow cress in an effort to detect ecogeographic patterns of variation. Surveys should be made to identify polymorphisms that may be unique to distributional subareas (lake quartiles), to generate basic genetic data for unsampled geographic subareas, and to identify patterns of genetic variation in populations that have been undersampled.

- Available genetic data should be analyzed by lake quartiles to determine validity of designating source populations for geographically based reintroduction efforts.

- Confirmation of the supposition of diploidy in Tahoe yellow cress should be made using chromosome counts.

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Appendices

Appendix A
Executive Committee Members

Agency/Group and Representatives

Tahoe Lakefront Owners' Association	Jan Brisco
League to Save Lake Tahoe	Jon Paul Harries
Tahoe Regional Planning Agency	Juan Palma
California Department of Fish and Game	Banky Curtis
California Department of Parks and Recreation	John Knott
California Tahoe Conservancy	Dennis Machida
California State Lands Commission	Mary Griggs
	Judy Brown
Nevada Division of Forestry	Pete Anderson
Nevada Division of State Parks	Wayne Perock
Nevada Division of State Lands	Pam Wilcox
Nevada Natural Heritage Program	Glenn Clemmer
U.S. Fish and Wildlife Service	Bob Williams
U. S. Forest Service, Lake Tahoe Basin Management Unit	Maribeth Gustafson

Appendix B
Technical Advisory Group Members

Agency/Group and Representatives

Tahoe Lakefront Owners' Association	Jan Brisco
League to Save Lake Tahoe	Jon Paul Harries
Western Botanical Services	Julie Etra
EDAW	Steve Patterson
Mills College	Bruce Pavlik
	Abigail Smith
	Alison Stanton
University of Nevada, Reno	Dennis Murphy
Tahoe Regional Planning Agency	Jerry Dion
	Pam Drum
	Shane Romsos
	Coleen Shade
California Department of Fish and Game	Daniel Burmester
California Department of Parks and Recreation	Ken Anderson
	Tamara Sasaki
	Scott Scheibner
California Tahoe Conservancy	Beth Gross
	Rick Robinson
	Brian Wilkinson
California State Lands Commission	Maurya Falkner
	Eric Gilles
Nevada Division of Forestry	Tim Rochelle
Nevada Division of State Lands	Jim Lawrence
Nevada Natural Heritage Program	Jim Morefield
	Jennifer Newmark
U.S. Fish and Wildlife Service	Jody Sawasaki
	Randi Thompson
U. S. Forest Service, Lake Tahoe Basin Management Unit	Gail Durham
	Mollie Hurt
	Linda Massey
	Rex Norman

Appendix C. Occurrence (X), absence (0), and stem count data for reintroduced populations of Tahoe Yellow Cress. Numbers separated by a ")" are conflicting estimates. The first estimate, confirmed in NNHP files, was used for calculations.

Year Surveyed	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Lake Elev (ft LTD)	6228	6226	6224	6224	6223	6223	6222	6223	6222	6227	6227	6228	6228	6228	6228
Occurrence Data															
Meeks Bay			X		X	X	NS	NS	NS	NS	NS	NS		X	
D.L. Bliss				X	X	NS	NS	X	X	X	X	X	X	X	X
Tallac Creek			X		X	X	NS	NS	NS	NS	NS	NS			
Baldwin Beach			X		X	NS	NS	NS	NS	NS	NS	NS			
Taylor Creek		X	X		X	X			NS	NS	X	NS	NS	NS	
Nevada/Kahle															
north-salvaged						X	0		0						
north-propagated						X	X		X						
south-salvaged						X	X		X						
south-propagated						X	X		X						
Stem Counts															
Meeks Bay			500		278)215)287	166								7	
D.L. Bliss				1168	832									2	6
Tallac Creek			500		80)64)95	78									
Baldwin Beach			500		64										
Taylor Creek		500	500		118)75)109	119					130				
Nevada/Kahle															
north-salvaged						9	0		0						
north-propagated						96	32		1						
south-salvaged						24	15		1						
south-propagated						60	56		15						

Appendix D. Occurrence (X) and absence (0) for native populations of Tahoe Yellow Cress, 1978-2000. NS = not surveyed, * = short-term record (80's or 90's), lq = low quality record. See Methods Appendix for sources.

Year Surveyed			1978	1979	1980	1981	1982	1983	1986	1988	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Lake Elev (ft LTD)			6224	6224	6226	6228	6228	6228	6228	6224	6223	6223	6222	6223	6222	6227	6227	6228	6228	6228	6228
site	**Xs**	**rec yrs**																			
Sunnyside	1	12	NS	0	0	0	NS	NS	NS	NS	0	NS	NS	X	0	0	0	0	0	0	0
Ward Cr.	10	15	NS	X	X	X	X	X	X	X	X	NS	NS	X	X	0	0	NS	0	0	0
Kaspian Camp (lq)	1	2	NS	NS	NS	NS	NS	NS	NS	NS	NS	X	NS	NS	NS	NS	NS	0	NS	NS	NS
Blackwood N.	12	17	NS	0	X	X	X	X	X	X	X	X	NS	X	X	0	0	X	0	0	X
Blackwood S.	14	16	NS	X	X	X	X	X	X	X	X	NS	NS	X	X	0	0	X	X	X	X
Cherry Street*	3	9	NS	NS	NS	NS	NS	NS	NS	NS	X	NS	NS	X	X	0	0	0	0	0	0
McKinney Cr.*	3	9	NS	0	NS	0	NS	NS	NS	NS	X	NS	NS	X	X	0	0	0	0	0	0
Tahoma	5	16	NS	X	X	X	0	0	0	0	0	NS	NS	X	X	0	0	0	0	0	0
Meeks Bay	12	17	NS	X	X	X	0	0	0	X	X	X	X	0	0	NS	X	X	X	X	X
Meeks Vista (lq)	3	10	NS	NS	X	X	0	0	0	NS	0	NS	NS	X	0	NS	NS	NS	0	NS	0
Rubicon Bay	8	12	NS	0	NS	X	X	X	X	X	X	NS	NS	X	X	NS	NS	NS	0	0	0
Dl. Bliss	0	16	NS	0	0	0	0	0	0	0	0	NS	NS	0	0	0	0	0	0	0	0
Emerald Pt.	6	16	NS	X	0	0	0	0	0	NS	X	X	X	X	X	0	0	0	0	NS	0
Emer. Bay Ava (lq)	2	2	NS	NS	NS	NS	NS	NS	NS	NS	X	X	NS	NS	NS	NS	NS	NS	NS	NS	NS
Emer. Bay Boat	4	14	NS	X	0	0	0	0	0	NS	X	0	0	X	X	0	0	NS	0	NS	NS
Eagle Cr.*	5	9	NS	X	NS	NS	NS	NS	NS	NS	X	X	X	X	X	0	0	NS	0	NS	0
Eagle Pt.*	4	9	NS	NS	NS	NS	NS	NS	NS	NS	NS	X	X	X	X	0	0	0	0	NS	0
Cascade	8	13	NS	0	NS	0	NS	0	0	NS	X	NS	NS	X	0	X	X	X	X	X	X
Tallac Cr.	13	16	NS	0	NS	0	0	NS	X	X	X	X	X	X	X	X	X	X	X	X	X
Baldwin Beach	12	18	NS	0	X	X	0	0	0	0	X	X	X	X	X	X	X	0	X	X	X
Taylor Cr.	18	18	NS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pope/Kiva	8	16	NS	X	0	0	NS	NS	X	X	X	X	X	X	X	0	0	0	0	0	0
Keys/Lighthouse	9	15	NS	X	0	X	0	0	NS	X	X	NS	NS	X	X	X	0	0	0	X	X
Upper Truckee W.	13	16	NS	X	X	X	X	X	X	X	X	NS	NS	X	X	X	X	0	0	0	X
Upper Truckee E.	14	14	NS	X	X	X	NS	NS	X	X	X	NS	NS	X	X	X	X	X	X	X	X
Regan/Al Tahoe	4	16	NS	X	0	0	0	0	0	0	X	NS	NS	X	X	0	0	0	0	0	0
El Dorado Beach	1	16	NS	X	0	0	0	0	0	0	0	NS	NS	0	0	0	0	0	0	0	0
Timber Cove	6	15	NS	0	NS	X	X	X	X	X	X	NS	NS	0	0	0	0	0	0	0	0
Tahoe Meadows	8	13	NS	X	X	X	0	NS	NS	NS	X	NS	NS	X	0	0	0	0	X	X	X
Edgewood	14	16	NS	X	X	X	X	X	X	X	X	NS	NS	X	X	0	0	X	X	X	X
4-H Camp	10	16	X	X	X	X	X	X	X	X	X	NS	NS	X	0	NS	0	0	0	0	0
Kahle/Nevada	15	19	X	X	X	X	X	X	X	X	X	X	X	X	X	0	0	0	0	X	X
Elk Pt. (lq)	4	9	NS	X	0	0	NS	NS	NS	NS	X	NS	NS	X	X	NS	NS	NS	0	O	O
Zephyr Cove*	6	12	NS	NS	NS	NS	X	NS	NS	X	X	X	X	X	X	0	0	0	0	0	0
Skyland (lq)	4	7	NS	X	0	0	NS	NS	NS	NS	X	NS	NS	X	X	NS	NS	NS	0	NS	NS
Cave Rock*	4	9	NS	NS	NS	NS	NS	NS	NS	NS	X	NS	NS	X	X	0	0	0	0	0	X
Logan Shoals*	9	13	NS	X	X	X	0	0	X	X	X	X	X	NS	X	NS	NS	NS	0	NS	0

Appendix D. Occurrence (X) and absence (0) for native populations of Tahoe Yellow Cress, 1978-2000. NS = not surveyed, * = short-term record (80's or 90's), lq = low quality record. See Methods Appendix for sources.

Year Surveyed				1978	1979	1980	1981	1982	1983	1986	1988	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Lake Elev (ft LTD)				6224	6224	6226	6228	6228	6228	6228	6224	6223	6223	6222	6223	6222	6227	6227	6228	6228	6228	6228
site	**Xs**	**rec yrs**																				
Glenbrook	8	13		NS	X	X	X	X	X	NS	NS	X	NS	NS	X	X	0	0	0	0	NS	0
Skunk Harbor*	1	9		NS	NS	NS	NS	NS	NS	NS	NS	X	0	NS	0	0	0	0	0	0	NS	0
Secret Harbor*	3	10		NS	NS	NS	NS	NS	NS	NS	NS	X	X	X	0	0	0	0	0	0	NS	0
Sand Harbor	1	12		NS	X	0	0	NS	NS	NS	NS	0	NS	NS	0	0	0	0	0	0	0	0
Crystal Pt. W.*	2	7		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	X	X	0	0	0	0	NS	0
Kings Beach*	1	9		NS	NS	NS	NS	X	NS	NS	NS	NS	0	NS	0	0	0	0	0	0	0	0
Agate Bay	0	12		NS	0	0	0	NS	NS	NS	NS	0	NS	NS	0	0	0	0	0	0	0	0
Dollar Point*	3	8		NS	NS	NS	NS	NS	NS	NS	NS	NS	X	NS	X	X	0	0	0	0	NS	0
sum X				2	23	16	19	13	11	14	17	32	16	12	33	29	7	7	8	9	10	14
sum X+O				2	32	28	33	26	23	24	22	39	19	13	42	43	36	38	36	43	30	41
presence (%)				100	71.9	57.1	57.6	50.0	47.8	58.3	77.3	82.5	84.2	92.3	78.6	67.4	19.4	18.4	22.2	20.9	33.3	34.1
misc. records																						
Truckee River				NS	NS	NS	0	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Tallac Lake				NS	NS	0	NS	NS	NS	NS	NS	NS	NS	NS	NS	0	NS	NS	NS	NS	NS	NS
Logan Shoals Vista													X	NS	NS	NS	NS	NS	NS	NS	NS	NS
Valhalla													X	X	NS	NS	NS	NS	NS	NS	NS	NS
Elk Pt. Private					X	NS	NS	NS	NS	NS	NS	X	NS	NS	X	NS	NS	NS	NS	NS	NS	NS
Kiva					X	NS	NS	NS	NS	NS	NS	NS	X	X	NS	NS	0	0	0	0	0	0
Roundhill													X	0	X	NS	NS	NS	NS	NS	NS	NS
Chimney Rock													X	X	NS	NS	NS	NS	NS	NS	NS	NS
all sum X				2	25	16	19	13	11	14	17	33	21	15	35	29	7	7	8	9	10	14
all sum X+0				2	36	29	34	26	23	24	22	41	24	17	44	44	37	39	37	44	31	42

Appendix E. Stem count data for native populations of Tahoe Yellow Cress, 1978-2000. Numbers separated by a ")" are conflicting estimates. Sums include first (left) estimate. See Methods Appendix for sources.

Year	1978	1979	1980	1981	1982	1983	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Lake Elev (ft LT	6224	6224	6226	6228	6228	6228	6228	6226	6224	6224	6223	6223	6222	6223	6222	6227	6227	6228	6228	6228	6228
Sunnyside		0	0	0							0				0	0	0	0	0	0	0
Ward Cr.		50	136	20	9	121	285		186		172					0	0		0	0	0
Kaspian Camp												11	10					0			
Blackwood N.		0	78	49	152	100	197		246		151	11				0	0		0	0	30
Blackwood S.		35	25	58	56	359	1073		423		814										600
Cherry Street																0	0	0	0	0	0
McKinney Cr.		0		0							19					0	0	0	0	0	0
Tahoma		2	1	1	0	0	0		0		0					0	0	0	0	0	0
Meeks Bay		40	25	91	0	0	0		4		152	290	148					10			1
Meeks Vista			15	15	0	0	0				0				0				0		0
Rubicon Bay		0		19	45	55	161		182		35					0	0	0	0	30	0
Dl. Bliss		0		0	0	0	0		0		0					0	0	0	0	0	0
Emerald Pt.			0	0	0	0	0					700	440	984		0	0	0	0		0
Emer. Bay Ava																					0
Emer. Bay Boat		15														0	0				0
Eagle Cr.		15	0	0	0	0					35	150	220	155		0	0		0		
Eagle Pt.												20	28	61		0	0	0	0		0
Cascade		0		0		0	0				170									100	100
Tallac Cr.		0		0	0	0	60		68		11	81	75							65	70
Baldwin Beach		0	35	45	0	0	0		0		4	1500	1821								
Taylor Cr.		5	100	111	429	408	191		52		329	383)530	73				30			3	50
Pope/Kiva		21	0	11	0		86		262		31	0		0/15			0	0	0	0	0
Keys/Lighthouse		20																0	0	100	250
Upper Truckee W.		37	20	172	148	211	80		167		537							0	0	0	8
Upper Truckee E.		50	165	1000			1500		2895		6529						415			1000	3000
Regan/Al Tahoe		14	0	0	0	0	0		0		90					0	0	0	0	0	0
El Dorado Beach		1	0	0	0	0	0		0		0			0	0	0	0	0	0	0	0
Timber Cove		0		7	325	478	150		4		22										0
Tahoe Meadows		25	10	10)20	0						6				0	0	0	0		15	60
Edgewood		11	120	619	778	738	600		1235		377									300	300
4-H Camp	65		12	26	24	5	210)25		96)75		6										0
Kahle/Nevada	57	200	8	2	176	385	760		519		66)19	8	13	10						25	100
Elk Pt.		30																			0
Zephyr Cove												100	145	53							0
Skyland		20									34										0
Cave Rock																0	0	0	0	0	18

Appendix E. Stem count data for native populations of Tahoe Yellow Cress, 1978-2000. Numbers separated by a ")" are conflicting estimates. Sums include first (left) estimate. See Methods Appendix for sources.

Year	1978	1979	1980	1981	1982	1983	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Lake Elev (ft LT	6224	6224	6226	6228	6228	6228	6228	6226	6224	6224	6223	6223	6222	6223	6222	6227	6227	6228	6228	6228	6228
Logan Shoals		100	12	428			309		133		1430	43	64								0
Glenbrook		500	9	143	800	500				10	70										0
Skunk Harbor												0	0								0
Secret Harbor												7	33								0
Sand Harbor		1	0	0																	0
Crystal Pt. W.			0													0	0	0	0		0
Kings Beach			0											0	0	0	0	0	0	0	0
Agate Bay		0	0	0							0			0	0	0	0	0	0	0	0
Dollar Point	0															0	0	0	0		0
sum stems	122	1192	771	2827	2942	3360	5662		6472	10	11090	3304	3070	1263			445	10	0	1638	4587
misc. records																					
Truckee River																					
Tallac Lake																					
Logan Shoals Vista												43									
Valhalla												84	31								
Elk Pt. Private		30									20			14							
Kiva		1										530	2449			0	0	0	0	0	0
Roundhill												50	0	15							
Chimney Rock												9	19								
all sum stems	122	1223	771	2827	5622	6085	5662		6472	10	11110	4020	5569	1292			445	10		1638	4587

Appendix F Summary of stem count (mean and mean maximum) and persistence data for 29 Tahoe Yellow Cress sites, 1978-2000.
Data sources include Kundent (1990), Garden Club (1992), CSLC (1998) and NNHP 2001. Raw data in Appendices and .

	Ward	Blackw N	Blackw S	Tahoma	Meeks Bay	Rubicon	Emer Pt	Eagle Cr	Eagle Pt	Cascade	Tallac Crk
2000 stem count	0	30	600	0	1	0	0	ns	0	100	70
mean stem count	122.4	112.7	382.6	1.3	84.6	75.3	708.0	115.0	36.3	123.3	61.4
coeff. variation (%	76.7	70.5	100.1	46.2	114.8	89.0	38.4	75.6	59.8	32.8	37.8
n (# survey estimates)	8	9	9	3	9	7	3	5	3	3	7
max. stem count	202.3	198.3	829.0	1.3	196.7	132.7	708.0	175.0	36.3	123.3	75.3
coeff. variation (%	37.5	23.7	28.6	46.2	41.1	51.3	38.4	22.3	59.8	32.8	7.3
n (# high estimates)	3	3	3	3	3	3	3	3	3	3	3
persistence	66.6	70.6	87.5	31.1	70.6	66.6	37.5	55.6	44.4	61.5	81.2
n (# of record years)	15	17	16	16	17	12	16	9	9	13	16

	Baldwin Be	Taylor Crk	Pope/Kiva	Keys/Light	Up Truc W	Up Truc E	Regan/Al	El Dorado*	Timbercove	Tahoe Mea	Edgewood
2000 stem count	5	45	0	250	8	3000	0	0	0	60	300
mean stem count	681.0	166.5	82.2	123.3	153.3	1839.0	52.0	1.0	164.3	21.0	507.8
coeff. variation (%	132.4	97.4	127.3	77.3	105.4	112.1	103.3	47	120.3	96.2	71.2
n	5	13	5	3	9	9	2	1	6	6	10
max. stem count	1122.0	406.7	126.3	123.3	306.7	4141.3	52.0	1.0	317.7	31.7	917.0
coeff. variation (%	84.3	5.7	95.6	77.3	65.3	49.9	103.3	47	51.7	80.8	30.1
n	3	3	3	3	3	3	2	3	3	3	3
persistence	66.7	100.0	50.0	60.0	81.1	100.0	25.0	6.2	40.0	61.5	87.5
n (# of record years)	18	18	16	15	16	14	16	16	15	13	16

	4-H	Kahle/Nev	Zephyr	Logan Sho	Glenbrook	Secret H	Sand Har*
2000 stem count	0	100	0	0	0	0	0
mean stem count	55.5	166.4	99.3	314.9	290.3	20.0	1.0
coeff. variation (%	126.3	139.2	46.3	150.1	106.7	92.0	47.0
n	8	14	3	8	7	2.0	1
max. stem count	123.7	554.7	99.3	722.3	600	20.0	1.0
coeff. variation (%	61.8	34.3	46.3	85.2	28.8	92.0	47
n	3	3	3	3	3	2.0	3
persistence	62.5	78.9	50.0	69.2	61.5	30.0	8.3
n (# of record years)	16	19	12	13	13	10	12

Appendix G
Biological Methods

The following section discusses the methods used to generate the data, figures, tables, and appendices referenced in the CS.

Figure 1
Frequency of maximum gap lengths (in years) derived from analysis of Tahoe yellow cress occurrence/absence data, 1978 to 2000 (Appendix D). Sites are shown above their recorded disappearance (less than 6 years) and extirpation (greater than 6 years) events.

Appendix D was examined for all "0" events that were flanked by "X" events on either side. If the survey record was continuous (e.g. 1980 and 1981 and 1982 and 1983), then the number of 0s equals the maximum gap length (in years) for a given site. If the survey record was discontinuous (e.g. 1982 and 1983, skip to 1986), then the number of 0s plus the number of assumed absence years equals the maximum gap length. This would overestimate gap length if the plant had returned in a missed year without being observed. Some sites had multiple gaps that were counted as separate events (e.g. Baldwin Beach). Gaps flanked by "NS" on one or both sides were not counted (e.g. Ward Creek).

Figure 2
Effect of colonization and extirpation probabilities (expressed as a ratio) and the relative proportion of occupied to unoccupied sites (1:9, 1:1, 9:1) on the calculated metapopulation dynamic. A negative dP/dt indicates net loss of populations, a positive value indicates net gain. Arrows show the no net change points for the 1:9 and 1:1 ratios.

The C/E and occupied/unoccupied site ratios were arbitrarily chosen to illustrate the model. C and E varied between 0.1 and 0.5 while the site ratios were 0.1, 0.5, or 0.9.
Model from Rickleffs 1997.

Figure 3
Alternative forms of metapopulation structures: a) Classical, with each population having a similar probability of persistence; b) mainland-island, with a persistent "core population" and more transient satellites; c) patchy, populations interconnected by frequent dispersal events that make extirpations unlikely; d) non-equilibrium, with populations linked by infrequent dispersal so that all have a high probability of extirpation; and e) complex, combining the features of a through d. Filled circles = occupied habitat, unfilled = vacant (potential) habitat, arrows = dispersal (the thicker the more frequent), outer line = boundaries of population or species.
Adapted from Harrison and Hastings (1996).

Figure 4
Patterns of Tahoe yellow cress persistence at 40 sites (high quality records only), 1978 to 2000. Typical gap lengths determine type of pattern (continuous, intermittent, or ephemeral).
* = short term record, spanning either the 1980s or 1990s.

Appendix D was examined first to determine the overall quality of the occurrence/ absence record. A high quality, long-term record was defined as having less than 4 NS events over the 22-year span (1978 to 2000). The range of survey years for these sites was 12 to 19. A low quality record could be ignored because of too many NS events spread irregularly across the span (e.g. Meeks Bay Vista, Skyland, Elk Point). Alternatively, it could be used as a short term, high quality record if: 1) It was surveyed in at least 7 consecutive years (usually 9); and 2) it had two or less NS events in that record (e.g. Cherry Street, Eagle Point). Usually, the short-term record was for either the 1980s or the 1990s.

A total of 40 high quality records were then separated into three gap categories: 1) Records with gaps of 4 years or less (likely due to disappearance); 2) records with gaps of 5 to 6 years (more likely due to extirpation and recolonization); and 3) records with gaps greater than 6 years (highest probability of being due to extirpation, with or without recolonization). Within each of these categories, the general trend for each site was determined: 1) Persistent (a population was found during the beginning, middle, and end of the record period); and 2) decreasing (found at the beginning but not the end) or increasing (found at the end but not the beginning). Most sites could readily be classified into one of these trend categories, although some required a subjective decision (e.g. Upper Truckee W, Cave Rock).

Figure 5
Mean presence + SE (n = 3 ownership categories, 31 total sites with long term, high quality records) for Tahoe yellow cress, 1979 to 2000.

Of the 40 high quality records, 31 had records that either spanned the entire 1979 to 2000 period (1978 only included 2 sites) or had records that were complete for at least one decade (e.g. 1980s = Logan Shoals, 1990s = McKinney Creek, Cave Rock) and had a Pr > 25%. These were grouped by one of three ownership/management categories. The USFS category had 5 sites, the State and County category had 8 sites, and the private category had 18 sites. Mean presence in each year was calculated for each category (see below under Appendix methods). This allowed a composite mean + SE to be calculated for each year (n = 3).

Figure 6
Presence by ownership categories (n = number of sites in each category with long term, high quality records) for Tahoe yellow cress, 1979 to 2000.

This contains the same dataset used for Figure 5 but with the three ownership categories displayed separately.

Figure 7
Relationship of mean presence as a linear function of mean lake elevation for Tahoe yellow cress, 1979 to 2000.

The 18 data points have as their coordinates 18 years of mean lake elevations (x = 1979 to 1983, 1986, 1988, and 1990 to 2000) for which there were mean presence estimates for the three ownership categories (y = mean presence for USFS, State/County, and private sites). The latter are the same means plotted in Figure 5. The r^2 value is significant at $P < 0.01$, and indicates that 75 percent of the variation in presence can be accounted for by variations in lake elevation.

Figure 8
Relationship of presence by ownership as a linear function of mean lake elevation for Tahoe yellow cress, 1979 to 2000.

This contains the same dataset used for Figure 7 but with the three ownership categories displayed separately.

Figure 9
Quartile distribution of Tahoe yellow cress in low lake level and high lake level years.

A comparison of presence for populations grouped by geographic quartiles around the lake in 1993 (mean lake level = 6,223 ft; 1,896.77 m)) and 1997 (6,228 ft; 1,898.29 m). Absolute number of populations and presence are indicated.

Figure 10
Changes in absolute number of extant Tahoe yellow cress populations (sites with Tahoe yellow cress, Appendix D) and mean population size (mean stem count per site), 1979 to 2000.

Tallies of the absolute numbers of sites with Tahoe yellow cress in a given year (populations present, rather than presence as a proportion of the total number surveyed in a given year) depend greatly on the amount of survey effort. If a low effort was made (i.e. only a few sites were visited for lack of time, personnel, dedication) then a low number of sites with populations of Tahoe yellow cress would be recorded regardless of how widespread it actually was in that year. Consequently, only years with a minimum amount of “reasonable” effort can be included in a tally of absolute number of sites. The reasonable level of effort was arbitrarily defined as a minimum of 24 sites surveyed in a given year (about 50 percent of the total known Tahoe yellow cress sites). This excluded 1978 (2 sites surveyed), 1983 (23), 1988 (22), and 1992 (17) (see Appendix D). Inclusion of 1983 and 1988 would not have changed the shape of the plot.

The 15 years included for the tallies of absolute numbers of sites with Tahoe yellow cress were the basis for estimates of mean population size per site (actually mean stem count per site). However, not all sites in a given year had stem count estimates. In 1996 and 1997, for example, only 5 and 7 sites, respectively, had stem counts out of the 39 and 37 that were noted as having Tahoe yellow cress. This represents a 71 to 87 percent "discrepancy" so that the estimates of mean population size per site would be greatly biased by the small sample size. Consequently, estimates of mean population size per site would only be made for years where this discrepancy was less than 30 percent. This excluded 1993 (8 counts for 35 sites with Tahoe yellow cress, discrepancy = 77 percent), 1996 (71 percent), and 1997 (87 percent). The years 1994, 1995, and 1998 had no stem counts at all. Therefore, only nine estimates of mean population size per site appear in the figure.

Figure 11
Relationship between absolute number of extant Tahoe yellow cress populations (sites with Tahoe yellow cress, Appendix D) and mean lake elevation, 1979 to 2000.

The 15 data points have as their coordinates 15 years of mean lake elevations (x = 1979 to 1982, 1986, 1990 to 1991, and 1993 to 2000) for which there were absolute site tallies that met the criteria discussed for Figure 10. Not all points are apparent because 1986 and 2000 had the same tally (14 sites with Tahoe yellow cress, lake elevation = 6,228 ft; 1,898.29 m), as did 1995 and 1996 (7 sites with Tahoe yellow cress, lake elevation = 6,227 ft; 1,897.99 m). The latter are the same means plotted in Figure 5. The r^2 value is significant at $P < 0.01$, and indicates that 72 percent of the variation in sites supporting Tahoe yellow cress populations can be accounted for by variations in lake elevation.

Figure 12
Relationship between mean stem count (mean for a given lake elevation) and lake elevation for Tahoe yellow cress, 1979 to 2000.

The nine estimates of mean population size per site (obtained for Figure 10) are plotted against mean lake elevation for their respective years. It has been fit with a third order polynomial described by the equation Y = 1.916 x 109 - 6.155 X 10 1+5x + 49.436X2.

Figure 13
Relationship between mean stem count (mean for a site in all record years, Appendix E) and persistence (for a site, Appendix D and F) for Tahoe yellow cress, 1978 to 2000.

Of the 40 sites with high quality records, 29 also had stem count estimates that could be used to calculate mean stem count over the 1978 to 2000 period (Appendix F). There were at least 3 estimates of stem counts at every site, with 2 exceptions; 1 estimate each for El Dorado Beach and Sand Harbor (both had only 1 occurrence out of a 12 to 16 year record). Some site had 13 to 14 estimates (Taylor Creek and Kahle/Nevada Beach, respectively), but most had 7 to 10. All were used to calculate a mean stem count for the site. If there were conflicting estimates for a given year, the value recorded by the NNHP was used. These 29 sites with mean stem counts were plotted against their persistence values and fitted with a log curve (equation shown). The r^2 value is significant at $P < 0.01$, and indicates that 63 percent of the variation in persistence of Tahoe yellow cress populations can be accounted for by variations in mean stem count. Exclusion of the point for Upper Truckee East had almost no effect on the equation for the curve.

Figure 14
Relationship between mean maximum stem count (mean of highest values for a site in all record years, Appendix E) and persistence (for a site, Appendix D and F) for Tahoe yellow cress, 1978 to 2000.

The same dataset described for Figure 13 is used here, except that the three highest estimates of stem count for each site were selected for calculation of mean maximum stem count (with the exception of sites with fewer than three estimates, in which case the mean and mean maximum values used were the same, Appendix F). The 29 sites with mean maximum stem counts were plotted against their persistence values and fitted with a log curve (equation shown). The r^2 value is significant at $P < 0.01$, and indicates that 68 percent of the variation in persistence of Tahoe yellow cress populations can be accounted for by variations in mean maximum stem count. Exclusion of the point for Upper Truckee East had almost no effect on the equation for the curve.

Figure 15
Linear ordination by viability index for all ranked sites of Tahoe yellow cress. See Table 10 for additional information.

The viability indices from Table 10 are simply plotted along a linear axis. See Table 10 methods, below.

Table 1
Genetic variability in Tahoe yellow cress and other categories of plants determined from isozyme electrophoresis.

These data were compiled from Bair (1997), Saich and Hipkins (2000) and Hamrick 1979, 1983. The sample sizes for Tahoe yellow cress are numbers of plants from a given site, whereas the sample sizes for other plants are numbers of species electrophoretically surveyed from a given life form or distribution category.

Table 2
Microhabitat characteristics associated with Tahoe yellow cress.

These data were distilled from reports by Knapp (1979a), Ferriera (1987), and CSLC (1998). Relative suitability was a subjective ranking (+ + = most suitable, -= least suitable) based upon comments from the sources and the analyses presented in Table 10.

Table 3
Plant community characteristics associated with Tahoe yellow cress. These data were distilled from reports by CSLC (1998), TRPA (1999), and Gross (2000).

Table 4
Factors that determine colonization probability (C), extirpation probability (E), the proportion of sites occupied (P) and unoccupied (1-P) in Tahoe yellow cress. Developed for this report.

Table 5
Factors that determine C, E, P, and 1-P that are readily manipulated by experimental or management actions. Developed for this report.

Table 6
Documented extirpation events for Tahoe yellow cress and their likely causes.

Using the criteria that distinguish disappearance/reappearance gaps from extirpations (see text), occurrence/absence records for 40 sites with high quality records (Appendix D) were examined for gaps 6 years in length or more. An additional criterion was applied to all records in order to be included in this analysis: No more than 12 percent of a sites' contiguous record could be occupied by NS events. For a 16-year record (spanning the 1980s and 1990s), this was NS in 2 years or less and for an 8 or 9-year record (for either the 1980s or the 1990s) this was NS in 1 year or less. This would better insure that the observed gaps could be accurately measured and, therefore, a better count of true extirpation events obtained. The total number of sites examined was 25. The difference between long term and short term extirpations was arbitrary, but in general, long term meant that the population was missing for the entire record period or longer (which averaged about 16 years overall).

The causes of extirpation were inferred from examination of site characteristics (topography, recreation visitation), lake elevation in the year last seen, and comments from the references cited.

Table 7
Documented colonization, recolonization, and reappearance events for Tahoe yellow cress.

Record selection followed that described for Table 6, above. Colonizations and recolonizations had to be preceded by surveys of the site in previous years. This was supported by text in the references cited. Reappearance was inferred from text in the references cited.

Table 8
Recreational visitation and Tahoe yellow cress presence during drought and wet years, 1989 to 2000.

Lake level data from USGS 2000; Nevada visitation data from J. Howard (11/14/2000, Nevada Department of Conservation and Natural Resources); California data from R. Michaely (11/29/2000, TRPA); Tahoe yellow cress habitat acreage data from Bair (1996); and presence data from Figure 5.

Visitor density was calculated by dividing the sum of California and Nevada visitor means by the habitat acreage. It is an inexact statistic and should be used for illustrative purposes only. This is because the visitation numerator does not include visitors to private and USFS lands and because the acreage does include habitat on private and USFS lands. Consequently, it probably is an underestimate of recreational impact within Tahoe yellow cress habitat.

Table 9
Calculated values of minimum viable population size (minimum mean stem count/site) for Tahoe yellow cress with different probabilities of persistence after 20 years.

The equation for 29 sites from Figure 13 was used to calculate the minimum mean stem count per site for arbitrarily chosen probabilities of persistence.

Table 10
Ranked Tahoe yellow cress sites and their characteristics.

An index of viability was calculated for each site based upon three components:

Index = Ra + -1(CoVar) + Pr

where Ra = relative abundance (mean stem count at a site/sum of mean stem counts of all sites X 100), -1(CoVar) = negative coefficient of variance (-1 X the coefficient of variance of mean maximum stem count at a site X 100) and Pr = persistence (number of occurrences at a site/record years X 100). Sites that lacked data to calculate all three components were classified as "unranked" (Table 11).

Ra indicates the ability of a particular site to produce and support Tahoe yellow cress stems relative to all sites around the perimeter of Lake Tahoe over the entire 22-year record period. The sum of mean stem counts of all sites = 6,562 stems.

The coefficient of variation of mean maximum stem count was chosen instead of the coefficient for mean stem count. Either would work, but it seemed that lack of variation in the maximum count would better indicate the constancy of favorable conditions to produce stems.

Persistence values for each site are found in Appendix D.

The component scalars (++, +, 0, and -) were assigned based on the following ranges:

scalar	Ra (absolute)	Coeff Var	Pr
++	>10% (>500 stems/pop)	5-10%	90-100%
+	2-10% (100-500 stems/pop)	11-25%	75-89%
0	0.3-2% (20-99 stems/pop)	26-50%	50-75%
-	< 0.3% (< 20 stems/pop)	>50%	< 50%

Owner category was assigned for the 1978 to 2000 period. Some sites have changed owners since that time (e.g. Upper Truckee East went from private ownership to CTC ownership in late 2000).

Relative development scalars (light, moderate, and heavy) were assigned based on the following characteristics:

light = limited to pilings, docks, and few or no permanent structures (e.g. those with concrete foundations). Little alteration of lakeshore, topography, or hydrology

moderate = few permanent structures, some alteration of lakeshore, topography, hydrology (e.g. channelization of streams by dredging, but not lined)

heavy = high coverage by permanent structures, alterations of lakeshore, topography, hydrology is extensive and permanent (e.g. concrete channels, storm drains)

Relative recreational impact scalars (light, moderate, and heavy) were obtained from site narratives found in Ferriera (1987), CSLC (1998), the 2000 site survey forms, and NNHP (2001). These have not yet been quantitatively or qualitatively defined.

Table 11
Unranked Tahoe yellow cress sites and their characteristics. See Table 10 methods, above.

Table 12
Habitat availability in low lake level (less than 6,225 ft; 1,897.38 m) and high lake level (greater than 6,225 ft) years for Tahoe yellow cress.

Lake level data from the USGS was examined for the period 1960 to 1999 from which it was determined that mean, maximum, and minimum levels for each year were symmetric around the 6,225 ft (1,897.38 m) level. Low and high levels could then be defined in terms of the magnitude of deviation from 6,225 ft. The low year period (1990 to 1994) had lake levels 2.5 to 3.5 ft (0.8 to 1.1 m) below 6,225 ft. High year periods (1982 to 1986 and 1996 to 2000) had lake levels 2 to 3 ft (0.6 to 0.9 m) above 6,225 ft. Years with levels between -1.0 and +1.5 ft (-0.3 to 0.5 m) relative to 6,225 ft were defined as part of a transition period (1987 to 1990)

The occurrence/absence dataset for each site (Appendix D, high quality records only) was then examined to determine if there was a correlation between Tahoe yellow cress (Xs and 0s) with these low, high, and transitional level periods. If a site's occurrences were found in all periods, then it was assigned to the low + high + t column of the table. Other permutations were also possible (e.g. high period only, low period only, low + t, etc.) and sites were assigned to those columns appropriately. These were checked against narratives presented in Ferriera (1987), CSLC (1998), the 2000 site survey forms, and NNHP (2001) to see if field observations of the same sites corroborated this analysis. There was a high degree of corroboration.

The stem count dataset for each site (Appendix E) was examined to determine if maximum estimates of stem count were correlated with low, high, and transitional level periods. Sites with constant stem counts in low and high year periods were separated from sites with peaks in low water or with peaks in high water years.

Methods for Appendix C
Occurrence (X), absence (0), and stem count data for reintroduced populations of Tahoe yellow cress. Data sources were the same as in Appendix D, with the addition of data from Kundert (1990), and Garden Club of America (1992). Numbers separated by a ")" are conflicting estimates found in alternative sources. Sums used for subsequent calculations used the first (left) estimate, usually obtained from NNHP 2001.

Methods for Appendix D
Occurrence (X) and absence (0) for native populations of Tahoe yellow cress, 1978 to 2000.

The core of this table (1978 to 1997) was obtained from CSLC (1998). Added records came from the following sources: The 1978 records were added from NNHP 2001 (element occurrences 001 and 008). The 1991 to 1992 records were added from USFS 1994 (unpublished management report, USFS, LTBMU). The 1998 to 1999 records were obtained from CTC compilation (Mary Small, CTC, pers. comm. 2000). The 2000 records were obtained from the fall 2000 survey data sheets compiled by the California State Lands Commission (Maurya Falkner, pers. comm. 2000). The miscellaneous records were obtained from the same sources, although the last six site records were found exclusively in the NNHP 2001 files.

Although all records are presented in the appendix, they vary in quality. Quality determines which records can be subjected to which analyses, as specified for particular figures and tables (see above). A high quality, long term record was defined as having less than 4 NS events over the 22-year span (1978 to 2000). The range of survey years for these sites was 12 to 19. A low quality record could be either ignored because of too many NS events spread irregularly across the span (e.g. Meeks Bay Vista, Skyland, Elk Point), or it could be used as a short term, high quality record if: 1) It was surveyed in at least 7 consecutive years (usually 9); and 2) it had 2 or less NS events in that record (e.g. Cherry Street, Eagle Point). Usually, the short-term record was for either the 1980s or the 1990s.

Calculation of persistence and presence is illustrated in Figure X (end of methods section). Persistence is defined as the ability of a Tahoe yellow cress population to maintain itself through time at a given site. It is calculated by determining the number of "X" marks for a given location ("Xs") and dividing by the number of record years (number of "X" and "0" marks) for that site (e.g. at Sunnyside this is 1/12 or 8.3 percent). Therefore, persistence measures temporal variation in occurrence. Presence is defined as the ability of Tahoe yellow cress populations to occupy multiple sites at a given time. It is calculated by determining the number of "X" marks in a given year (sum X) and dividing by the number of sites surveyed ("sum X+0") in that particular year (e.g. in 1979 it was 72 percent for the non-miscellaneous records). Therefore, presence measures spatial variation in occurrence and is synonymous with geographical frequency.

Methods for Appendix E
Stem count data for native populations of Tahoe yellow cress, 1978 to 2000.

Data sources were the same as in Appendix D, with the addition of data from Kundert (1990), and Garden Club of America (1992). Numbers separated by a ")" are conflicting estimates found in alternative sources. Sums used for subsequent calculations used the first (left) estimate, usually obtained from NNHP 2001.

Methods for Appendix F
Summary of stem count (mean and mean maximum) and persistence data for 29 Tahoe yellow cress sites, 1978 to 2000. Data sources were the same as in Appendices D and E.

Appendix H
Agency Policies and Guidelines

The following policies and guidelines provide the basis for protection of Tahoe yellow cress and other sensitive species and their habitats by the various regulatory and resource agencies around the Lake Tahoe basin.

Tahoe Regional Planning Agency

The relevant TRPA threshold for Tahoe yellow cress is the Second Vegetation Threshold, which articulates the number of rare plant occurrences for Tahoe yellow cress and other sensitive plant species.

> Sensitive Plants
> NUMERICAL STANDARD
>
> Maintain a minimum number of population sites for each of five sensitive plant species as follows:

Carex paucifructus	1
Lewisia pygmaea longipetala	2
Draba asterophora var. *macrocarpa*	2
Draba asterophora var. *asterophora*	5
Rorippa subumbellata	26

The third goal in the vegetation section of the conservation element of the regional plan states:

> Conserve threatened, endangered, and sensitive plant species and uncommon plant communities of the Lake Tahoe basin.
>
> A few examples of rare plants and uncommon plant communities can be found in the Lake Tahoe basin. These resources are a real part of the basin's natural endowment and need to be protected from indiscriminant loss or destruction. Otherwise, the danger of extinction can become a reality. Direction for preservation is provided through adopted environmental thresholds.

The second policy under the third goals states:

> The population sites and critical habitat of all sensitive plant species in the Lake Tahoe basin shall be identified and preserved.
>
> The Lake Tahoe basin provides a favorable habitat for a few species of exceptionally scarce plants. Without proper protection, these sensitive plants may become extinct. Thresholds for vegetation specifically refer to five sensitive plant species (see above). Monitoring and evaluation programs will be

necessary, in cooperation with the USFS and other interested agencies and individuals, to implement this policy.

Chapter 75 of the Regional Plan for the Lake Tahoe basin is focused on sensitive and uncommon plant protection and fire hazard reduction:

Chapter Contents

75.0 Purpose: This chapter sets forth standards for the preservation and management of vegetation of significant scenic, recreational, educational, scientific, or natural values of the region, and for management of vegetation to prevent the spread of wildfire.

75.1 Applicability: This chapter applies to all projects and activities that could have a detrimental effect on designated sensitive plants or uncommon plant communities, and to all areas where vegetation may contribute to a significant fire hazard.

75.2 Sensitive Plants And Uncommon Plant Communities: Designation of plants for special significance is based on such values as scarcity and uniqueness. The following standards shall apply to all sensitive plants and uncommon plant communities referenced in the environmental thresholds, and to other plants or plant communities identified later for such distinction. The general locations of sensitive plant habitat and uncommon plant communities are depicted on the TRPA Special Species map overlay.

75.2.A Sensitive Plants: Projects and activities in the vicinity of sensitive plants and their associated habitat, shall be regulated to preserve sensitive plants and their habitat. All projects or activities that are likely to harm, destroy, or otherwise jeopardize sensitive plants or their habitat, shall fully mitigate their significant adverse effects. Those projects and activities that cannot fully mitigate their significant adverse effects are prohibited. Measures to protect sensitive plants and their habitat include, but are not limited to:

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

75.2.B Uncommon Plant Communities: Uncommon plant communities shall be managed and protected to preserve their unique ecological attributes and other associated values. Projects and activities that significantly adversely impact uncommon plant communities, such that normal ecological functions or natural qualities of the community are impaired, shall not be approved.

75.3 Vegetation Management To Prevent The Spread Of Wildfire: Within areas of significant fire hazard, as determined by local, state or federal fire agencies, flammable or other combustible vegetation may be removed, thinned, or manipulated, up to 30 feet from any structure to prevent the spread of wildfire. Sufficient quantities of residual vegetation should remain in this 30-foot zone to stabilize the soil and prevent erosion. Whenever possible, vegetation in this zone should be thinned, tapered, cut back, or otherwise selectively manipulated, rather than removed entirely. Revegetation with approved species may be required where vegetative groundcover has been eliminated or where erosion problems may occur.

California State Lands Commission

The CSLC has jurisdiction and authority over all ungranted State tidelands, submerged lands, and the beds of navigable rivers, sloughs, lakes, etc. All tidal and submerged lands, granted or ungranted, as well as navigable rivers, sloughs, etc. are impressed with the Public Trust.

The Public Trust is a sovereign public property right held by the State or its delegated trustee for the benefit of all the people. This right limits the uses of these lands to waterborne commerce, navigation, fisheries, open space, recreation, environmental protection or other recognized Public Trust purposes.

The lands under the stewardship of CSLC are vast, biologically diverse, rich in natural resources, and within the public's ownership.

In 1975, the CSLC published, pursuant to the provisions of Public Resources Code Sections 6370 *et seq*., the "Inventory of Unconveyed State School Lands & Tide & Submerged Lands Possessing Significant Environmental Values." The CSLC adopted regulations to permanently protect the identified lands and their natural resources, which include plant species. These provisions are contained in Title 2, Division 3, Article 11, California Code Regulations.

In addition, there are three State laws that specifically protect plants: the California Native Plant Protection Act (1977), CESA (1984) and the California Native Plant Society listings that are subject to protection under the CEQA (1973). The CSLC's management of its lands, either directly or through its leases, is consistent with such laws, as well as with the provisions of the federal ESA. As an example, CSLC has consistently sought to fully protect the Tahoe yellow cress at Lake Tahoe in cooperation with other public agencies, public interest groups and affected landowners.

California Department of Fish and Game
Under CESA, CDFG (along with all California agencies) is restricted from approving projects that would likely jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of habitat essential to the continued existence of those species, if there are reasonable and prudent alternatives available consistent with conserving the species or its habitat which would prevent jeopardy (Fish and Game Code Sec. 2053).

California Department of Parks and Recreation

Policy number 7: Preservation of Vegetative Entities

It shall be the policy of this CDPR commission, in concert with other agencies and organizations, to acquire and preserve outstanding examples of native California species, and to acquire and perpetuate significant natural plant communities associations, and examples of rare, endangered endemic, or otherwise sensitive native California plants, as indicated on state and federal lists.

Whenever possible, significant vegetative entities shall be acquired in natural ecological units so that their integrity may be better perpetuated.

In order to maintain the genetic integrity and diversity of native California plants revegetation or transplant efforts in the State Park System will be from local populations, unless shown by scientific analysis that these populations are not genetically distinct from populations being proposed for use. If local populations have been decimated the closest existing populations(s) to that State Park System unit will be used.

(29) In the State Park System, perpetuation of values in today's environmental may require a purposeful guiding of dynamic ecological factors that are constantly undergoing a success ional trend through the interaction of natural and extraneous forces. This guidance may not always involve simply the static protection of the features or elements that happen to be part of the existing environmental in any particular period of time.

(30) Following careful consultation with the public and with cooperating agencies, the department shall identify, in the individual resources elements, the values that constitute significant park system resource. These values shall be expressed in terms of ecological factors, successional trends, and related recreational opportunities.

(31) In carrying out the provisions of the resource elements for units of the state park system, it is an objective of the department to apply creative and effective techniques of environmental resource management found by scientific analysis to be required to

achieve the protection and perpetuation of the values around which the units are built.

(32) In order to assure a continuity of effort in management and preservation of resources, it shall be an objective of the department to prepare for each unit of the state park system a resource management program or programs, identifying the field management actions required to achieve unit purpose(s) in relation to the resources. When approved by the Director, the resource management program or programs for each unit will form the basis for resource management activities at that unit.

Under CESA, CDPR is restricted from approving projects that would likely jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of habitat essential to the continued existence of those species, if there are reasonable and prudent alternatives available consistent with conserving the species or its habitat which would prevent jeopardy (Fish and Game Code Sec. 2053).

California Tahoe Conservancy

The CTC is an independent State agency within the Resources Agency of the State of California. Its jurisdiction extends only to the California side of the Lake Tahoe basin. CTC is governed by a seven-person board. All management actions and funding decisions in support of the CS are subject to approval by the CTC's governing board. Such actions need to be consistent with its authorities, program objectives, and availability of funding. CTC posses the authority to acquire land and interests in land, including easements; accept donations and dedications of land; manage and restore lands; and provide grants to local governments, state agencies, federal agencies, and non profit organizations to help carry out the purpose of the CTC's programs.

The CTC's mission is to protect the natural environment of the Tahoe basin; to increase public access and recreational opportunities for visitors to the lake; and to preserve and enhance the broad diversity of habitat in the Region. CTC places a priority on the preservation of habitat involving endangered, threatened or special interest species.

The CTC was established to develop and implement programs through acquisitions and site improvements to preserve water quality at Lake Tahoe, preserve the scenic beauty and recreational opportunities of the Region, provide public access, preserve wildlife habitat areas, restore lands to protect the natural environment, and provide equitable treatment of landowners.

Within the CTC's Wildlife Enhancement Program, special emphasis is placed on the preservation of marsh, meadow, and riparian habitats which support wildlife and plant species that are endangered, threatened, or rare or listed in category of special concern.

Nevada Division of Forestry

Protection of Trees and FloraNRS 527.050 Unlawful removal or destruction of trees or flora; penalty; enforcement.

1. It is unlawful for any person, firm, company or corporation, his, its or their agent or agents, willfully or negligently:

(a) To cut, destroy, mutilate, pick or remove any tree, shrub, plant, fern, wild flower, cacti, desert, or montane flora, or any seeds, roots or bulbs of either or any of the foregoing from any private lands, without a written permit therefor from the owner or occupant or his duly authorized agent.

(b) To cut, destroy, mutilate, pick or remove any flora on any state lands under the jurisdiction of the division of state parks of the state department of conservation and natural resources except in accordance with regulations of the division.

(c) To cut, destroy, mutilate, pick or remove any flora declared endangered by the state forester firewarden from any lands, other than state park lands provided for in paragraph (b), owned by or under the control of the State of Nevada or the United States without a written permit therefor from the state forester firewarden or his designate. For the purposes of this subsection, the state forester firewarden may establish regulations for enforcement, including the issuance of collecting permits and the designation of state and federal agencies from which such permits may be obtained.

2. Every person violating the provisions of this section is guilty of a public offense proportionate to the value of the plants, flowers, trees, seeds, roots or bulbs cut, destroyed, mutilated, picked or removed, and in no event less than a misdemeanor.

3. The state forester firewarden and his representatives, public officials charged with the administration of reserved and unreserved lands belonging to the United States, and peace officers shall enforce the provisions of this section.

4. Except as to flora declared endangered by the state forester firewarden pursuant to NRS 527.270 or as to flora on state park lands regulated by the division of state parks, the provisions of this section do not apply to Indians, native to Nevada, who gather any such article for food or medicinal use for themselves or for any other person being treated by Indian religious ceremony.

[1:180:1937; 1931 NCL § 5581.21] + [2:180:1937; 1931 NCL § 5581.22]-(NRS A 1957, 317; 1967, 608; 1969, 461; 1971, 1462; 1973, 1587; 1977, 1166; 1979, 1485)

Protection and Propagation of Selected Species of Native Flora

NRS 527.270 List of species declared to be threatened with extinction; special permit required for removal or destruction.

A species or subspecies of native flora shall be regarded as threatened with extinction when the state forester firewarden, after consultation with competent authorities, determines that its existence is endangered and its survival requires assistance because of overexploitation, disease or other factors or because its habitat is threatened with destruction, drastic modification or severe curtailment. Any species declared to be threatened with extinction shall be placed on the list of fully protected species, and no member of its kind may be removed or destroyed at any time by any means except under special permit issued by the state forester firewarden. (Added to NRS by 1969, 775)

U.S. Fish and Wildlife Service

The Endangered Species Act of 1973, as amended (ESA), is regarded as one of the most comprehensive conservation laws in the world. Under the ESA, species may be listed as either endangered or threatened. Endangered means a species is in danger of extinction throughout all or a significant portion of its range. Threatened means a species is likely to become endangered within the foreseeable future.

All federal agencies are required to protect species and preserve their habitats. Federal agencies must utilize their authorities to conserve listed species and ensure that their actions do not jeopardize the continued existence of listed species. The USFWS works with other agencies to plan or modify federal projects so that they will have minimal impact on listed species and their habitat.

The protection of species is also achieved through partnerships with the states. Section 6 of the ESA encourages each State to develop and maintain conservation programs for resident federally-listed threatened and endangered species. Some State laws and regulations are even more restrictive in granting exceptions or permits than the current ESA.

Working with non-federal landowners, the USFWS provides financial and technical assistance to landowners to implement management actions on their lands to benefit listed and non-listed species.

Species are listed on the basis of the best scientific and commercial data available. Listings are made solely on the basis of the species' biological status and threats to its existence. Listings are determined using sound science and peer review to ensure the accuracy of the best available data.

In addition, the USFWS also maintains a list of candidate species. These are species for which enough information is available to warrant a listing proposal. The USFWS works with the States and private partners to carry out conservation actions for candidate species to prevent their further decline and possibly eliminate the need to list them as threatened or endangered. The Tahoe yellow cress is currently on the USFWS's candidate list.

The ESA's ultimate goal is to recover species so they no longer need legal protection. The ESA provides for recovery plans to be developed describing the steps necessary to restore a species' health. Appropriate public and private agencies and institutions and other qualified persons assist in the development and implementation of recovery plans. Involvement of the public and interested "stakeholders" in development of recovery plans is encouraged. Recovery teams may be appointed to develop and implement recovery plans.

The ESA requires federal agencies to consult with the USFWS to ensure that the actions they authorize, fund, or carry out will not jeopardize listed species. A biological opinion may be issued that outlines various terms and conditions and conservation recommendations the implementing agency should follow to minimize impacts to the listed species.

Activities prohibited under the ESA:

Without a permit, it is unlawful to commit, attempt to commit, solicit another to commit, or cause to be committed any of the following activities involving endangered and threatened wildlife and plants:

1) Import into or export from the United States;
2) Take (includes harass, harm, pursuer, hunt, shoot, wound, trap, kill, capture, or collect) any wildlife within the U.S.;
3) Take on the high seas;
4) Possess, sell, deliver, carry, transport, or ship any species unlawfully taken within the U.S. or on the high seas;
5) Deliver, receive, carry, transport, or ship in interstate or foreign commerce in the course of a commercial activity;
6) Sell or offer for sale in interstate or foreign commerce; and
7) Remove and reduce to possession any plant from areas under Federal jurisdiction.

There are a number of other provisions under the ESA that address critical habitat, habitat conservation plans, and compliance with other laws. Discussions on these topics can be found at the USFWS website at www.fws.gov under the endangered species heading.

U.S. Forest Service

The USFS currently operates under the Lake Tahoe Basin Management Unit Land and Resource Management Plan (LRMP) (1988) and the Forest Service Manual (FSM).

The FSM identifies policies and requirements specific to designated Forest Service sensitive species, which Tahoe yellow cress is designated. FSM 2672.1 states that sensitive species of native plant and animal species must receive special management emphasis to ensure their viability and to preclude trends toward endangerment that would result in the need for Federal listing. There must be no impacts to sensitive species without an analysis of the significance of adverse effects on the populations, its habitat, and on the viability of the species as a whole. It is essential to establish population viability objectives when making decisions that would significantly reduce sensitive species numbers.

The LRMP describes the direction of all management practices implemented on the LTBMU under the following Practice Standards and Guidelines:

In resolving conflicts, the following list of resources or uses are in order of priority and will normally apply:

a. Highest priority will be given to the protection of water quality and the enhancement of the clarity of water in Lake Tahoe.
b. Protection of threatened and endangered plant and animal species native to the area;
c. Preservation of cultural resources determined or believed to be of significant:
d. Achievement of air quality standards for health, and visibility, and to prevent the adverse impacts of atmospheric deposition upon water quality;
e. Maintenance of viable populations of wildlife;
f. Achievement of diverse vegetation communities;
g. Establishment of a variety of outdoor recreation facilities and uses at a level that assures a "fair share" of the basin capacity;
h. Harvesting and treatment of timber stands to maintain health and diversity of the vegetation and to provide for the safety of people and property;
i. Lowest priority will be given to forage grazing.

Selection of management practices to achieve forest goals and objectives and to resolve problems will be made at the project level based upon site-specific analysis. Normally, procedures established in the National Environmental Policy Act and regulation of the Council of Environmental Quality 40CFR 1500-1508 will be used for analysis and documentation.

Appendix I
Tahoe Yellow Cress Project Review Guidelines

The TRPA shorezone project review process, as it relates to Tahoe yellow cress, is described below and in Figure I.1:

Step 0. If a project is lakeward of low water and can be conditioned such that the beach will not be accessed during construction, the Tahoe yellow cress issue is considered resolved.

Step 1. Determine if the proposed project location contains Tahoe yellow cress habitat Check TRPA 1993-1994 Shorezone Survey Database.

- If Tahoe yellow cress habitat is <u>not contained</u> on the parcel and the parcel is not considered TYC habitat, complete the TRPA Initial Environmental Checklist form (and any California and Nevada requirements);
- If Tahoe yellow cress habitat is contained on the parcels, go to Step 2.

Step 2. Determine if Tahoe yellow cress plants have been or currently on-site.

a. Review database containing known historic and present locations of Tahoe yellow cress, if Tahoe yellow cress is known to occur on the parcel, go to step 3.
b. Conduct project review site evaluation between June 15 and September 30 (note: surveys conducted outside the survey period will not be considered valid).

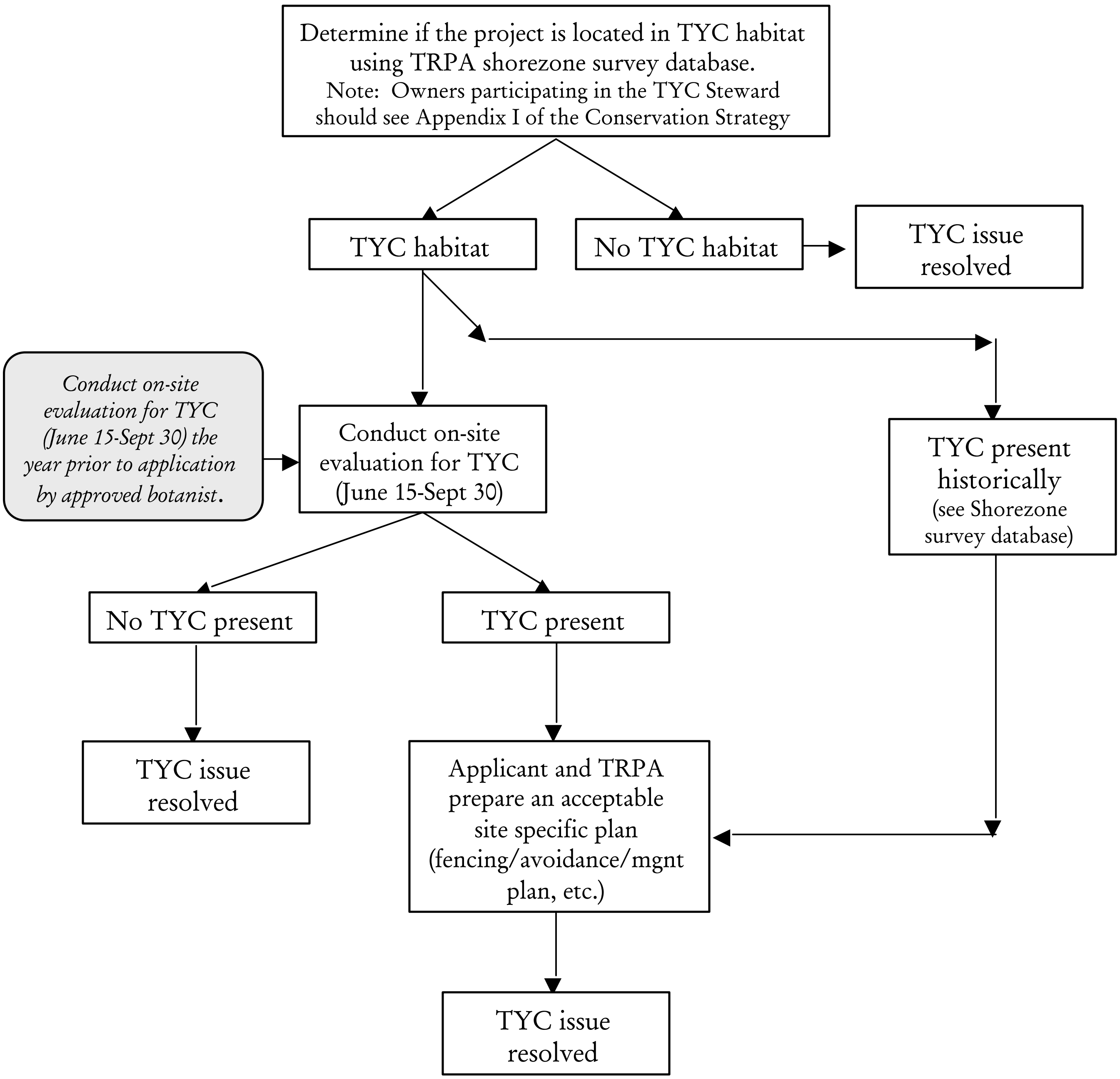
- If Tahoe yellow cress plants are <u>not observed,</u> complete the TRPA Initial Environmental Checklist form (and any California and Nevada requirements). If there is sufficient reason to believe the site does support plants, a pre-project review inspection may be included as a condition of the permit. After the resolution of impacts to potentially suitable habitat (see note below), the Tahoe yellow cress issue is considered resolved at this point;
- If Tahoe yellow cress plants are observed, go to Step 3.

Step 3. When Tahoe yellow cress plants are found on a site or are known to occur on a site, a site-specific management plan shall be developed. The plan shall include, but not be limited to: 1) A pre-construction site survey; 2) project modifications to prevent any impact to Tahoe yellow cress during construction such as enclosure fencing, avoidance measures through redesign, etc.; 3) construction monitoring; and 4) a long-term management plan for the site including, but not limited to, placement of educational signage, access agreement for annual site surveys, and possible development of landscape practices guidelines. Information contained in the plan will be used as a basis for TRPA's Initial Environmental Checklist. This plan must be accepted by TRPA and all other responsible agencies.

Notes:

- For Step 0, if the project may impact potentially suitable habitat, additional studies may be required.
- Projects that cannot mitigate the take of Tahoe yellow cress plants to an insignificant level shall not be approved.
- For projects within Tahoe yellow cress habitat, if the project construction extends over more than a 1-year period or not be constructed within the first growing season of permit issuance, TRPA shall be notified a minimum of 30 days prior to shorezone construction disturbance. TRPA or other responsible agency staff will conduct another survey between June 15 and September 30 when the potential presence of Tahoe yellow cress would be evident and identifiable.
- If the plant is discovered during a pre-construction survey a site-specific plan will be required as in Step 3.
- If an application is submitted outside of the survey season, an on-site evaluation for Tahoe yellow cress may be conducted in the field season prior to permit application. If necessary, a pre-construction survey may be required. A TRPA-approved botanist may conduct the survey.
- For landowners participating in the Tahoe yellow cress stewardship program who submit an application with an acceptable Tahoe yellow cress management plan, the issue is considered resolved. An acceptable management plan will serve as an alternative mechanism for the above-described steps. Any participant may request a pre-application meeting with TRPA and other permitting agencies to discuss their stewardship management plan.
- The consideration of the impact to potentially suitable habitat is required for projects even if the plant is not found on site. TPRA will develop a set of guidelines and approved by the TYC TAG for consideration of impacts to potentially suitable habitat.

Figure I.1. Project Review Flowchart



Note: An application to TRPA is not considered complete until the TYC issues are resolved. Applicants requesting that TRPA survey for TYC may submit and application at any time, however TRPA will conduct the survey between June 15 and September 30.

Appendix J
Proposed Actions for Core and High Priority Sites

The proposed management activities for the publicly managed core sites and high priority restoration sites are outlined below:

Site Name: Taylor Creek:

Status:	Core site
Ownership/Management:	USFS
Management Concerns:	Recreational impacts
Past Actions, 2000:	The fence was reconstructed and enlarged. New fencing material was used to allow sand movement into and out of the enclosure. Permanent transects were installed and monitoring was initiated to document changes within the site. Signs were installed.
Proposed Actions, 2001:	The water level of the adjacent marsh has receded. Therefore, the fence will be extended this year to deter entry into the enclosure. Monitoring and fence maintenance will continue.
Proposed Actions, 2002:	Monitoring and fence maintenance will continue.
Proposed Actions, 2003:	Monitoring and fence maintenance will continue.

Site Name: Upper Truckee East Marsh:

Status:	Core site
Ownership/Management:	CTC
Management Concerns:	Dispersed recreational use including access from the lake shore has potential to conflict with *Rorippa* protection, and minimal understanding of environmental factors other than recreational disturbance that affect the Tahoe yellow cress populations.
Past Actions, 2000:	Up to the early 1980's, under agreement with previous landowner, the beach area was operated as a popular public recreational facility by the City of South Lake Tahoe (CSLT). Early 1980 to 2000 the CSLT abandoned maintaining the site as a recreation facility. The previous owner allowed continued access to the beach up to the time of

Conservancy purchase. During the months of June through September, while cattle grazing was active public access to the beach was permitted by the previous owner. Access from the south to the beach was restricted by fencing and patrols. During the months of October through May, access was not controlled from the south.
1979 to present - Presence/absence surveys conducted intermittently.
1993 to 1995 - TRPA population monitoring service.
2000 to 2001 - Tahoe Conservancy monitoring of percent cover of Tahoe yellow cress populations.
2000 - Conservancy acquired the Upper Truckee Meadow from the Barton Family.

Proposed Actions, 2001:

Restricting public access to the existing Tahoe yellow cress population on the western portion of the beach by creating a fenced and signed enclosure.
Organizing a public outreach and education program to inform the public about the sensitivity of the property's resources. The outreach and education program will includes the following components.·
--Posting signs around the existing population informing pubic of presence and significance of plant of plant.
--Making on site contacts by full time land steward to inform public about the importance of minimizing human disturbance in areas where the plant is found.
--Holding community meetings to inform the public about the sensitivity of the resources on the property.
Continue monitoring of Tahoe yellow cress cover.
Conducting presence/absence surveys.
Review and revise management actions as warranted and approved by the Conservancy board based on monitoring results to assure protection of the species.

Proposed Actions, 2002:

Maintaining a fenced and signed enclosure for the existing Tahoe yellow cress population .
Continue public outreach and education program as described above.
Continue presence of Land Steward May through September.
Continue monitoring of Tahoe yellow cress cover.
Continue monitoring of Tahoe yellow cress cover.
Conducting presence/absence surveys.
Review and revise management actions as warranted and

	approved by the Conservancy board based on monitoring results to assure protection of the species.
Proposed Actions, 2003:	Maintaining a fenced and signed enclosure for the existing Tahoe yellow cress population . Continue public outreach and education program as described above. Continue presence of Land Steward May through September. Conduct feasibility assessment of outplanting Tahoe yellow cress. Continue monitoring of Tahoe yellow cress cover. Conducting presence/absence surveys.

Site Name: Upper Truckee West Marsh:

Status:	Medium priority restoration site
Ownership/Management:	CTC
Management Concerns:	Dispersed recreational use including access from the lake shore has potential to conflict with *Rorippa* protection, and minimal understanding of environmental factors other than recreational disturbance that affect the Tahoe yellow cress populations.
Past Actions, 2000:	Presence/absence surveys intermittently conducted from 1979 to present. 1988 Acquisition of property by the Conservancy. 1993 - 1995 TRPA population monitoring survey.
Proposed Actions, 2001:	Conducting presence/absence surveys.
Proposed Actions, 2002:	Submit this plan to TRPA in order to meet requirements of the Lower Westside Restoration Project permit and implement these actions. Monitoring to determine effectiveness of management actions. Conducting presence/absence surveys. Review and revise management actions as warranted and approved by the Conservancy board based on monitoring results to assure protection of the species.
Proposed Actions, 2003:	Continue to implement management actions. Monitoring to determine effectiveness of management actions.

	Conducting presence/absence surveys. Review and revise management actions as warranted and approved by the Conservancy board based on monitoring results to assure protection of the species.

Site Name: Tallac Creek

Status:	Core site
Ownership/Management:	USFS
Management Concerns:	
Past Actions, 2000:	
Proposed Actions, 2001:	A fence will be constructed along the parking lot to deter people from walking across vegetation and onto known Tahoe yellow cress site. A boardwalk will be constructed for passage from the parking lot to the beach.
Proposed Actions, 2002:	If the fence does not deter people from walking across vegetation between the parking lot and the beach, the fence will be reconfigured to create an enclosure around known Tahoe yellow cress site. Monitoring and fence maintenance will continue.
Proposed Actions, 2003:	Monitoring and fence maintenance will continue

Site Name: Kahle/Nevada Beach

Status:	High priority restoration site
Ownership/Management:	USFS
Management Concerns:	Recreation impacts
Proposed Actions, 2001:	This enclosure will removed. The site will be evaluated to determine the extent of suitable habitat, and reassessed for its potential as a reintroduction site for the species.
Proposed Actions, 2002:	Activities for 2002 will be based on 2001 assessment.

Site Name: Eagle Creek

Status:	High priority restoration site
Ownership/Management:	CDPR

Management Concerns:	The site is inundated during high water years. Beaching of watercraft and occasional foot traffic are largest concerns.
Past Actions, 2000:	
Proposed Actions, 2001:	CDPR will conduct an evaluation of the area to select an optimum location for establishing a reintroduction site. CDRP will complete the environmental documentation and permitting required for experimental activities. CDPR will investigate sources of Tahoe yellow cress stock for reintroduction project. CDPR will meet and confer with scientists to determine appropriate design for enclosure and planting levels.
Proposed Actions, 2002:	CDPR will install fencing and plant stock. Monitoring program will be implemented.
Proposed Actions, 2003:	CDPR will plant more stock, if appropriate. Monitoring efforts will continue.

Site Name: Meeks Bay

Status:	High priority restoration site
Ownership/Management:	USFS
Management Concerns:	Recreational impacts
Proposed Actions, 2001:	The Meeks Bay enclosure will be reconstructed and new signs will be installed.
Proposed Actions, 2002:	Monitoring and fence maintenance will continue.
Proposed Actions, 2003:	Monitoring and fence maintenance will continue.

Site Name: Baldwin Beach/Cascade Enclosure

Status:	Medium priority restoration site
Ownership/Management:	USFS
Management Concerns:	Recreation impacts
Past Actions, 2000:	The fence was reconstructed. New fencing material was used to allow sand movement into and out of the enclosure. Permanent transects were installed and monitoring was initiated to document changes within the site. Signs were installed.

Proposed Actions, 2001:	Monitoring and fence maintenance will continue.
Proposed Actions, 2002:	Monitoring and fence maintenance will continue.
Proposed Actions, 2003:	Monitoring and fence maintenance will continue.

Site name: Baldwin Beach

Status:	Medium priority restoration site
Ownership/Management:	USFS
Management Concerns:	Recreational impacts
Proposed Actions, 2001:	
Proposed Actions, 2002:	
Proposed Actions, 2003:	

Appendix K
Regulatory Authority and Enforcement Guidelines

In California, CESA prohibits the "take" of plant species designated by CDFG as threatened or endangered without a permit. Tahoe yellow cress is State-listed as endangered. The State of Nevada declares Tahoe yellow cress a critically endangered species under the Nevada Revised Statutes (NRS 527.260-300), which also prohibits any unauthorized "take" of the species. This species is not currently protected under the federal ESA; however, it is categorized as a candidate species for listing.

Nevertheless, CESA provides CDFG with full administrative responsibilities over protection of State-listed species. CESA also provides CDFG with the authority to permit incidental take of State-listed species under certain circumstances and otherwise lawful activities (Fish and Game Code 2050-2068 and 2080-2081). Similarly, the State of Nevada provides NDF full administrative responsibilities to fully protect critically endangered native species where taking a declared species can only be authorized by special permit (see NRS 527.260-300).

Because of the sensitivity of Tahoe yellow cress and state laws protecting this species, the primary goal is to educate the public and private land users about the species and its ecological significance. When in the field, if a violation or unauthorized take is observed, the first step is to educate the person(s) responsible for the action that has directly or indirectly impacted an existing Tahoe yellow cress plant and/or population. Initial contact should be handled as an opportunity for outreach and provide a recommendation for corrective measures. Each agency is responsible for reporting significant disturbances that occur within lands managed by the agency or jurisdictions. This reporting does not commit any agency to enforce regulations of another agency.

Types of disturbances include, but are not limited to, the following:

- Deliberate removal of Tahoe yellow cress individuals without a permit (subject to criminal penalty under CESA and NRS);
- unauthorized entry into designated Tahoe yellow cress enclosures resulting in disturbance to individuals or their habitat;
- destruction or vandalism to designated Tahoe yellow cress enclosures;
- unintentional removal of Tahoe yellow cress (raking, burial, etc.);
- storage of boats and other recreational equipment on sites supporting Tahoe yellow cress and/or potentially suitable habitat;
- use of off-highway vehicles and mountain bikes within known Tahoe yellow cress populations;
- allowing new public access to known Tahoe yellow cress sites without appropriate environmental review and prescribed management guidelines (e.g. physical enclosures);
- public land-use management changes that may directly or indirectly affect Tahoe yellow cress populations and potentially suitable habitat without environmental documentation and review; and

- unauthorized recreational pier modifications within known Tahoe yellow cress populations.

Regulatory and resource agency contacts for reporting impacts and violations include the following:

Public lands - contact on-site staff and off-site agency representative

- California Department of Fish and Game – Enforcement Dispatch at (916) 445-0045, and Daniel Burmester at (916) 358-2874, dburmester@dfg.ca.gov
- California Department of State Parks – Ken Anderson (530)-581-2458, kande@parks.ca.gov
- California Tahoe Conservancy – Bruce Eisner (530) 542-5580 ext. 115, bruce@tahoecons.ca.gov
- Nevada Division of State Parks – Lake Tahoe Nevada State Park Supervisor at (775) 831-0494
- Nevada Division of Forestry – Tim Rochelle, Nevada Tahoe Resource Team Forester at (775) 687-4898
- USFS, Lake Tahoe Basin Management Unit – (530) 573-2600. After business hours, contact USFS Dispatch (530)-573-2606

.

Private lands - contact property owner and off-site agency representatives

- Tahoe Lakefront Owners' Association -- Jan Brisco at (530) 583-6882, janbrisco@ltol.com
- Tahoe Regional Planning Agency -- Jerry Dion at (775) 588-4547, jdion@trpa.org
- California Department of Fish and Game – same as above
- California State Lands Commission -- Maurya Falkner at (562) 499-6312, falknem@slc.ca.gov or Eric Gillies at (916) 574-1897, gilliee@slc.ca.gov
- Nevada Division of Forestry – same as above

Appendix L
Beach Raking Guidelines

1. Conduct a visual survey of property for evidence of Tahoe yellow cress.
   a) Tahoe yellow cress is a small, fleshy plant with small yellow four-petaled flowers, growing close to the ground. Tahoe yellow cress has been observed in flower from May to October.
   b) The size of a Tahoe yellow cress colony can vary from a single aerial stem to many individuals forming a continuous stand.
   c) Typically found on open sandy beaches or dunes, especially near the water's edge, stream mouths, back lagoons and backshore depressions where soil moisture may accumulate.
   d) Tahoe yellow cress has also been found under the litter line created as a result of wave action.

2. When removing beach litter -
   a) Whenever possible remove litter and winter debris by hand or with a soft, leaf rake.
   b) The goal is to avoid removing plants and minimize disturbance to the sand surface where seeds may lie.

3. Pay particular attention to litter lines, backshore depressions and sheltered, shaded areas where soil moisture is generally higher than an open sandy beach.

4. If Tahoe yellow cress is thought to occur on your on a property, and you would like a Tahoe yellow cress survey conducted on your property or if you have any questions, please contact Maurya Falkner, CSLC, at (562) 499-6312 (falknem@slc.ca.gov), Jerry Dion, TRPA, at (775) 588-4547 (jdion@trpa.org), or Jan Brisco, Tahoe Lakeshore Owners Association, at (530) 583-6882 (janbrisco@ltoa.com).

Reglas para la limpieza general de las playas

1. Revisar la propiedad para Tahoe yellow cress antes de comenzarla limpieza de la playa.
    a. Tahoe yellow cress es una planta pequeña y pulposa con pequeñas flores amarillas de cuatro hojas, de poca altura. Se ha observado que florece de mayo a octubre.
    b. El tamaño de una colonia de Tahoe yellow cress puede variar de un solo tallo a muchos tallos individuales formando una mata. Vea dibujos abajo.
    c. Tahoe yellow cress típicamente se encuentra en playas arenosas o dunas, especialmente al borde del agua, bocas de arroyos, lagunas y pozos de aguas estancadas (hoyos) donde se acumula la humedad en la tierra.
    d. También se ha encontrado al limítrofe que hacen las olas con la la escombro (usualmente vegetación muerta, corteza, etc)

2. Recuerde a remover la escombro
    a. Cuando sea posible saque la basura y el escombro del invierno con la mano o con una recogedor suave. Primavera es la temporada critica, ya que las plantas están recién empezando a crecer y son muy sensitivas a cualquier perturbación. Si usted ve Tahoe yellow cress, no barra directamente sobre las plantas, como puede arrancarlas.
    b. Lo más importante es evitar arrancar las plantas y minimizar la perturbación de la superficie donde puede haber semillas. Para evitar perturbación de la arena, barre suavemente y no se cave profundamente.

3. Preste mucho atención a los limítrofes de las olas y pequeños pozos (hoyos), áreas de sombra y abrigadas donde humedad de la tierra generalmente está más concentrada que en playa abierta. Es muy posible que en esos lugares haya Tahoe yellow cress y por eso son más sensitivos.

4. Si ud. cree que hay Tahoe yellow cress en su propiedad y quire verificarlo o si tiene preguntas, por favor comuníquese con Maurya Falkner, CSLC, al (562) 499-6312 o m.e. (falknem@slc.ca.gov) o Jan Brisco, Tahoe Lakeshore Owners Association, al teléfono (530) 583-6882.

Photographs of Tahoe Yellow Cress

Appendix M
Tahoe Yellow Cress Informational Sign for Private Landowners

The following sign may be placed on private property to help avoid damage to Tahoe yellow cress. This sign is approved by TRPA and does not require a permit. All other signs require a permit. The signs can be purchased at TRPA, TLOA, and other locations.

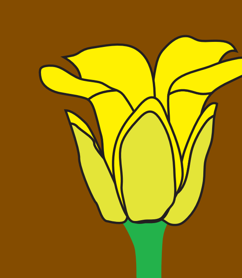
In order to allow this sign as an exempt sign Chapter 26 -- Signs must be amended as follows:

26.3 List of Exempt Activities: The following sign activities are not subject to review and approval by TRPA provided they do not result in the creation of additional land coverage or relocation of land coverage, and they comply with all restrictions set forth below:

(18) The placement of the "Tahoe Yellow Cress Informational Sign" within the shorezone of Lake Tahoe is allowed provided the sign is within 3 ft of a population of Tahoe yellow cress. The current design is kept on file at TRPA.

PLEASE

HELP PROTECT THE
ENDANGERED
TAHOE YELLOW CRESS
BY NOT VENTURING
BEHIND THIS SIGN



Appendix N
Survey Protocols and Archival and Annual Data Sheets

Surveys shall be conducted following established protocols. All known population sites will be surveyed annually between June 15 and September 30. Surveys will include all beach and associated backshore segments along the entire length of a given site. Each site length is based on previously defined geographic boundaries. In general, site boundaries are dictated by either natural (creek mouths, substrate change (sandy beach to boulder)) or human-constructed features (private property fences, rock jetties, etc.) that ultimately restrict the surveyor's lateral movement along the lakeshore. For example, the Blackwood Creek South site extends from the mouth of Blackwood Creek, south to the boat launch at the end of Grand Avenue. The southern border is dictated by private property, which restricts lateral access to adjacent potential Tahoe yellow cress habitat. If available, the boundaries of each site will be delineated using high-resolution GPS technology.

In general, the surveyor walks two full lengths of a beach segment at each site. On the first pass, the surveyor walks approximately 10 ft (3 m) on the shore side of the waters-edge, surveying a 15 ft-wide (9 m) section of beach. Upon reaching the end of a site, the surveyor focuses on the backshore section of the site. Special attention should be paid to backshore depressions that are likely to have increased soil moisture, and ecotonal boundaries between vegetation and beach substrate. Additionally, on open sandy beaches, microtopographic differences should be investigated closely. Small rises and associated depressions, leeward sides of prominent natural or human-created debris, and litter lines created through wave action provides potentially suitable habitat along any given lakeshore segment and again should be investigated carefully.

All information is recorded on Tahoe yellow cress Plant Survey Forms and provided to NNHP and CNDDB. Provide a brief description of the site (narrow strand, wide cobble beach, etc.), including width (backshore to water). Record all vascular plants at the site and estimate coverage. Estimate and record level of disturbance (light, moderate, heavy), type (raking, foot traffic, recreation, vegetation removal, etc.) and area. Estimate and record amount of debris (natural or human-related). Estimate and record percent substrate type (sand, gravel, cobble, boulder).

If Tahoe yellow cress is present, count the number of individuals within a site. Estimate percent juvenile, reproductive (flowering and fruiting) and senescent individuals. Estimate size of the occurrence. Note any disturbance (natural or human-caused) within the habitat. Draw a sketch map of the area and location of plants within the site. Map population(s) carefully onto aerial photographs and/or large-scale topographic maps. When available, the occurrence perimeter should be delineated using high-resolution GPS technology.

The TAG will provide guidance to field workers on using high-resolution GPS technology to delineate population areas. Coordinates must be given for the perceived "center" and "edges" of all populations. This will allow a more critical evaluation and clarification of population extent and habitat occupancy (such as defining the boundary between Baldwin Beach and Taylor Creek), as well as provide more reliable data for mapping and allow for easier relocation during subsequent surveys.

TAHOE YELLOW CRESS *(Rorippa subumbellata)* *SURVEY FORM*
Archival Data Sheet

Survey date (mm-dd-yy): ____________________

Surveyor: ____________________ Affiliation: ____________________

Email: ____________________ Telephone: ____________________

LOCATION (attach cop of quad map showing boundries and and pictures taken)

Site name: ____________________ Site code number: ____________________

County: ____________________

1:24,000 USGS quadrangle Name: ____________________

Site Ownership: ____________________

Landowner contact information: ____________________

Best access: ____________________

____

Coordinates of corners of TYC patch (in Decimal Degrees; 5 decimal planes - 0.xxxxx)

north: ____________________

south: ____________________

east: ____________________

west: ____________________

Archive photos of population from four compass directions taken? Yes No

PHYSICAL ATTRIBUTES

Elevation: ____________________

Soil moisture (saturated, damp, dry): ____________________

Depth to wet soil (cm): ____________________

substrate / soils (within 1 foot):

____________________% gravel

____________________% cobble

____________________% small boulder

____________________% large boulder

____________________% sand

____________________% other

____________________% TOTAL (Must equal 100%)

Aspect (N, NE, E, SE, S, SW, W, NW): ____________________

Slope (0, 1-2%, 3-5%, 5-10%, >10%): ____________________

HUMAN LAND USE

Note vegetation removal, trash, recreational impacts, vandalism and/or other impacts:

____

____

____

____

____

OTHER NOTES: ____________________

____

____

____

____

____

TAHOE YELLOW CRESS *(Rorippa subumbellata)* *SURVEY REPORT*
Annual Data Sheet

Survey date (mm-dd-yy): ____________________

Surveyor: ____________________ Affiliation: ____________________

Email: ____________________ Telephone: ____________________

LOCATION (attach copy of quad map showing boundaries and and pictures taken)

Site name: ____________________ Site code number: ____________________

County: ____________________ Record ID number: — **2001** — ☐ — ☐

1:24,000 USGS quadrangle Name: ____________________

Best access: ____________________

Coordinates of corners of TYC patch (in Decimal Degrees; 5 decimal planes - 0.xxxxx)

north: ____________________
south: ____________________
east: ____________________
west: ____________________

TYP Present? Yes No

Amount of person minutes spent in search? ____________________

Patch confined to enclosure? Yes No *(if yes, do not include introduced plants on form. see* NOTE below)*

Previous plant occurrence? Yes No

If YES, what was the date of the last occurance: ____________________

If NO, is this a new patch? Yes No

If this is a NEW PATCH, what is the distance and direction to the nearest existing patch? ____________________

TYC stems present outside previous population patch? Yes No *(If YES, fill out a new Archival and Annual Data Sheets for those plants)*

Specimens collected? Yes No

Stems (= rosettes) counted? Yes No If YES, # Stems counted? ____________________

Stems estimated? Yes No If YES, # Stems estimated? ____________________

if ESTIMATED, what is the likely error (+/-5%, 10%, >10%)? ____________________

Minimum rosette diameter (cm): ____________________ resolution (cm): ____________________

Maximum rosette diameter (cm): ____________________ resolution (cm): ____________________

% juvenile (= nonreproductive): ____________________ typical size (cm): ____________________

% reproductive Flowering ____________________ typical size (cm): ____________________

% reproductive Fruiting: ____________________ typical size (cm): ____________________

% senescent (= post-reproductive): ____________________ typical size (cm): ____________________

** Estimate within 10%*

PHYSICAL ATTRIBUTES

Shortest distance to lake water line (meters): ____________________

Lomgest distance to lake water line (meters): ____________________

Soil moisture (saturated, damp, dry): ____________________

Depth to wet soil (cm): ____________________

Lake level on Day of Survey (use data from Tahoe Dam): ____________________

TAHOE YELLOW CRESS *(Rorippa subumbellata)* *SURVEY REPORT*
Annual Data Sheet

Survey date (mm-dd-yy): ______

Surveyor: ______ Affiliation: ______

Email: ______ Telephone: ______

BIOLOGICAL ATTRIBUTES

Dominant vegetation (list by common and latin name and estimate total percent cover of site):

Percent Cover *Name*

Other vegetation

Percent Cover *Name*

Other rare species

Percent Cover *Name*

Weedy species in enclosure or in vicinity of TYC population? Yes No

if YES, list species: ______

Percent cover of weeds in enclosure or vicinity (<1%, 1-3%, 4-10%, 11-30%, 31-100%): ______

LAND USES and IMPACTS

Cover of footprint within patch (<5%, 5-25%, 26-50%, 51-75%, >75%): ______

Note vegetation removal, trash, recreational impacts, vandalism and/or other impacts:

Enclosure effectiveness (good, fair, poor): ______

Comments: ______

Possible Management actions: ______

OTHER NOTES:

** NOTE: Reintroductions must not be considered within the Annual Survey of an existing patch. A seperate Annual Survey form should be completed for the reintroduced population.*

Appendix O
Core and High Priority Restoration Site Histories

TYC Core or High Priority Restoration Sites	(Historical) Activities that Influence(d) the Site
Taylor Creek	Site of thousands of years of summer Washoe encampments; Tallac Resort was developed to Tallac Point on the west side of the creek/marsh with extensive turn-of-the-century activity, including piers and 100% of the visitors arriving via steamer; flows in Taylor Creek are regulated by a dam on Fallen Leaf Lake (MOU between USFS and Fallen Leaf Protection Assn., 3/6/72).
Upper Truckee East	Lake Tahoe's largest watershed; considerable urban residential development in the upland; airport located partially within the floodplain; marsh/streamcourse was altered in the 1960s with the construction of the Tahoe Keys subdivision; grazing in meadow adjacent to the lake (and headwaters since 1860s) discontinued in 2001; grazing of Barton Meadow south of Hwy 50 continues today.
Tallac Creek and Cascade	Site of thousands of years of summer Washoe encampments; fall horse grazing allotment (100+ years) along the creek; creek divides the boater's beach ("Ski Beach") from the developed recreation beach (Baldwin Beach)
Edgewood Creek	The Edgewood Creek watershed has been grazed for 100+ years. A golf course was built along the lakeshore around 1960.
Blackwood North & South	High sediment rates are the result of past logging, road construction, grazing, operation of a sawmill, and a gravel quarry; significant watershed restoration activities in the early-1980s to return stream that was diverted from quarry activities to its natural channel; contains a fish ladder structure that is proposed for removal; sheep from a grazing allotment cross through the area to load each fall.
Kahle/Nevada Beach	Burke Creek realigned in the early-1990s attempted relocation of a Tahoe yellow cress population; Jennings Casino site restoration in early-1980s buried the casino foundation rather than removed it; Rabe Meadow was site of (pre)historic Washoe use; numerous instream water rights in the area.

Glenbrook	Area was stripped of its trees during the Comstock era and in the 1950s, extensively logged in the steep, rocky high elevation areas; served as the key population center during the Comstock logging and the logs were rafted into the beach at Glenbrook and railroaded through Slaughterhouse Canyon to Virginia City; area burned in the early-1880s.
Eagle Creek	Severe highway slides (1953 and 1956); no sewer lines; site of considerable 1930s-era activity.
Ward Creek	Alpine Meadows Ski Area is in the upper watershed and 5,000 PAOT of additional capacity is reserved; area is roaded and used for motorized recreation; a paved road parallels the creek in its lower reaches
Meeks Bay	Meeks Bay Resort Marina is located within the mouth of Meeks Creek; prior to the 1970s, the campground on the south side of Meeks Creek had a density of 200 campsites (currently 40 sites); the capacity at Meeks Bay resort was also dramatically decreased after 1974 when the USFS acquired the property; both the resort and the campground are partially developed in SEZ; dramatic insect mortality in the 1970s to 1990s led to large tree removal projects in the meadow, resort, and campground.

Memorandum of Understanding/Conservation Agreement

This Memorandum of Understanding/Conservation Agreement (MOU/CA) is made among the Tahoe Regional Planning Agency (TRPA), the U.S. Fish and Wildlife Service (USFWS); the U.S. Forest Service; the Nevada Division of State Parks; the Nevada Division of State Lands; the Nevada Division of Forestry (NDF); Nevada Natural Heritage Program; the California Department of Fish and Game (CDFG), the California Department of Parks and Recreation; the California Tahoe Conservancy; the California State Lands Commission; the League to Save Lake Tahoe, a non-profit organization; and the Tahoe Lakefront Owners' Association, a non-profit organization. The above entities are collectively known as "the Parties."

RECITALS

WHEREAS, Tahoe Yellow Cress (TYC) is a plant species endemic to the shores of Lake Tahoe; and

WHEREAS, imminent threats coupled with a reduction in the distribution and number of TYC populations caused the States of Nevada and California to list the species as endangered; and

WHEREAS, USFWS declared TYC to be a candidate for listing under the Endangered Species Act of 1973, as amended (ESA); and

WHEREAS, the protection and conservation of TYC requires a coordinated effort of all the Parties, and

WHEREAS, it is the intent of the Parties to prevent the extinction and promote the recovery and conservation of TYC through coordinated management and cost sharing; and

WHEREAS, an Executive Committee of directors and executive officers was formed to guide the preparation and implementation of a Conservation Strategy (CS) for the protection and conservation of the TYC and the Executive Committee appointed a Technical Advisory Group (TAG) to develop the CS; and

WHEREAS, the CS developed in response to the Executive Committee's direction provides the basis for avoiding, minimizing, and mitigating the effects of human activities within occupied and potentially suitable TYC habitat; and

WHEREAS, the CS coordinates conservation efforts among the Parties to adaptively manage this species and coordinate monitoring to provide for the recovery of this species; and

WHEREAS, the actions described within the CS for TYC are grounded in a rigorous review and analysis of this species and the Lake Tahoe region; and

WHEREAS, the key aspect of the biology of TYC is the metapopulation dynamic of its life history, which makes it necessary to consider both occupied and potentially suitable habitat for management; and

WHEREAS, the role of the private land owner in the stewardship of TYC is crucial and this critical role is reflected within the CS and this MOU/CA; and

WHEREAS, the Parties desire to formalize their commitment to implement the CS.

NOW, THEREFORE, the Parties agree as follows:

A. PURPOSES

1. To ensure the implementation of conservation measures and management activities identified in the CS to provide long-term conservation benefits and achieve long-term survival of the TYC; and

2. To facilitate voluntary cooperation between the Parties to provide long-term protection for TYC and its habitat; and

3. To describe a process to be undertaken if a Party is unable to perform a conservation measure or management activity set forth in the CS; and

4. To set forth the miscellaneous provisions of the Parties' agreement to implement the CS.

B. COMMITMENT TO TYC CONSERVATION STRATEGY

1. Subject to the provisions of this MOU/CA, each Party agrees to implement the CS, including but not limited to the actions specified for each Party in Table 14 and the adaptive management strategy outlined in Chapter II.H of the CS. Table 14 will be reviewed and revised after 5 years. Each Party shall also designate individuals to serve on the Executive Committee and TAG. Any action taken by an individual Party must be consistent with that Party's governing authority and decision making processes.

2. The Parties incorporate by reference into this MOU/CA the TYC CS, attached hereto as Exhibit A, and any future revisions to that document pursuant to Paragraph G.7 of this MOU/CA.

C. ANNUAL REPORTS

1. By January 1 of each year, the TAG shall prepare an annual report describing the status of TYC following each survey year. This report will be a primary source of resource information for decision making for entities involved in conservation efforts.

2. The report shall include the following information:

   a. Number of populations identified during the most recent survey
   b. Number of individuals estimated during the most recent survey
   c. Copies of the annual data sheets
   d. Graphical representation of the population trend
   e. Conservation activities undertaken in the previous growing season
   f. Recommended conservation activities for the upcoming season
   g. Number of shorezone projects permitted within potentially suitable habitat
   h. Number of significant disturbances to the species or its habitat and subsequent responses
   i. Status of reintroduced populations (where appropriate)
   j. Brief summary of any reported research findings
   k. Estimate of staff time spent in past year
   l. Approved management plans

3. When preparing the annual report, the TAG shall, inter alia, explore the following questions as necessary:

   a. To what degree is each goal of the CS being achieved?
   b. Are conservation efforts effective in conserving the species and the metapopulation dynamic?
   c. Is reintroduction an effective conservation technique?
   d. Should the monitoring scheme be altered, and why?
   e. What regulatory changes should be made to ensure the survival of this species?
   f. What research questions are important to answer?

4. The TAG's production of the annual report and data analysis of the 2001 survey data shall initiate the adaptive management process described in the CS.

5. The TAG shall also develop recommended actions to be undertaken in each successive year by each land management agency and regulatory agency that are integral to the conservation effort. This list shall be prioritized in order of importance of protecting the species. Each recommended action item shall include a rough cost, schedule, and rationale to

allow the Executive Committee to make decisions or recommendations to Governing Authorities for the coming year's work program.

6. To the extent permitted by law, all Parties agree to provide to each other all relevant information in their possession or control related to implementation of the CS within 30 days of a request by another Party.

7. The Executive Committee shall approve the annual report or request specific modifications within 60 days of the TAG delivering the report to the Parties. TRPA shall post an electronic copy of the final report on its web page for general access.

D. FUNDING

1. The Parties warrant necessary funds exist to implement the CS for Fiscal Year 2001-2002 and commit to seek funding necessary to implement the CS in succeeding years. However, implementation of this MOU/CA and the CS is subject to the requirements of the Anti-Deficiency Act and the availability of appropriated funds. Nothing in this MOU/CA will be construed by the Parties to require the obligation, appropriation, or expenditure of any money from the U.S. Treasury, or from state or local funds. Any Party will promptly notify the Parties of any material change in a Party's financial ability to fulfill its commitments.

2. This instrument is neither a fiscal nor a funds obligation document. Any endeavor or transfer of anything of value involving reimbursement or contribution of funds between the Parties to this instrument will be handled in accordance with applicable laws, regulations, and procedures including those for Government procurement and printing. Such endeavors will be outlined in separate agreements that shall be made in writing by representatives of the Parties and shall be independently authorized by appropriate statutory authority. This instrument does not provide such authority. Specifically, this instrument does not establish authority for noncompetitive award to the cooperator of any contract or other agreement. Any contract or agreement for training or other services must fully comply with all applicable requirements for competition.

E. ENFORCEABILITY OF THIS MOU/CA

1. Successful implementation of the MOU/CA, CS, and adaptive management process should remove the threats to the species and ensure the long-term survival of TYC by maintaining and enhancing existing habitat in the Lake Tahoe basin and integrating new information on the biology of the species into future conservation and management activities. As a result, the need to list the species under the ESA should be avoided. If conservation and management practices are effective in removing the threats and long-term protection of the species and its habitat are achieved, the USFWS may modify the listing priority number or

remove the TYC from candidate status under the ESA. When or if it becomes known that threats to the survival of the TYC exist that are not or cannot be resolved through the CS, the USFWS may choose to reassign candidate status, an appropriate listing priority number, and list the species. The sole consequence of failure by a Party or Parties to implement this MOU/CA shall be reconsideration by the USFWS to list the TYC under the ESA if it has not already done so.

2. Without limiting the applicability of rights granted to the public pursuant to any law, this MOU/CA or the CS shall not create any right or interest in the public, or any member thereof, as a third-party beneficiary hereof, nor shall it authorize anyone not a Party to this MOU/CA to maintain a suit for enforcement of the MOU/CA or CS, personal injuries or damages. The duties, obligations, and responsibilities of the Parties to this MOU/CA with respect to third parties shall remain as imposed under existing law.

F. DURATION OF MOU/CA AND TERMINATION CLAUSE

1. This MOU/CA shall terminate 10 years from the date of the last signature of the Parties hereto ("the initiating date"). The Parties shall meet and assess this MOU/CA after 5 years from the initiating date. if more than one party remains, this MOU/CA shall automatically extend for the remainder of the 10-year term.

2. If any Party anticipates that some portion of the CS cannot be carried out by their agency, then that Party must notify other Parties in writing within 60 days prior to final determination of its inability to carry out such action. Within that time frame, the remaining Parties will meet to discuss alternatives to the implementation of the unfulfilled action.

3. Any Party may suspend or terminate its participation in this MOU/CA and CS by providing 90 days written notice to all other Parties. Suspension or termination by one or more Parties shall not alter this MOU/CA between the remaining Parties.

G. MISCELLANEOUS PROVISIONS

1. Notices

Any notice permitted or required pursuant to this MOU/CA or CS shall be in writing, delivered personally to the appropriate persons listed in Exhibit B hereto, or shall be deemed to be given five (5) days after deposit in the United States mail, certified and postage prepaid, return receipt requested, and addressed as follows, or at such other address as any Party may from time to time specify to the other Parties in writing. Notices may be delivered by facsimile or other electronic means, provided that they are also delivered personally or by certified mail. Notices shall be transmitted so that they are received within the specified deadlines.

2. Elected officials not to benefit

No member of or delegate to the U.S. Congress or California or Nevada legislatures shall be entitled to any share or part of this MOU/CA, or to any benefit that may arise from it.

3. Relationship to Legal Authorities

a. The terms of this MOU/CA and the CS shall be governed by and construed in accordance with the federal ESA, the California ESA (CESA), the Nevada Revised Statutes (NRS), the TPRA Compact and Code of Ordinances, and other applicable federal and state laws.

b. Nothing in the MOU/CA or CS is intended to limit the authority of the USFWS, CDFG, NDF, and TRPA to seek penalties or otherwise fulfill their responsibilities under the ESA, CESA, NRS, and TRPA Code, respectively. Moreover, nothing in the MOU/CA or CS is intended to limit or diminish the legal obligations and responsibilities of the USFWS, CDFG, NDF, and TRPA as agencies of the federal and state governments. Nothing in this MOU/CA or CS limits the right or obligation of any state or private entity to engage in appropriate consultation or permitting process required under any applicable federal or state law; however, it is intended that the rights and obligations of the Parties under the MOU/CA and CS may be considered in any consultation affecting a Party's use of the specified lands.

4. Successors and assigns

This MOU/CA and each of its covenants and conditions shall be binding on and shall insure to the benefit of the Parties and their respective successors and assigns. Assignment or other transfer of the MOU/CA shall be governed by the TRPA, USFWS, CDFG, and NDF regulations in force at the time.

5. Public documents

Information provided to any governmental agency pursuant to this MOU/CA and CS may be subject to release to members of the public under either state or federal law including but not limited to information furnished to the USFWS under the Freedom of Information Act (5 U.S.C. 552).

6. Modification

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

7. **Participation in similar activities**

This instrument in no way restricts the Parties from participating in similar activities with other public or private agencies, organizations, and individuals.

8. **No regulatory approvals**

Neither this MOU/CA nor CS constitutes regulatory approval by any Party of any projects mentioned in the MOU/CA or CS. All projects and actions must follow the otherwise applicable regulatory process for all necessary permits or approvals.

IN WITNESS WHEREOF, the Parties hereto have caused this agreement to be executed as of the day and year first above written

TAHOE REGIONAL PLANNING AGENCY

By: ______________________________ _______________
Juan Palma, Executive Director Date

U.S. FISH AND WILDLIFE SERVICE

By: ______________________________ _______________
Steve Thompson, Manager, Date
California/Nevada Operations Office

U.S. FOREST SERVICE

By: ______________________________ _______________
Maribeth Gustafson, Forest Supervisor Date

NEVADA DIVISION OF STATE PARKS

By: ______________________________ _______________
Wayne Perock, Administrator Date

NEVADA DIVISION OF STATE LANDS

By: ______________________________ _______________
Pamela B. Wilcox, Administrator Date

NEVADA DIVISION OF FORESTRY

By: ______________________________ ______________
Steve Robinson, State Forester Firewarden Date

NEVADA NATURAL HERITAGE PROGRAM

By: ______________________________ ______________
Glenn Clemmer, Program Manager Date

CALIFORNIA DEPARTMENT OF FISH AND GAME

By: ______________________________ ______________
Banky Curtis, Regional Manager Date

CALIFORNIA DEPARTMENT OF PARKS AND RECREATION

By: ______________________________ ______________
John Knott, Superintendent Date

CALIFORNIA TAHOE CONSERVANCY

By: ______________________________ ______________
Dennis Machida, Executive Officer Date

CALIFORNIA STATE LANDS COMMISSION

By: ______________________________ ______________
Paul D. Thayer, Executive Officer Date

LEAGUE TO SAVE LAKE TAHOE

By: ______________________________ ______________
Rochelle Nason, Executive Director Date

TAHOE LAKEFRONT OWNERS ASSOCIATION

By: ______________________________ ______________
Jan Brisco, Executive Director Date