Disclaimer: The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the STATE OF CALIFORNIA or the FEDERAL HIGHWAY ADMINISTRATION. This report does not constitute a standard, specification, or regulation.
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Bear Creek Botanical Management Area

Table of Contents

I. Executive Summary ........................................................................................................ 2-8
II. Introduction .................................................................................................................. 9-10
III. Botanical Features ..................................................................................................... 10-12
IV. Non-native Invasive Species ....................................................................................... 12
V. Integrated Vegetation Management ............................................................................. 13
VI. Monitoring .................................................................................................................. 13-16
VII. Conclusion .................................................................................................................. 16-19
VIII. Improved Vegetation Management Protocols, and Applications to other ROW’s in the State .................................................................................................................. 20-26
IX. Recommendations for Future Management on the BCBMA and Vicinity .......... 26-29
X. References and Literature Cited .................................................................................. 30-31

Appendices

GIS Maps of BCBMA ....................................................................................................... Appendix I
BCBMA Flora .................................................................................................................. Appendix IIa
Characteristic Plants Outside of Core Area .................................................................. Appendix IIb
GPS map of Baseline Weeds and Burn Map of Core Area .............................................. Appendix III
Occurrence, Chronology, and A-IVM Synopsis of Invasive Plants ................................. Appendix IV
Yellow Starthistle Baseline Densities and Reductions from A-IVM ................................. Appendix V
Releve Plots ..................................................................................................................... Appendix VI
Photographs Depicting Baseline Conditions, Non-native Invasive Species, Management, and Restoration Results .................................................................................................. Appendix VII
Adaptive Management, IVM Flow Chart, and Yellow Starthistle Control Calendar ........... Appendix VIII
Tom Golden Acknowledgement, Prescribed Burning Articles

Bear Creek Watershed Restoration Program
I. Executive Summary
This report contains three interrelated parts. 1) Sections II-VII summarizes the Bear Creek Botanical Management Area (BCBMA) program, findings from botanical inventories and five years of Adaptive-Integrated Vegetation Management practices that were conducted on the BCBMA. 2) Section VIII discusses management protocols and explains how this work applies to other right-of-ways in the state. 3) Section IX recommends future management activities for BCBMA and nearby roadside areas.

1) The BCBMA is a significant natural area and scenic resource that has statewide, regional, and local value. The core area is a species-rich serpentine grassland that harbors over 100 native plant species and supports spectacular assemblages of spring wildflowers, native grasses, and associated perennial forbs. Sections outside of the core area support examples of blue oak, riparian, and serpentine chaparral communities. Within the entire BCBMA, 222 vascular plant species have been recorded, including 12 serpentine endemics and five special-status plant species. Yellow-legged frogs, a special-status animal, were observed in a drainage and a stone mortar was found, providing evidence of past use of the BCBMA by Wintun Indians.

Five years ago, yellow starthistle and barb goatgrass dominated two-thirds of the BCBMA in the core area, presenting a major threat to the native plants on the site. Adaptive-Integrated Vegetation Management (A-IVM) practices were implemented to control these and five other non-native invasive species with the goal of enhancing native vegetation. To help achieve this goal, many agencies and individuals participated in management activities. The results provide an ecological restoration success story for Caltrans and the site is an important demonstration site for the larger Bear Creek Watershed Restoration Program.

2) The vegetation management protocols used on the BCBMA have useful applications for right-of-ways elsewhere in the state. To illustrate this, six key categories, i.e., prioritizing activities, management tools, proper timing, mapping, partnership development, and long-term commitment to management are discussed, using yellow starthistle as the primary weed control example.

Since vegetation management resources are limited, an essential component for designing local, regional, or statewide programs is to prioritize where and what kind of work should be done. As part of the Bear Creek Watershed Restoration Program, management of the BCBMA was deemed a priority because of its overwhelming ecological value, the opportunity to conduct A-IVM through a partnership with Caltrans, and the potential to use the BCBMA as a research and demonstration site.

On the BCBMA, non-native invasive species (NIS) control were a clear management priority, so a long-term program was initiated to address this major ecological problem. The program has eradication, suppression, and containment objectives.

Eradication of target plants is always desirable in control programs, but very difficult to achieve once weeds gain a strong foothold. One of the requirements for eradicating target plants is to deplete the seed bank, something that usually takes years to accomplish, especially with plants that have a persistent seed bank. The most cost-effective means is to take a preventative
approach by detecting incipient infestations and quickly removing them before they have an opportunity to develop a large seed bank and spread. This approach was used on the BCBMA and has merit throughout the state, even with widespread NIS such as yellow starthistle, where outliers occur far from infestation strongholds.

Purple starthistle was eradicated on the BCBMA through early detection and removal, showing the value of a rapid weed-control response. A single giant reed plant was also eradicated. Perennial pepperweed and tamarisk are close to being eradicated and follow-up efforts are recommended.

Although very common, eradication of yellow starthistle and barb goatgrass is being attempted in the core area of the BCBMA because of their clear threat to the ecological integrity of the BCBMA. Yellow starthistle has been reduced by 99.9% from baseline levels, but an ongoing effort will be needed to eliminate it and to prevent re-infestation. Barb goatgrass has been greatly reduced but more control work is also needed.

Although eradication of a well-established target species is desirable and sometimes warranted, it is emphasized that lower-intensity management approaches such as suppression and containment are also worthwhile. Well-executed suppression programs can lead to substantial weed reductions, while enhancing native vegetation. Additionally, containment programs have been used for many decades by the California Department of Food and Agriculture for their statewide noxious weed control programs to stop the spread of NIS.

Prescribed burning, mowing, manual control, and herbicide applications were used as management tools to achieve eradication, suppression and containment objectives. Combinations of all these tools proved to be the most effective approach.

Prescribed burns were conducted for four consecutive years to aid in yellow starthistle, barb goatgrass, and medusahead control. The burns required cooperation with California Department of Forestry, Caltrans, and Bureau of Land Management. Proper timing and fuel conditions were needed for effective yellow starthistle control. One hundred percent control of yellow starthistle and barb goatgrass was achieved with the first burn, but subsequent burns required follow-up spot removal of plants. Fuel loads decreased with each burn leaving large patches of unburned vegetation, including target weeds.

Herbicide applications played an important role in the integrated program for many target weeds, especially outside of the core area. Damage to non-target plants was minimized by using selective herbicides, timing applications after non-target plants had completed their life cycle, or by not using them in places when non-target, susceptible plants were present, and applying herbicides carefully. Although Transline is the herbicide of choice for yellow starthistle in the early growth stages, it was not used in the core BCBMA because of concern for its effects on non-target native plants in the \textit{Apiaceae, Asteraceae, Fabaceae} and \textit{Polygonaceae}.

Steel-bladed weed eaters, stringer mowers, and tractor-mounted mowers were used for mowing yellow starthistle and barb goatgrass. Properly-timed mowing, i.e., early-flowering stage, was effective in reducing yellow starthistle, but repeat mowings, followed by spot control was needed.
to achieve 100% control. Mowing too early or too late exacerbates yellow starthistle infestations by removing competition or spreading seed. Additionally, caution was used when yellow starthistle was growing in the presence of barb goatgrass and medusahead. Since these plants mature earlier, mowing would have helped disseminate their seed over larger areas.

Hand-pulling target plants was an important adjunct to the BCBMA program, both as a follow-up measure to mowing and prescribed burns, and as a primary means for eliminating outliers. Work crews consisted of volunteers, paid assistants, “probationaries” supplied by Caltrans, and juvenile labor from the Fouts Springs Youth Facility.

Finally, many of the protocols presented in the narrative are not a direct product of the BCBMA program. Rather, they are a synthesis and site-specific application of a large body of information and personal experience in vegetation management. Additionally, it is emphasized that the information is not intended as a comprehensive treatment for the myriad conditions that exist on ROW’s supporting natural vegetation. Some examples are given, but many more management permutations exist that are beyond the scope of this contract. Nevertheless, if the suggested protocols are incorporated into District programs they will improve the effectiveness of roadside vegetation management by reducing weeds, enhancing native vegetation, and ultimately, saving money.

3) The future management recommendations presented in Section IX are an outgrowth of BCBMA work, as well as from other activities conducted in the larger Bear Creek watershed. Many partnerships have been developed and there is an excellent opportunity to build on existing work. Further vegetation management benefits will occur if recommendations are implemented in part or in their entirety, and the program could serve as a model for other Caltrans districts and statewide Weed Management Areas.

California poppy (*Eschscholzia californica*)
PHOTOGRAPH SUMMARY

BEFORE:

Baseline: dense yellow starthistle skeletons (left), with grazed BLM property (right) May, 1999, Section 1.

Baseline: June 10, 1999.

Baseline, east parcel, Section 1.

George Hartwell mowing YST on rocky knoll with weed eater.
MOWING:

Stringer mower used for mowing YST in early flowering stage, June 1999.

Mowed YST with unmowed patch of barb goatgrass (right)

Post YST mowing by Caltrans with dense patches of barb goatgrass left unmowed to reduce spreading seed. Year 1, preceding burns.

Response to mowing by *Collinsia sparsiflora* in Section 1 the following spring, March 2000.
BURNS:

Caltrans cooperating with sign informing travelers of proposed burn.

Fire intensity increasing from higher levels of fuel.

Fire moving through last stand of YST

Charred YST skeletons after burn June 29, 2000.
AFTER:

Agoseris (*Agoseris grandiflora*) goldfields (*Lasthenia californica*), tidy tips (*Layia chrysanthemoides*), plectrits (*Plectritis macrocera*) in foreground

Knoll with diverse wildflower display. This is the same knoll that was depicted with George Hartwell mowing.

Collinsia sparsiflora, early spring.

Late-spring with pale larkspur (*Delphinium hesperium* ssp. *pallescens*) with purple owl’s clover (*Castilleja exerta* ssp. *exerta*) and Agoseris (*Agoseris grandiflora*)
II. Introduction
The BCBMA is located on a Caltrans right-of-way (ROW) along State Route 20 in Colusa County, 1/5 mile west of the State Route 20/16 intersection, just beyond the Bear Creek bridge. It is 60' wide and extends for one mile to the west. The contract provided funds to manage the BCBMA during the 2003 growing season and to summarize practices and results of A-IVM over the last five years.

This work was built on past efforts by Caltrans and Federal Highway Administration (FHWA) personnel, and botanical consultants as part of the statewide Botanical Management Area program. George Hartwell, (retired, Caltrans), developed the statewide program in cooperation with Bonnie Harper-Lore (FHWA roadside vegetation manager), Gary Bush (retired, Caltrans), Matt Gause (Botanist, May Consulting), and Dr. Rob Preston (Botanist, Jones & Stokes).

The BMA program was initiated to comply with the Surface Transportation and Uniform Relocation Assistance Act, allowing Caltrans to divert and pool funding intended for wildflower plantings towards management of natural ecosystems along California roadways. The BMA identification process involved solicitation of state, federal, and local government agencies, academic institutions, NGO’s and individuals for recommendations on locations of roadside native plant communities that were known to be biologically diverse, representative of remnant ecosystems, and potentially threatened by ROW management activities or invasive plants (Hartwell, per. comm.). Twenty sites that supported significant stands of native vegetation were identified and documented along ROW’s to insure that they were protected in perpetuity through recognition and management. Signs that identify BMA locations have been placed along corridors to inform travelers of sites.

The work conducted on the BCBMA is part of a larger land stewardship effort, i.e., the Bear Creek Watershed Restoration Program, with over 30 cooperating entities (Appendix X). The overriding goals of the program are to preserve and manage the ecological, agricultural, and recreational landscapes in the watershed. Ongoing ecological restoration efforts also occur on adjacent Bureau of Land Management property to the south and on private land to the north of State Route 20.

With the goal of preserving native plants on the BCBMA, the focus of the work has been to document the flora and to implement a management program to control seven non-native invasive species (NIS). The BCBMA is a key parcel in the watershed and has many noteworthy features:

Inner Coast Range Prairie Remnant
- It is a botanically-rich natural area, supporting 41% of the flora recorded for the entire 65,000-acre watershed. Successive waves of spring annual wildflowers and perennial forbs appear from February to August in the core area and intermingle with native bunch-and sod-forming grasses.
**Unique Reference Area**
- It supports one of the few grassland sites in the Bear Creek watershed that may never have been grazed by livestock and has never been cultivated. As such, it is a valuable roadside reference area for botanists, landscape architects, and restoration ecologists.

**Scenic Right-Of-Way**
- It is an important roadside scenic resource, enjoyed by many travelers in the spring who stop and visit to view the spectacular wildflower displays.

**Bank of Native Plant Material**
- The remnant native vegetation is a source of plant material for revegetation, erosion control, and ecological restoration programs in the Bear Creek watershed. Seed from native grasses and forbs have been collected for nearby Caltrans revegetation projects and for planned restoration efforts on adjacent BLM land.

**Interpretation, Training and Education**
- The BCBMA has been used for spring wildflower tours in the Bear Creek watershed and to interpret results of ecosystem management. CDF has used the site for training over 30 personnel for the summer fire seasons. Seven botanists from the Natural Diversity Data Base Dept. of Fish and Game, and the California Native Plant Society assisted with monitoring as part of a plant community training session for their employees. Specimens from the BCBMA have been used by Dr. Ellen Dean for UC Davis Botany classes and Dr. Ken Chambers, emeritus professor, University of Oregon, has collected material there for genetic and taxonomic research (Battjes, J. and K. Bachmann 1994). The California Native Grass Association will be listing the site in their “Grasslands Resource Guide.”

**Wildlife Refuge**
- The BCBMA is a refuge for native pollinators that benefit from stands of intact native vegetation for their pollen, nectar, and larval host plant needs.

- Yellow-legged frogs, a special-status animal, were observed in two drainages, Sections 1 & 2.

**Archeological Site**
- A Native American artifact was observed in Section 1, indicating previous use of the area by Wintun people.

**III. Botanical Features**
David Magney, the botanist who first suggested the Bear Creek Botanical Management Area as a potential site for recognition, described it as a “microcosm of Bear Valley.” Bear Valley is renowned for its vast and diverse spring wildflower displays that stretch for miles across the valley floor, attracting thousands of visitors annually. An underlying reason for the floristic resemblance is that the soils from both areas are derived from serpentinite parent material and share similar properties.
To document the flora, 446 specimens of known and unknown taxa were collected, pressed, and identified. Voucher specimens are being deposited in the UC Davis Herbarium. From these collections, a total of 222 taxa were identified, 178 (80%) of which are native. This is 41% of the entire 536 taxa reported for the Bear Creek watershed. Five special-status plants and 12 serpentine endemics were confirmed.

Adobe lily (*Fritillaria pluriflora*), special-status species, Section 1

The BCBMA was divided into three sections and maps were developed using GPS and GIS technology, i.e., ARC-INFO (*Appendix I*). Section 1, the core area, comprises part of the area originally surveyed by Matt Gause in 1998. In the core area alone, over 100 native species were identified from inventories between the spring of 2000 and 2002. Native plant assemblages in this section include numerous examples of serpentine communities including upland wildflower, native grassland, and riparian. Lowland riparian terrace prairie and blue oak savannah are also featured at the edges of the large turnout. A large valley oak (12’- circumference) occupies the northwest corner of this section.

Valley Oak (*Quercus lobata*) with 12’ circumference.
Sections 2 and 3 are delineated by drainages and were not included in earlier Caltrans’ reports (Hartwell and Gause, 1998). However, subsequent inventories revealed that these sections supported a significant number of native plants not present in the core area, including woody, herbaceous, special-status and serpentine endemic species. The diversity of soil substrates and topography provides a rich variety of sites for native plants, and unrecorded species were documented every year. Appendix IIa provides a list of all known taxa from the BCBMA. Appendix IIb lists plants that characterize assemblages outside of the core grassland area.

IV. Non-native Invasive Species

The primary stewardship issue for the BCBMA is non-native invasive species (NIS). Non-native plants comprise 20% of the BCBMA flora. Seven of the non-native plants are listed as “Noxious” weeds by the California Department of Food and Agriculture and as “Exotic Plants of Greatest Ecological Concern” by the California Exotic Plant Pest Council. These include:

- Barb goatgrass (*Aegilops triuncialis*)
- Giant reed (*Arundo donax*)
- Medusahead (*Taeniatherum caput-medusae*)
- Perennial pepperweed (*Lepidium latifolium*)
- Purple starthistle (*Centaurea calcitrapa*)
- Tamarisk (*Tamarix parviflora*)
- Yellow starthistle (*Centaurea solstitialis*)

**Yellow Starthistle and Barb Goatgrass**

Five years ago, about two-thirds of the core BCBMA was heavily infested with yellow starthistle (*Centaurea solstitialis*) and barb goatgrass (*Aegilops triuncialis*). In some portions, yellow starthistle formed solid stands to the exclusion of most other species (Appendix VII, photos 2, 3, 4, 6). Barb goatgrass had also formed large patches and many incipient infestations were present, preparing the way for more expansion. It is abundant elsewhere in the watershed, including adjacent BLM property, and has clearly demonstrated its potential to increase, even on serpentine soils (Appendix VII, photos 13, 14). Appendix III-a is a GPS-derived map 1999 that delineates dense yellow starthistle and barb goatgrass infestations in Section 1, Hwy 20 and the large turnout. Additional occurrence information for other NIS that were targeted for control is found in Appendix IV. Appendix VII, photos 12-18, depict some of the NIS.

**Unlisted Invasive Plants**

Although other non-native species that occur in the BCBMA are not on either list, at least four other species are invasive and may pose future problems if not managed. Two non-native grasses, Italian ryegrass (*Lolium multiflorum*) and soft chess (*Bromus hordeaceous*) are dominant throughout much of the grassland core area. Although now mostly confined to the edge nearest the roadside on Section 1, bulbous bluegrass (*Poa bulbosa*) is abundant on adjacent land and will probably expand on the BCBMA if not controlled. Intermediate wheatgrass (*Elytrigia intermedia*) arrived at the site through a previous Caltrans seeding. It is spreading and can be...
expected to displace native plants over time, due to its robust habit and tendency to form monocultural stands.

V. Vegetation Management in the Context of Ecological Restoration
To address the NIS that occupied the BCBMA, weed control measures were initiated. Management decisions were based on Adaptive Management and Integrated Vegetation Management (A-IVM) protocols, past research and principles of weed control.

Adaptive Management
Adaptive Management is a cycle of activities used by ecosystem managers to help achieve specified land stewardship goals (Appendix VIII-1,2,3). The steps include setting goals for the site, identifying stewardship issues, assessing management options, developing and implementing a management plan, monitoring results, and revising plans based on results, new information, or changing goals. Some of the “assumptions” of the Adaptive Management model are that resources for management are scarce, management is ongoing, management-decisions should be site-specific, and managers or other specialists do not know everything. This latter assumption indicates the importance of research as well as collaboration.

Integrated Vegetation Management
As the name implies, IVM is a branch of Integrated Pest Management (IPM) with a focus on managing plant pests and other vegetation to achieve specified landscape goals. The UC IPM program (www.ipm.ucdavis.edu/IPMPROJECT/) defines IPM as follows:

“Integrated pest management (IPM) is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment.”

The Final Environmental Impact Report on Caltrans’ Vegetation Control Program outlines the specific IVM steps (Jones and Stokes, 1992) (Appendix VIII-4).

Within an A-IVM framework, combinations of mowing, prescribed burning, manual control, cutting, and herbicide applications were used to control seven NIS. Appendix IV provides descriptions of weed occurrences, weed control chronology, and an IVM synopsis of individual weeds.

VI. Monitoring
To monitor baseline conditions and trends of target weeds and native plants, a monitoring program was established using plant density counts, Natural Diversity Data Base “Releve” plots, and photographs.

Yellow starthistle was the primary NIS affecting native plants, so in March 2000, four permanent plots were established to monitor results from ongoing eradication efforts. Three of the plots had
not been mowed in 1999 due to the presence of barb goatgrass or rocky conditions, and therefore provided pre-treatment baseline seedling densities. Mean baseline densities for these plots were 422 seedlings/m². The other plot, #1, had been mowed in 1999 as part of the 1st year effort to control yellow starthistle. As a result, the pre-burn starthistle densities were lower (160 seedlings/m²) than elsewhere. The plot sizes were 700 m², 275 m², 144 m², 468 m², reflecting the area of unmowed barb goatgrass and the rocky slope at the east end of the BCBMA. Since eradication was the objective, untreated experimental “controls” were not incorporated into the sampling scheme, because that would have left a seed source to re-infest the site.

Within each plot, 40 yellow starthistle density samples were taken each year. Four randomly selected transects were established and 10 samples/transect were taken with a .10 m² circular sampling frame, divided into four sections to facilitate counts. Appendix V shows plot data from four years of sampling starthistle seedling densities before and after management. Mean yellow starthistle densities from the four plots show that yellow starthistle densities declined by 99% as a result of control efforts (Table 1).

### Table 1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Baseline</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
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<tr>
<td>2003</td>
<td>250</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

In 2001, two 400m² Releve plots (Table 2) within Section 1 were established to quantify relative abundance of vegetation in the core area. It relies on visual estimates to characterize vegetation, and provides useful information on composition, relative abundance, and other site features. Under the direction of Dr. Todd Keeler-Wolf, seven botanists assisted with this effort in 2001, and the sampling was continued in 2002 and 2003. Appendix VI shows species composition and relative cover data from three years of Releve sampling.
Table 2

Releve 1:

<table>
<thead>
<tr>
<th>Year</th>
<th>Native</th>
<th>Exotic</th>
<th>Bare Ground</th>
<th>Litter</th>
<th># of native taxa with &lt; 1% cover</th>
<th># of non-native taxa with &lt; 1% cover</th>
</tr>
</thead>
<tbody>
<tr>
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<td>42</td>
<td>21</td>
<td>5</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>2002</td>
<td>47</td>
<td>28</td>
<td>20</td>
<td>5</td>
<td>19</td>
<td>3</td>
</tr>
<tr>
<td>2003</td>
<td>45</td>
<td>26</td>
<td>23</td>
<td>6</td>
<td>25</td>
<td>6</td>
</tr>
</tbody>
</table>

Relative Cover, Releve 1

Releve 2:

<table>
<thead>
<tr>
<th>Year</th>
<th>Native</th>
<th>Exotic</th>
<th>Bare Ground</th>
<th>Litter</th>
<th># of native taxa with &lt; 1% cover</th>
<th># of non-native taxa with &lt; 1% cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>58</td>
<td>20</td>
<td>20</td>
<td>2</td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td>2002</td>
<td>50</td>
<td>29</td>
<td>20</td>
<td>1</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>2003</td>
<td>63</td>
<td>16</td>
<td>20</td>
<td>1</td>
<td>13</td>
<td>4</td>
</tr>
</tbody>
</table>

Relative Cover, Releve 2

* The large decline recorded in the yellow starthistle plots are not reflected in this data set, because major starthistle reductions had already occurred from previous management.
Releve 1 included a swale that supported some plants typical of moist sites with deep soil, including *Lasthenia glabrata*, *Juncus balticus*, *Leymus triticoides*, and *Eryngium aristulatum*. Forty-nine species were recorded, 41 of which are native (84%). Unfortunately, the Releve sampling was initiated two years after management measures for yellow starthistle control, i.e., mowing, Year 1, followed by burning, Year 2, were implemented, so the dramatic declines recorded in the yellow starthistle plots are not reflected in the Releve data set, since major starthistle reductions had already occurred. Nevertheless, the values in Releve 1 show a 30% increase overall in native cover from the first sample taken April 7, 2001. Conversely, there was an overall 29% decrease in exotic plant cover, due mainly to the decline of barb goatgrass from 12% in 2001 to a trace amount in 2003. However, Italian ryegrass (*Lolium multiflorum*), a widespread, exotic annual grass increased from 9% cover in 2001 to 19% cover in 2003.

Releve 2 supports plants that are more characteristic of less productive upland sites with a lower water-holding capacity. For example, fewer perennials were present and several low-statured annual forbs, more typical of well-drained soils, occurred in some abundance, i.e., *Lasthenia californica*, *Micropus californicus*, and *Plantago erecta*. Forty taxa were recorded, 31 of which are native (78%). Unlike Releve 1, native plant cover (57%) was already much higher than non-native cover (19%) at the first year of sampling. Similar to Releve 1, this was two years after intensive yellow starthistle control work had been initiated. Native plant cover decreased in 2002 due to a decline in *Lupinus bicolor* and non-native cover increased due to greater amounts of soft chess (*Bromus hordeaceous*). However, the 2003 measurement in Releve 2 showed an 8% overall increase in native cover and a 21% decrease in non-native cover compared to the 2001 sample.

**VII. Conclusion**

The ecological value of the BCBMA has been greatly enhanced by the Integrated Vegetation Management program. The decline in seven noxious weeds over the last five years has created conditions that are allowing native plants to flourish. Yellow starthistle was reduced by 99% in the core grassland area; the dense yellow starthistle canopies, high seedlings densities, and thick thatch that characterized infestations have been eliminated. Intensive control efforts this year further reduced yellow starthistle and barb goatgrass, bringing them closer to eradication. Purple starthistle and giant reed have been eradicated and tamarisk and perennial pepperweed have nearly been eliminated. Successful A-IVM practices have been demonstrated, emphasizing reduced herbicide use, with judicious spot applications as part of a total program.

**Restored Native Prairie**

The native seed bank, formerly inundated by weeds in much of the core BCBMA, responded well to the management. A series of photographs illustrate some of the changes that have occurred (*Appendix VII*, photos 19-36). Spectacular displays of wildflowers and native grasses appear in successive waves from late February to June. In the core area, Adobe lily (*Fritillaria pluriflora*), a special-status species with a tulip-like flower is one of the first plants to bloom. By mid-March large pink displays of *Collinsia sparsiflora* appear along with an abundance of *Athysanus pusillus* var. *pusillus* and *Phlox gracilis*. In April, the core area reaches its’ spring peak with a great variety of spring wildflowers including this partial list:
Diverse wildflower display.
By mid-May, the peak spring bloom is passed, but another noteworthy display appears that is characterized by unusually dense stands of the cream-colored, pale larkspur (*Delphinium hesperium* ssp. *pallescens*), growing in association with other species.

Late-spring with pale larkspur (*Delphinium hesperium* ssp. *pallescens*) with purple owl’s clover (*Castilleja exerta* ssp. *exerta*) and Agoseris (*Agoseris grandiflora*).

Following the peak Spring bloom, some important summer-active plants appear such as gum plant (*Grindelia camporum*) turkey mullein (*Eremocarpus setigerus*), Spanish clover (*Lotus purshianus*), tarplants (*Hemizonia* and *Madia*) narrow-leaf milkweed (*Asclepias fascicularis*), narrow-leaf goldenrod (*Euthamia occidentalis*), i.e., terrace riparian prairie. These serve as important nectar and pollen sources for native pollinators and larval host plants for butterflies.

Monarch on narrow-leaf goldenrod (*Euthamia occidentalis*) in riparian terrace prairie.
Native grasses
In addition to the rich assemblages of wildflowers and other native forbs, the core area of the BCBMA supports many native grasses including perennial bunchgrasses and sod-forming, rhizomatous taxa, as well as three annual species:

<table>
<thead>
<tr>
<th>Grass Type</th>
<th>Scientific Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>annual hairgrass</td>
<td><em>Deschampsia danthonioides</em></td>
<td>annual</td>
</tr>
<tr>
<td>salt grass</td>
<td><em>Distichlis spicata</em></td>
<td>sod-forming</td>
</tr>
<tr>
<td>squirrel tail</td>
<td><em>Elymus elymoides</em></td>
<td>bunchgrass</td>
</tr>
<tr>
<td>blue wildrye</td>
<td><em>Elymus glaucus</em></td>
<td>bunchgrass</td>
</tr>
<tr>
<td>creeping wildrye</td>
<td><em>Leymus triticoides</em></td>
<td>sod-forming</td>
</tr>
<tr>
<td>meadow barley</td>
<td><em>Hordeum brachyantherum</em></td>
<td>bunchgrass</td>
</tr>
<tr>
<td>annual barley</td>
<td><em>Hordeum depressum</em></td>
<td>annual</td>
</tr>
<tr>
<td>pine bluegrass</td>
<td><em>Poa segunda ssp. segunda</em></td>
<td>bunchgrass</td>
</tr>
<tr>
<td>California melic</td>
<td><em>Melica californica</em></td>
<td>bunchgrass</td>
</tr>
<tr>
<td>purple needlegrass</td>
<td><em>Nassella pulchra</em></td>
<td>bunchgrass</td>
</tr>
<tr>
<td>annual vulpia</td>
<td><em>Vulpia microstachys</em></td>
<td>annual</td>
</tr>
</tbody>
</table>

Visibility and Adjacent Ecological Restoration Projects
The BCBMA’s highly visible location and proximity to other nearby vegetation management programs has made it one of the focal points in the Bear Creek Watershed Restoration Program. The results achieved from A-IVM practices, combined with other adjacent ecological restoration efforts are producing many positive changes in the local landscape. Last June, BLM conducted the first of many planned prescribed burns on 160 acres of adjacent land to the south. Additionally, on adjacent private land to the north, 10 acres of upland grassland and high-quality riparian terrace are being restored on both sides of Bear Creek (*Appendix III-b, Burn Map, P-2, 3, 4, 5*).

Follow-up Management Needed
Although there have been numerous successes with the program, it would be a major setback to abandon the eradication efforts initiated for several NIS in the core area, especially yellow starthistle and barb goatgrass. Research elsewhere (Kyser and DiTomaso 2002, Heise, per. Comm.) has demonstrated that these species will quickly increase if eradication efforts are abandoned, even where 99% reductions have been achieved. Spot removal of these target plants in late spring should be performed until they have been eradicated. Additionally, occasional burns every three or four years along with performing some of the tasks recommended in Section IX may be needed to help maintain the botanical integrity of the BCBMA.
VIII. Improved Vegetation Management Protocols and Applications to Other ROW’s

The vegetation management practices used on the BCBMA have many applications for California’s ROW’s. This is illustrated by discussing six key categories: prioritizing, timing, mapping, tools, partnerships, and persistence, using yellow starthistle control as a primary example.

A. Prioritizing

Since vegetation management resources are limited, an essential component for designing local, regional, or statewide programs is to prioritize where work should be done. In the 65,000 acre Bear Creek watershed, the management of the BCBMA was deemed a priority because of its 1) overwhelming ecological value, 2) the opportunity to conduct management through funding from Caltrans, and 3) its potential use as a research and demonstration site.

Statewide, one of the priority areas for management should be sites of known ecological value. ROW’s that are designated as Botanical Management Areas are an example. As the Rembrandts, Monets, and Van Goghs of the state’s ROW’s, these areas should be preserved in perpetuity. Additionally, identifying and maintaining other significant remnant stands of native vegetation should be incorporated into Caltran’s statewide planning, training, and contract work to insure that the biological diversity along ROW’s is preserved to the maximum level possible.

Within each management unit, stewardship issues must also be prioritized. On the BCBMA, NIS control was a clear management priority, so activities were focused on the most troublesome species, all of which have a proven track record of invasion in the watershed and elsewhere in the state.

As the BCBMA program developed, botanical surveys were extended beyond the core area and determined that there were other native plant assemblages that deserved recognition and protection, i.e., Sections 2 and 3. This prompted weed control work on small infestations that occurred in close proximity to native vegetation.

One of the operating principles of strategic weed control is that early detection and rapid response to incipient weed infestations is the most efficient method of control (Schoenig and Thomsen 1999, BLM 1996) and should be a priority management consideration for statewide IVM programs. Weeds often spread along lines of travel, by first establishing themselves along roadsides and then moving onto adjacent land. There are numerous examples of this in the project area, some of which are a result of past road work that has caused disturbance and deposited soil that is contaminated with weeds.

The massive control effort for yellow starthistle that is now needed in many parts of the state could have been avoided if there had been an ongoing, strategic program to control incipient infestations. Yet, even with the current large infestations, programs can be developed and management practices modified to reduce infestations and prevent still more spread of NIS. One of the standard methods of preventing more weed invasion is by containing established infestations. Containment is accomplished by delineating perimeters of large infestations and eradicating any “outlier” plants that are found beyond the containment boundaries. Meanwhile,
the larger infestation can be addressed through appropriate suppression practices. In this regard, the California Department of Food and Agriculture and Caltrans (CDFA 1999, 2001) proposed to work together to coordinate a multi-agency mapping program for yellow starthistle in the central and south-western Sierra, with the objective of identifying high and low priority areas for stopping the spread of yellow starthistle.

B. Management Tools
One of the most important steps in developing an effective A-IVM program is deciding what tools are most appropriate for the site. The decisions should reflect site goals, the management infrastructure in place, and whatever social and legal constraints exist. Every tool has desirable and undesirable features. Sifting through these variables and arriving at the best solution requires management skill, knowledge of the site, and monitoring once the program begins. Flexibility and willingness to alter management practices as new information is obtained about the site is also essential to achieving management goals.

The level of management complexity and tools needed for ROW’s will vary widely, ranging from rather simple to more complicated solutions, so it is imperative that programs are tailored to site-specific conditions. However, this does not mean that the “wheel must be re-invented” for every site. An abundance of weed and ecosystem management information now available is applicable to sites throughout the state.

Prescribed burning
The consecutive burns that were conducted on the BCBMA were the first of their kind for Caltrans vegetation management programs and demonstrate the value of this tool for other sites (Appendix VII, photos 38-49; Appendix III, burn maps, P-1, P-2). The benefits on the BCBMA included a reduction in invasive plants (i.e., yellow starthistle, barb goatgrass, and medusahead), enhancement of native flora through weed control, thatch reduction, and seed bank stimulation. Additionally, the prescribed flora through weed control, thatch reduction, and seed bank stimulation. Additionally, the prescribed burns were an excellent example of inter-agency cooperation. Many articles describing these burns were written (Appendix IX).

Prescribed burn with much YST but sufficient dried annual grass to carry the fire.
In addition to benefiting weed control efforts and restoring native vegetation, properly conducted prescribed burns can reduce fire hazards and improve visibility by reducing flammable and tall-statured vegetation. If not prohibited by air quality issues, prescribed burning has the potential to be one of the most useful management tools for ROW vegetation management programs, especially in zones that are dominated by exotic annual grasses and weeds.

One caveat is that burning may also stimulate NIS seed banks. Managers should be aware of this, plan A-IVM programs accordingly, and use this information to their advantage. For example, in yellow starthistle control programs where Transline is being considered, it is better to apply Transline as a 2nd year treatment following a burn, than to apply Transline the first year, followed by a burn. When burning follows a Transline treatment, the yellow starthistle seed bank is released, requiring greater control efforts the third year. This was observed in another project on adjacent land.

In planning revegetation programs with native grasses, especially on sites where the seed bank is entirely dominated by exotic plants, a late-spring/early summer burn, followed by a post-weed germination (pre-plant) herbicide application of Roundup in Autumn is one of the many sequences that might be used to more rapidly reduce the seed bank prior to planting desired species.

**Mowing**
Steel-bladed weed eaters, stringer mowers, and tractor-mounted mowers were used for mowing yellow starthistle and barb goatgrass (*Appendix VII*, photos 5,6,7). Mowing was used to cut dense patches of yellow starthistle about two weeks before the prescribed burn in 2001 to increase the fuel load. Yellow starthistle is still green at the optimal burn period (early flowering stage), so an abundance of dried annual grasses or another fuel source must be present to carry a fire. By first cutting starthistle and allowing the stalks to dry, a hotter fire was created.

As indicated previously, properly-timed mowing could be used by Caltrans to make significant improvements in reducing yellow starthistle on many ROW’s. However, similar to many tools, one application will have minimal impact. Multiple mowings (2-3X) in late May through early July should be anticipated because yellow starthistle has a tremendous ability to regrow. The amount of regrowth is variable and dependent on timing and amount of rainfall, plant competition, and plant architecture, i.e., branching height. In general, managers should anticipate that a second mowing will be needed about four weeks after the initial mowing, and targeted to the same stage as the first, i.e., when plants are in the very early flowering stage, but before flowers have faded from bright yellow to straw color. In some cases, one or two mowings may result in mortality for the majority of plants, whereas in other situations, such as plants with a low branching pattern, regrowth will continue despite repeated mowings and will produce ample seed to replenish the seed bank.

When mowing programs are being planned, it is important to be aware that other NIS may occur in association with yellow starthistle. For example, barb goatgrass or medusahead may be present, both of which are likely to have mature seed at the time of mowing. In such a case, an indiscriminate mowing could quickly create a large infestation from what was only a small patch. This can be avoided by monitoring and flagging patches to avoid hitting them with the
mower. Another approach is to spot treat small barb goatgrass patches with Roundup (in the early flowering stages about one month before a starthistle mowing) to prevent plants from developing mature seed. Since early infestations of barb goatgrass often grows in discrete, visible patches, it is relatively easy to apply an herbicide with minimal damage to non-target plants.

It is noteworthy that under some conditions, prescribed burns can be used to control yellow starthistle, barb goatgrass, and medusahead, making burning an attractive alternative to mowing + herbicide combinations where these species are present.

**Herbicides**

Herbicides were used to assist with control of perennial pepperweed, tamarisk, giant reed, and yellow starthistle. In most cases, they were applied as spot treatments, outside of the core area.

Transline is the herbicide of choice for yellow starthistle during early growth stages, due to its effectiveness at low rates, low toxicity to animals, and selectivity. However, it can affect members of the sunflower, parsley, legume, and buckwheat family, and there are many species of plants in these families that occur on the BCBMA. Therefore, Transline was not used in the core area or on other sites where there appeared to be non-target vegetation that might be affected. Its use was restricted to controlling incipient patches along roadsides and larger infestations on turnouts where non-target plants were less of an issue.

Herbicides have an important role in statewide A-IVM programs. If chosen as a tool, damage to non-target plants can be minimized by: 1) using selective herbicides, 2) timing applications after non-target plants have completed their life cycle or by not using them in places when non-target, susceptible plants are present, and 3) applying herbicides carefully. Herbicides should be selected according to their known efficacy on target plants, and applications should be timed to vulnerable stages in the plant’s life cycle.
Manual Control (Hand Pulling)
Hand pulling weeds was an important adjunct to the BCBMA program. Hand-pulling was useful as a follow-up treatment to mowing and prescribed burning treatments. It was also used for eliminating outliers, an important preventative step to reduce the spread of NIS. Additionally, since there was uncertainty in being able to conduct consecutive burns, it was an insurance method to make sure that no new seed was deposited in the seed bank.

Statewide, hand-pulling is probably most applicable to intensively managed sites with high ecological value, similar to the BCBMA. However, Caltrans uses crews to pick up litter and some of this labor could be applied to weeding. Hand-pulling should also be considered for “Adopt-a-Highway” programs, where participants pull NIS as part of containment efforts or ROW enhancement and restoration activities.

C. Timing
Properly-timed vegetation management activities are mandatory for carrying out successful programs, since many weeds have a narrow optimum “window” for treatment. For example, mowing can be an effective means to suppress yellow starthistle, but mowing can also exacerbate infestations. Mowing too early favors yellow starthistle by decreasing competition. Mowing too late helps spread seed. The optimum period for controlling yellow starthistle with mowing (and burning) is during the early stages of flowering, something that was adhered to closely on the BCBMA. Similarly, prescribed burns and herbicide applications that occur at the wrong time will not be effective and may exacerbate infestations.

Statewide, most ROW’s are routinely mowed without much thought of how this practice might be affecting NIS infestations. This has led to more yellow starthistle-infested ROW’s, which in turn leads to reduced visibility, increased fire hazard, displacement of desirable species, and degradation of scenic highway corridors. By altering the timing (and frequency, see below) of mowing, a major improvement to Caltrans’ vegetation management could be made.
Appendix VIII-5 shows yellow starthistle growth stages and associated control measures for the Sacramento Valley (Thomsen, et al.1996). This is a general guide; actual dates and optimal control periods will vary according to local conditions, i.e., weather patterns, soil type, resident plants and competition, and genetic differences in yellow starthistle populations. Because repeat mowings are usually needed for further YST suppression, onsite monitoring is necessary and control decisions should be made accordingly.

D. Mapping
Maps are useful in planning, implementing, and documenting A-IVM programs. Maps were developed by using a GPS unit to delineate Section divisions, baseline weed infestations, native plant populations, monitoring plots, and landmarks. This information was processed and data files were given to GIS specialists who gathered area geographic information, incorporated the GPS data, and produced the finished product (Appendix I).

Statewide, there is a wealth of relevant geographical and ecological information that could be used for improving vegetation management practices on ROW’s. Information within Caltrans, data from Natural Diversity Data Base, and California Dept. of Food and Agriculture, are all sources of information that could be incorporated into maps to better plan and implement A-IVM programs.

E. Partnerships: BCBMA Partners & Statewide Weed Management Areas
Cooperation is essential for effective ecosystem management programs. It allows partners to share knowledge and resources and to achieve many things that would not be possible without working together. Whenever possible, partnerships were developed to conduct work in the Bear Creek Watershed Restoration Program, some of which were developed directly for the BCBMA. Below is a list of partners that assisted on the BCBMA:

**Caltrans.** Provided funding for the project manager, staff time, traffic control and probationaries.

**California Dept. Food and Agriculture.** As part of the Bear Creek Watershed Restoration Program, CDFA provided funding through the statewide Weed Management Area program. Funds were used to help pay an assistant to hand-pull barb goatgrass.

**California Dept. Forestry and Fire Protection.** Provided staff, fire engines, and related equipment to conduct prescribed burns.

**California Native Plant Society.** Provided a botanist to assist with Releve sampling.

**DowAgro Sciences.** Assisted with Transline applications on north edge of turnout, Section 1.

**Fout Springs Youth Facility.** Provided crews to construct fire breaks and hand pull weeds.

**Konocti Conservation Crews.** Provided crews to construct fire breaks.

**National Fish and Wildlife Foundation.** As part of the Bear Creek Watershed Management Program, NFWF provided funding for the project manager and assistants.
Natural Diversity Data Base. Provided six botanists to train and assist with Releve sampling.

UC Davis. The Dept. of Agronomy and Range Science provided office space, telephone, computer, and GIS support for project management.

Volunteers. This included students from UC Davis, amateur botanists, and people who arranged “trades”, i.e., use of facilities, with Wilbur Hot Springs in exchange for stewardship work in the Bear Creek Watershed.

Wilbur Hot Springs. As part of the Bear Creek Watershed Restoration program, WHS provided lodging for the project manager, assistants, and volunteers.

Statewide, many potential partnerships are available to help achieve vegetation management goals. Caltrans is a signatory to the State and Federal Memorandum of Understanding for Noxious Weed Control. This is an example of Agency interest in cooperative management. On the ground, the establishment of Weed Management Area groups throughout the state is a mechanism by which these cooperative programs are moving forward.

F. Long-term Commitment to Management
Successful vegetation management requires ongoing efforts. Multiple NIS, extensive seed banks, the ability of target plants to regrow after certain treatments, and new weed invasions are some of the ecological realities that must be incorporated into planning, implementation, and monitoring activities. Rarely will one or even a few weed control attempts accomplish management objectives. A long-term commitment is needed where A-IVM efforts are conducted in ways that are strategically, ecologically, and economically thoughtful.

IX. Recommendations for Future Management on the BCBMA and Vicinity
During the course of this work, the possibility of conducting a model program on the BCBMA and other ROW’s in the area was envisioned. This has partially been achieved, but there are many other opportunities for expanding this effort. The groundwork has been developed and the partners are in place. This work could link up with other projects currently being funded by Caltrans and would provide an excellent example for Caltrans staff, Weed Management Area groups, and the public at large. Some future management recommendations include:

• At a minimum, eradication efforts for yellow starthistle and barb goatgrass in the core area should be continued. Research at Sugarloaf State Park to control yellow starthistle with prescribed burning demonstrated that control efforts must be maintained until infestations are eradicated or yellow starthistle will rapidly re-infest the site (Kyser and DiTomaso. 2002). Similarly, Heise (per. comm.) indicated that despite barb goatgrass reductions of 95% from two years of prescribed burning at Hopland Field Station, the site has become heavily re-infested after control measures were stopped.

• Follow-up efforts on other NIS would also be desirable. A meeting with BLM would be appropriate to request cooperation for fenceline weed control. This could be done as part of other work the BLM has initiated on the adjacent “Cache Creek Natural Area.”
• Continue controlling barb goatgrass and medusahead in the wildflower area in Section 2 to maintain Jepson’s milkvetch (Astragalus rattanii var. jepsonianus), a special-status species.

• Reinstate control efforts for small roadside infestations and patches of yellow starthistle that occur in proximity to stands of native vegetation in Sections 2 and 3.

• Initiate control on bulbous bluegrass (Poa bulbosa) and intermediate wheatgrass (Elytrigia intermedia). Action now can prevent these species from spreading further. The exotic wheatgrass arrived at the site through a Caltrans erosion control planting. While successful for this purpose, it is spreading into native vegetation and can be expected to displace more native plants over time.

• Revegetate road-cut and fill-slope areas that are denuded and eroding. The sediment from these sites is being released into Bear Creek during storm events. The watershed is known to have high levels of mercury; soil stabilization is an important remedial measure to minimize sediment loads and mercury release.

• Plant native trees and shrubs on fill-slope portions on the north side of Highway 20 between Sections 1 and 2 to restore native vegetation and help stabilize slopes. The zone is mostly a monotonous stand of intermediate wheatgrass. The area would be improved by using native vegetation that blends with surrounding vegetation and provides a deep root structure for stabilizing soil.

• Plant appropriate native vegetation on the turnout “island” and strip between Bear Creek bridge and the core area.

• Control yellow starthistle and perennial pepperweed infested ROW along State Route 20 adjacent to a significant natural area, i.e., (Destanella Flat, USGS Wilbur Springs Topo
Map R5, T13, S3) on BLM property near the watershed crest. Without control measures on the ROW, this native plant meadow will be under constant threat by dispersal and expansion from these weeds.

Dense infestation of YST on ROW with perennial pepperweed in drainage, adjacent to significant natural area on BLM land

- Expand cooperation with BLM and CDF to manage other ROW’s in the immediate vicinity. For example, BLM plans to continue their weed control work (yellow starthistle, barb goatgrass, and medusahead) adjacent to the ROW along Highway 16 by conducting prescribed burns. The burn borders could be extended to Highway 16 rather than stopping at the ROW fence line.

Fenceline with BLM land on left. Yellow starthistle and medusahead-infested on unmanaged ROW (right) with suppressed wildflowers.
Additionally, BLM is conducting a large-scale tamarisk removal program from Highway 20 to Cache Creek. ROW vegetation management and native plant restoration by Caltrans would augment this work and further enhance the beauty of this scenic highway, which has Bear and Cache creeks as prominent features, as well as remarkable geologic formations in Rumsey Canyon. Additionally, there is diverse ROW native vegetation including prairie/wildflower remnants, massive redbuds and valley oaks, and many other native plants that would benefit from NIS management.

Some of this proposed work could be linked with projects currently being conducted by Steve Young, Vic Claassen, and Monica Finn. Additionally, Tom Golden, District 3 Maintenance Supervisor, has helped with many aspects of the BCBMA program and would likely be open to additional cooperation (Appendix IX).

Snowdrop bush (*Styrax officinalis* var. *redivivus*)
X. References and Literature Cited


Heise, K. 2002. Personal communication with Hopland Field Station botanist.


