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Special Status Plant Species in the Merced River Corridor within Yosemite National Park

ON THE COVER: Vernal slab-seep community near Merced Lake.

Credits: Photo by Dean Taylor

Special Status Plant Species of the Merced River Corridor within Yosemite National Park

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Contents

Executive Summary

Targeted botanical surveys were undertaken in the following areas of high human impact along the Merced River corridor within Yosemite National Park: Merced Lake, Little Yosemite Valley, Yosemite Valley, El Portal and Wawona. The intention of these surveys is to assist the planning process for the Wild and Scenic River designation for the Merced River by filling in gaps in existing knowledge about park special status plant distribution and condition along the river. The overall pattern of special status species occurrence in these areas was found to be primarily in unusual habitat types that are often restricted in size. Unusual habitat types are those typically associated with specific kinds of water abundance, such as waterfall spray zones, braided river channels, oxbow cutoffs, gravelbars resulting from flooding, water seepage on rock walls, vernal pools, and the average high water margin of streams and rivers. The overarching management goal for preserving biodiversity in the Merced River corridor should therefore be 1) to avoid adverse impacts to restricted or unusual habitat types essential to the specialist species that occupy them and 2) to avoid interfering with the natural processes that allow dispersal between, and colonization of, these habitats to occur (e.g., do not exacerbate fragmentation of habitats). The adverse impacts to special status species habitats noted by these surveys: trampling and encroachment by invasive species were primarily.

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Photos are by the authors unless otherwise noted.

These [mountain torrents] have worn deep and picturesque channels in the granite rocks, and in the moist shadows of their recesses grow tender plants of rare and peculiar loveliness. The broad parachute-like leaves of the peltate saxifrage, delicate ferns, soft mosses, and the most brilliant lichens abound…

– Frederick Law Olmsted, 1865.

From: *Yosemite and the Mariposa Grove: A Preliminary Report.*

Introduction

The botanical studies described in this report were undertaken to provide information for the planning process for the Merced Wild and Scenic River designation. Current data on the location and condition of rare plant species associated with the Merced River in developed areas in Yosemite National Park was identified as an information gap. Therefore, surveys targeting five areas (Merced Lake, Little Yosemite Valley, Yosemite Valley, El Portal Administrative Site, and Wawona) were undertaken in the summer and fall of 2010 and the spring of 2011. This report presents results of these survey efforts. This report also summarizes the state of the knowledge of the flora for the surveyed areas as well as the rest of the Merced River corridor within Yosemite National Park.

In this report, we will use the term 'special status species' in lieu of the term 'rare species', because Yosemite recognizes and gives additional protection to species that may have wide distribution outside of the park but are rare within the park (Moore 2004). This is in addition to recognizing those listed as rare by federal agencies, the State of California, and the California Native Plant Society, the designation 'special status species' therefore includes all rare species.

As knowledge of plant distributions and occurrences within Yosemite changes and the taxonomy of the special status plants changes, the list of officially recognized special status species must be periodically updated. The special status species list used by these surveys was updated in 2006 and the subset of the species on that list which have been found within 0.5 kilometer of the Merced River is Appendix 3.

This report deals with vascular plants only (ferns, fern allies, conifers, and flowering plants). Rare non-vascular plants, such as mosses, liverworts, lichens, and algae, also exist in Yosemite, and some occur in the same locations covered in this report, but Yosemite does not yet confer 'special status' on these groups.

The Drivers of Floristic Diversity and Species Richness in the Region

The flora of Yosemite National Park has been recognized as being unusually rich and diverse since scientists began documenting it in the 1860s. During the 170 years that the flora has been under scientific study, over 1600 vascular plant species have been documented in the park (equalling approximately 8% of the number of species known in the US and Canada.). Recently initiated surveys of other plant groups are uncovering a similarly rich and diverse flora for those groups, with over 200 moss and liverwort species, over 600 lichen species and over 400 algae species documented to date. This flora also includes a high percentage of rare species and endemic species (Endemic species are those occurring only in this region.).

There are three main drivers generating this unusual biodiversity: landscape heterogeneity, landscape fragmentation and landscape stability. The first driver,

landscape heterogeneity, has three main components. The first component is variation in topography along the river course. The second component is variation in moisture abundance in the habitats surrounding the river. The third component is the variation in soils, which have different nutrient components, water-retention capacities, as well as other unique traits. All three components are in large part the result of the presence of multiple substrate rock types along the river corridor that vary in their susceptibility to erosion, in the slope stability and steepness in this eroding terrain, and to the soil texture and structure generated by erosion and weathering of bedrock. Together, these generate an unusually large variety of habitats for plant species specialists. Because of the restricted size of many of these habitats (e.g., the waterfall spray zone, braided river channels, oxbow cutoffs, gravel bars resulting from periodic flooding, water seepage on rock walls, vernal pools, and the average high water margin of streams and rivers), many of the species present at such sites are necessarily highly restricted in their ranges.

The second driver of regional biodiversity is landscape fragmentation, caused primarily by the cumulative effects of millions of years of erosion and glaciations (Huber 1989; Glazner and Stock 2010). The scale of this in the region is dramatic: erosion in combination with mountain uplift has carved deep, steep-sided canyons. At the same time, from Yosemite Valley upstream, glaciation events have enhanced the process by repeatedly isolating interfluves from each other with masses of ice, the ice carving ever wider east-west canyons, each time enlarging these already substantial natural barriers to north-south dispersal of plants and their insect pollinators. These chasms have isolated populations of species from each other, and prevented many species from tracking climate warming and cooling shifts as they normally do by moving up and down in latitude, thereby accelerating extinctions, evolutionary diversification, and speciation, which today is manifested in the larger than usual number of rare and endemic species found here.

The third driver of regional biodiversity is the great age of the montane habitat. Much of the uplands through which the two branches of the Merced River flow in Yosemite remained largely free of ice during recent glacial epochs (Matthes 1930; Alpha et al. 1987), and were local refugia to plant species as masses of ice ground past in the valley bottoms. Colonization of the post-glaciation valley bottoms was then a simple matter of gravity-aided short-distance dispersal. Therefore species that may have been more widespread in previous epochs (giant sequoia is a good example), have been able to survive here where climate and topography have remained stable. Furthermore, mounting evidence in recent decades favors a greater age of montane habitat in the south and central Sierra Nevada that previously thought (Small and Anderson 1995; Wernicke et al. 1996. Others (Stock et al. 2004, 2005; Mulch et al. 2006; House et al. 1998, 2001) have suggested that the region through which the Merced River flows has been mountainous throughout the Cenozoic (65 mya) and possibly since some time in the Mesozoic. This means that the cooler, moister montane habitat characteristic of most of Yosemite has been stably present in this region for sufficiently long time periods (tens of millions of years) for evolutionary processes to have operated in place, creating species found only in this region because they evolved here and have not yet dispersed elsewhere (Kimball et al. 2004).

These three landscape factors that are important drivers of biodiversity may yet offer refugia for species threatened with extinction during the current episode of rapid climate shift. The presence of heterogeneous habitats closely juxtaposed within the Merced River canyons presents opportunities for species to disperse to and colonize nearby newly favorable sites. The over arching management goal for preserving biodiversity in the Mer-

ced River corridor should therefore be 1) to avoid impacts to restricted habitat types essential to the specialist species that occupy them and 2) to avoid interfering with the natural processes that allow dispersal and colonization to occur (e.g., do not exacerbate fragmentation of habitats).

Study area

The Merced River within Yosemite National Park contains two main branches, in separate watersheds: the South Fork (which flows from its headwaters at the southern tip of the Clark Range through Wawona and exits the west boundary of the park a few miles downstream of Wawona at an elevation of 1,100 meters) and the main stem (which flows from its headwaters between the Clark and Cathedral Ranges through Merced Lake to Yosemite Valley and exits the park to the west at El Portal, at an elevation of 600 meters). These two branches join several miles west of Yosemite in the Sierra National Forest. Within the park boundary, these two branches follow similar trajectories: they have each cut deep channels into the varied layers of ancient rock that once were sea floor, carbonate deposits, upwelling molten rock, or remnants from volcanic events or erosional deposits. From the headwaters of these branches, where the crest of the Sierra Nevada reaches up over 4,000 meters, to the western park boundary, they pass through a variety of plant communities, from alpine at the summits, to subalpine, montane and finally through mixed hardwood and conifer that interdigitates with chaparral community types that barely pass the western park boundary. Much of the river channel terrain is extremely rugged, bordered for most of its length only by pedestrian and pack stock trails, with paved roads maintained only between El Portal and the upper end of Yosemite Valley on the main stem and for a few miles in the vicinity of Wawona on the South Fork. Both branches are largely unnavigable as they flow rapidly and are punctuated at regular intervals by cascades, boulders, or woody debris, such as fallen trees.

Effect of Past Human Use

The Merced River within Yosemite National Park has supported substantial human habitation for thousands of years, and the entire length of both rivers in the park continues to be seasonally visited by humans, and is thus entirely affected by human use to some extent. The prehistoric influence of humans is unknown, but it is possible that a few special status species may have been introduced. Currently, the greatest effect of human activity is found where flat topography, relatively easy access to the riverbank, or structures occur. The concomitant increase in the number of people present leads to greater disturbance of the environment. The impact on special status plant species is more likely if a high-activity area coincides with an unusual habitat. This type of area was therefore the focus of the surveys conducted for this report.

Effect of Invasive Species on Special Status Plants

Non-native species have dramatically changed the composition of plant communities in the western U.S. over the past few centuries. Many non-native species are strong competitors and have shown themselves to be able to successfully disperse widely and compete with native species for habitat and have thus earned invasive species status. Those native species with restricted ranges and specialized habitat requirements (such as most of Yosemite's special status species) are especially vulnerable to local extirpation where out-competed by invasive species. Yosemite's early protection, its lack of roads and the efforts of an active non-native prevention, detection and eradication program have all been instrumental in slowing the spread of weed species. Continued vigilance is necessary, however, as new non-natives are constantly entering the park. For example, an assessment of herbarium records collected over the past 160 years reveals that non-native

A native species of filamentous algae in the genus *Mougeotia* becomes dominant in lower park water bodies as channel flows drop and water warms. Climate change in the form of higher temperatures and less moisture, will likely expand conditions that favor filamentous algae.

species have appeared in Yosemite Valley at an average rate of 1.7 per year (Dean Taylor, unpublished data). Although most of these non-natives have either remained in low numbers or have been eradicated, some have proven to be highly invasive locally and have become a serious threat to native plant communities within the park. The two that pose the most serious threat to special status species in the Yosemite Valley, Wawona and El Portal segments of the Merced River are Himalayan blackberry (*Rubus discolor*), and velvet grass (*Holcus lanatus*), both of which can attain high densities and large population sizes on riverbanks, in moist forest openings and in bottomlands where most special status species are located. The presence of these invasives and the significant presence of Kentucky bluegrass (*Poa pratensis* var. *pratensis*) in Yosemite Valley meadows is documented in a related study (Ballenger et al. 2011, unpublished report). Both Himalayan blackberry and velvet grass are under aggressive treatment by the Yosemite Invasive Plant Program, which is of long term benefit to special status species in the affected areas. Kentucky bluegrass is not being treated in Yosemite.

Effect of Climate Warming and Nitrogen Input

All waterways of the park are showing increases in the prevalence of certain species of filamentous algae in the genera *Mougeotia* and *Spirogyra*. These are native species that grow more profusely with increases in water temperature and nitrogen availability (Colwell et al. 2010, unpublished report). These algae compete with other aquatic plants for light and space. The submerged aquatic special status species that have been located within the study areas and thus would be most impacted by this shift in species composition, are common mare's-tail (*Hippuris vulgaris*), western quillwort (*Isoetes occidentalis*), and lesser bladderwort (*Utricularia minor*). Common mare's-tail and western quillwort have been documented in 2 meter deep water in a low gradient stretch just above Nevada Falls, and likely exist in other deep, slow water stretches in the upper reaches of the river, such as in Washburn and Merced Lakes. Lesser bladderwort was found in a pool in a Yosemite Valley meadow and at Lost Lake. It may occur at other sites as well.

Methods

The methods employed for this project were of two kinds: 1) an assessment of the state of knowledge of the flora, and 2) conduct of new surveys in areas where current information was found to be lacking.

Assessment of Prior Knowledge

The flora of the Merced River is incompletely known. Although easily accessible areas (near roads) have been well inventoried, the many sheer rock walls have put large areas out of reach of nearly all botanists. The areas more than one day's hike from a trail head have also been very sparsely studied. This means the South Fork corridor upstream of Wawona and the main stem corridor upstream of Washburn Lake are essentially undocumented botanically. A list of park special status plants that have been documented to occur within 0.5 kilometer of the Merced River (main stem or South Fork) prior to 2010 surveys was developed so that surveyors would have a sense of what their target species and target habitats would be (Appendix 4). Future surveys will doubtless add to this list. Typically special status species are found grouped together in unusual or in highly stable habitats, so locations and habitats of known special status species would inform where to focus current surveys.

Historical Records Reviewed

Historical observations of plant species were tracked down from a variety of sources. Anecdotal accounts from the latter nineteenth century (Brewer 1864; Muir 1869; Olmsted 1865) offer useful general descriptions of the habitats encountered by the authors. More detailed descriptions from targeted botanical and floristic studies for the Yosemite region began appearing in early twentieth century (Brandegee 1903, Hall 1911). Ecological studies were conducted each summer from 1925 to 1943 in Yosemite by the students of the Yosemite Field School and the unpublished class reports are available in the Yosemite Library. A definitive flora of Yosemite was published by Steve Botti in 2000, describing 1473 vascular plant taxa. (All varieties and subspecies are included in the total.) In 2010, a technical flora of the Yosemite region was released by Dean Taylor, which includes 1671 taxa within the park boundaries.

Below, Willis Lynn Jepson's herbarium specimen of the Mono Hot Springs primrose (*Camissonia sierrae* ssp. *alticola*) collected at Merced Lake in 1927. Efforts to locate this plant at Merced Lake in 2010 failed, but a site in Little Yosemite Valley reported by Steve Botti was found. Lower left, Thousands of these tiny plants (inset), as well as a dozen other tiny annual species, surround the data taker in this vernally moist forest opening containing shallow gravel over bedrock.

Left, California bog asphodel (*Narthecium californicum*), is a showy special status species that in our region is found on rock ledges in the spray zones of waterfalls and in a single fen meadow. Right, a fifth location of this species, and the first for Yosemite Valley, was noted in 2009 on the wall to the right of Bridalveil Falls, where it dominates ledges in the spray zone. This new discovery illustrates how poorly known is the flora of the walls of Yosemite Valley.

The definitive source of information for species occurrences is the herbarium specimen. This simple procedure of collecting diagnostic plant parts (flowers, fruits, leaves, etc), pressing them flat, drying them and mounting them on an archival sheet of paper with a label containing pertinent location and morphological information has been standard practice for several hundred years. It remains the accepted method of referencing species for presence in a location and for verification of their identity. For this reason, we used herbarium specimen database records as our primary source for past presence/absence data, referring to descriptive records to augment the data or replace it in the few cases where the original herbarium specimen record is missing. Appendix 3 contains a table of 51 special status species expected to occur in the Merced River corridor within 0.5 km of the river channel. These species have herbarium records that either state the plant was found within this area or, for older specimens, have records that imply that they were found within this area (See discussion in next section.).

This study also contributed to the information archive of specimen data by documenting new occurrences of special status species with herbarium specimen vouchers.

Historic Collections not Relocated

An effort to relocate all species previously documented from Yosemite Valley was begun by Dr. Dean Taylor in 2009. Dr. Taylor has compiled a spreadsheet with all herbarium specimen records labeled "Yosemite Valley" (available from the authors upon request), amounting to just over 900 species. He has attempted to relocate all of these documented species within Yosemite Valley and has so far located approximately 500 of them. A factor complicating this endeavor is that collections made in the period between 1864 and 1890 typically listed for location only "Yosemite" or "Yosemite Valley", meaning the area of the Yosemite Grant, which included Yosemite Valley, its slopes, and the adjoining uplands one mile back in all directions from the valley rim. For this reason, many of the 900 species documented from this era actually reside on the walls of the valley or even beyond the rim, making relocation and assessment of presence/absence an enormous and difficult task. Much additional terrain remains to be covered by this effort so at this point in time none of the 400 missing species can be defini-

tively stated to have been extirpated from Yosemite Valley. The surveys conducted for this project were structured so as to contribute to the data collection for this ongoing effort.

The following species on the special status plant list (Appendix 3) have not been previously targeted for surveys in the five areas covered by this project, and were not observed in 2010 surveys. However, we consider these species either overlooked by this survey or not occurring within the primary survey area for this project: spurred snapdragon (*Antirrhinum leptaleum*/*Sairocarpus cornutus*), Sierra sun cups (*Camissonia sierrae* ssp. *sierra*), canyon sedge (*Carex fissuricola*), silver sedge (*Carex canescens*), Northern mannagrass (*Glyceria borealis*), redray alpinegold (*Hulsea heterochroma*), false pimpernel (*Lindernia dubia* var. *annagallidea*), azure penstemon (*Penstemon azureus* ssp. *angustissimus*), Purdy's penstemon (*Penstemon heterophytus* var. *purdyi*), lacy scorpion-weed (*Phacelia tanacetifolia*), Nuttall's pondweed (*Potamogeton epihydrus* ssp. *nuttallii*) box saxifrage (*Saxifraga oregana*) and Sierra skullcap (*Scutellaria bolanderi* ssp. *bolanderi*). These species require further survey effort.

There are, however, five species historically documented from Yosemite Valley but which recent targeted survey efforts and the 2010 surveys have not turned up, raising the possibility that these have been extirpated from Yosemite Valley:

1) The fawnlily, also known as the dog-tooth violet, presents the most interesting 'missing plants' case. Katherine Brandegee (1903) states "The purple dog-tooth violet (*Erythronium purpurascens*) is found on the south side of the valley, from the upper iron bridge to Tooloolaweack Canon." There is no specimen of this species from Yosemite known, although it would have been normal practice for Katherine to have made a specimen, perhaps it was lost in the 1904 earthquake and fire that destroyed the California Academy of Sciences. No species of *Erythronium* has since been found in Yosemite. Tooloolaweack Canon is now known as Illilouette Canyon, and the upper iron bridge is likely in the vicinity of Happy Isles (Linda Eade, pers. comm.), although there is also an iron bridge above Illilouette Falls on the Panorama Trail. Four species of *Erythronium*, all rare, occur in small populations outside of the Yosemite park boundaries. Possibly the Illilouette population was extirpated in Yosemite by overzealous early collecting, but it is entirely possible that it still exists on rarely-visited rock faces or moist, shady wooded slopes.

2) A specimen of the pansy monkeyflower (*Mimulus pulchellus*), collected in 1900 by the monkeyflower specialist F.T. Bioletti, is labeled "Yosemite Valley". This is a typically vague location of Bioletti's and could indicate the slopes of the valley, possibly even Big Meadow (a current location of this species); the label should be considered inconclusive evidence of this species having existed here in the past. This species prefers vernally moist, sparsely vegetated granite pans, of which there are many on the slopes around Yosemite Valley that remain unexplored.

3) The Western yew is known from two collections (John Muir, 1874, in "Yosemite Valley" and J.W. Congdon, 1901, in "Yosemite") and the following mention by Katherine Brandegee (1891): "The yew (*Taxus brevifolia*) grows near the water in the cañon of the Merced. The "nutmeg-tree" (*Torreya californica*) grows also in the cañon of the Merced but farther from the water. Neither this tree nor the last quite reaches the valley." These pieces of information suggest that this tree at one time inhabited the stretch of river between Arch Rock and Yosemite Valley. It has not been collected or reported since 1901 and we have not

located any during the course of this survey. It is thus possibly extirpated from this drainage, signifying a range retreat to the north. The nearest extant location to the north is in Basin Creek in the Stanislaus N.F. No specimens are known to the south.

4) Sierra sweetbay (*Myrica hartwegii*) may have occurred in the section of river between Yosemite Valley and El Portal. A systematic survey for California sweet bay *Myrica hartwegii* along the main stem of the Merced River from Pohono Bridge at the lower end of Yosemite Valley west to the park boundary was conducted and no specimens of this species were observed. There are only two records of this species occurring in the main stem, Katherine Brandegee's statement that "*Myrica hartwegi*, a rather rare wax-myrtle, though not found in the valley grows on the Merced below it" (Brandegee 1891), and an entry in Hall's *Flora of Yosemite* which states, "Rare, but found on Big Creek, below the Mariposa Grove, and in the Merced Canon below the Yosemite." (Hall 1912). No historic herbarium specimens of this plant in the main stem of the Merced River are known to exist, so this species was probably never common in this drainage. The vague descriptions quoted above leave open to interpretation whether the species ever existed below the valley within the current park boundary or further down the Merced River Canyon. A logical place to search would be at or downstream of the junction of the South Fork with the main stem, as this species could easily have dispersed down the South Fork from the populations in Wawona area. If Sierra sweetbay cannot be confirmed on the main stem below the confluence with the South Fork, then it should be presumed extirpated from this section of river.

5) A variety of the parasitic plant species known as California dodder (*Cuscuta californica* ssp. *apodanthera*) was described from a single collection in Yosemite Valley made by Willis Lynn Jepson in 1900 but has not been relocated. The label for this specimen lacks further detail, but the host plant shown on the sheet is mustang mint (*Mondarella lanceolata*), a dry ground annual, which reduces the potential habitat area somewhat. This species has not been recognized by current dodder specialists, the distinguishing feature (the length of the anther filaments) being considered to be insufficient to distinguish it as a variety. This subspecies will not be recognized as distinct in the forthcoming edition of the Jepson Manual (Baldwin 2012).

Survey Methods

The Merced River flows a total of 81 miles within the park boundaries, most of which is difficult to access. To survey the entire corridor was beyond the time or funding available to gather data for this report, so targeted surveys based on the experience of botanists Dr. Dean Taylor and Dr. Alison Colwell were undertaken. The focus of the 2010 surveys was primarily on heavily used areas and within those areas the focus was on potential special status species habitat.

The following survey methods were used:

1) Habitat-targeted survey and species list. When surveys were conducted by botanists experienced with the flora, the targeted area was walked through in such a manner as all likely habitat for special status species was surveyed. Methods used to determine likely habitat were aerial imagery, topographic maps, and visual inspection from multiple vantage points. The surveyor kept a list of species observed and species not previously documented in the area were collected for vouchers. Any special status species populations encountered were mapped, photographed and databased. In this manner about 25% of the total target area would be covered visually but a higher percent-

age (50%–75%) of likely special status plant habitat would be covered.

2) Gridded survey. When surveys were conducted by crews of inexperienced botanists, the crews were trained by experienced botanists on what species of special status plants would occur in the area, either by showing the crew examples of the species and habitat beforehand, or giving them photographs and key characteristics to look out for. Crews walked the target area in parallel, approximately 15 meters distant, covering 75-90% of the target area visually. If a crew member encountered an unfamiliar plant, a portion of it was turned over to an experienced botanist for identification.

3) Species-targeted survey. At sites where special status species had been observed historically (from reported observations such as in Botti, 2000, or from historical specimen records (Consortium California Herbaria, 2011), targeted surveys were undertaken. In this case, either experienced botanists or experienced botanists with additional crew members surveyed the area completely. In all cases, an experienced botanist was within hailing or radio contact distance and if a crew member came across an unfamiliar plant, the experienced botanist was called in to identify it.

In all types of surveys, both natural and human-affected vegetation was surveyed, including landscaping on park lands occupied by hotels, visitor services and residents. Specimens collected were dried, pressed and processed according to accepted herbarium standards.

Areas Not Surveyed for This Study

For this survey, the river channel and banks of the South Fork of the Merced River were surveyed from the wilderness boundary above Wawona to near the park boundary downstream of Wawona. The upper reaches of the river within wilderness to the headwaters were not surveyed for this report. Similarly, the main fork of the Merced River was surveyed from 2 km upstream of Merced Lake through Yosemite Valley to the west park boundary at El Portal. The portion of the river from above Merced Lake to the headwaters was not surveyed for this report. Appendix 3 lists the special status species with existing documentation within 0.5 kilometer of the river channel, from the park boundary to the Merced River headwaters. The upper reaches of both rivers not covered in this survey are otherwise very sparsely documented, and we predict that many more populations of special status species will be found in these segments. However, in areas of low human usage, we do not expect to find significant adverse impacts to existing populations of special status species. This was the case for the special status plant survey conducted for the Tuolumne Wild and Scenic River planning in 2006. For that survey, the entire length of the Tuolumne River and Lyell and Dana Forks was surveyed to 0.5 kilometer each side of the river channel (Acree et al. 2007). Special status species were found scattered along the entire length of the river, but primarily in areas with unusual habitats (waterfall spray zones, mineral springs, areas with unusual geology). Adverse effects were found to occur primarily in high-visitation areas. Therefore, the scope of this project was reduced to focus effort on those areas along the Merced River with the greatest human use: Merced Lake, Little Yosemite Valley, Yosemite Valley, Wawona and El Portal.

GPS Data Collection and Analysis

GPS data were collected with Trimble Juno SB units. For all rare plant populations, at least 50 points were collected and averaged for point position data. A data dictionary with plant name, observer and data on the population such as number, phenology and population diameter were recorded. Population perimeters were also collected for large populations using either a line or polygon shapefile. Points and lines were buffered based on population

diameters to create polygons. Lines and polygons were also converted to points. Both points and polygons are displayed on the maps. Projection is NAD 1983 11N. The data were not geo-corrected and was checked visually in ArcGIS for accuracy.

Map Information

The maps generated by the 2010 surveys are intercalated into the relevant sections of the report. Where possible, the same color was used on every map for the special status species that occur on more than one map. Maps display GPS data collected in 2010 for this study as well as GPS data collected in 2003-2007 for previous studies, if the older data is in or near the area of interest for this study. Most special status species occur in patches too small to display on maps of this scale. Therefore, the point or polygon data that represent their occurrences was converted to square points of a standard size for display on the maps in this report. Those with occurrences larger than the standard display size were left in their actual polygon shape.

A few special status species have names too long to fit on the map legends so they were truncated as follows: *Arabis repanda* var. *repanda* is shortened to *Arabis repanda*, *Camissonia sierrae* ssp. *alticola* is shortened to *Camissonia sierrae*, *Lithocarpus densiflorus* ssp. *densiflorus* is shortened to *Lithocarpus densiflorus*, *Madia elegans* ssp. *vernalis,* is shortened to *Madia elegans*, and *Plagiobothrys torreyi* var. *torreyi* is shortened to *Plagiobothrys torreyi*. Rare species which have been found since the park special status list was last updated are mapped and listed in the map legend under the heading "Candidate Species". These species will be considered for special status when the park special status species list is next revised.

Location of Data and Specimens

The mapping data, collected during this survey and containing actual occurrence perimeters, will be posted in 2011 on the park GIS data server for Yosemite staff and will be available from Yosemite Resources Management and Science to authorized users upon request. The citation for this report will be posted in the Yosemite Digital Science Library Catalog, with the full text version of this report available to Yosemite staff, and upon request by authorized users, on the Yosemite Sharepoint site.

Specimen label data will be retained in the Yosemite Museum Herbarium (YM) specimen database. Special status species data will be compiled and submitted to the California Natural Diversity Database (CNDDB) of the California Department of Fish and Game in 2011.

Specimens of plants collected as part of this study will be deposited in 2011 at the following herbaria, according to the requirements stated in the Research Collecting Permit YOSE-2010-SCI-0087:

- All unicate specimens of all taxa collected reside at Yosemite Museum (YM);
- Duplicates of vascular plants, lichenized and non-lichenized fungi reside at University of California Herbarium, Berkeley (UC);
- Duplicates of mosses and liverworts reside at California Academy of Sciences, San Francisco (CAS);
- Duplicates of freshwater algae reside at New York Botanical Garden, Bronx, New York (NY).

Results & Discussion

The following results and discussion sections have been combined under headings for each river segment, as each river segment has its own character and its own special status plant issues. The survey maps are located at the end of the report.

> *At the upper end of Lake Merced eight miles east of the Nevada Fall is a beautiful grove of [aspen] which are 60 to 80 feet high with trunks 1 to nearly 2 feet in diameter at 4 ½ feet.*
>
> *Single individuals [of white fir] of exceptional size are often found on gentle mountain slopes or in canon bottoms in deep soil. Near the upper end of Lake Merced (east of Yosemite) is a tree 160 feet high with trunk 8 ½ feet in diameter at 4 ½ feet above the ground…These individuals of exceptional size which arrest the attention of the traveler are in most cases apparently of great age.*
>
> –Willis Lynn Jepson, 1909.
>
> From: *The Trees of California*.

Merced Lake

Results of Surveys of Merced Lake

Drs. Colwell and Taylor surveyed the vicinity of Merced Lake on July 13-15, 2010, paying particular attention to site where previously reported special status plants occurred (Appendix 3) and to invasives around developed areas. A candidate special status species, Nevada City buckwheat (*Eriogonum prattenianum*) was surveyed for the first time. This species was found at Merced Lake but is discussed in the Little Yosemite Valley & Vernal Falls section, as it was also found from Bunnell Point to above Merced Lake.

Discussion of Special Status Species Occurrences

The upper main fork of the Merced River flows into many granite basins on its way downhill, and two of these basins are large enough that sizable, deep lakes have formed: Washburn Lake and Merced Lake. In a region where glaciers have relatively recently scoured away soils to the substrate rock, Merced Lake has already developed considerable soil, especially at its upper end. This hospitable oasis, at 2200 meters elevation and one hard day's hike from the nearest road, has doubtless been a preferred stopping place for travelers for millennia. In the last century, the infrastructure to support travelers' needs has been made semi-permanent: a High Sierra Camp has a barn, a dining hall and a fleet of small cabins. A kilometer uphill is the site of the Merced Lake Ranger Station, occupied by a ranger all summer and a revolving suite of park staff on various projects. Little has changed in the way of life here in a hundred years: hikers come and go, and pack strings stop to deliver supplies here or pass through to supply trail crew camps farther in the back country. Horses and mules wait patiently for their loads in corrals, or wander in certain meadows in search of forage. This place functions as a transit depot, serving park functions in the entire upper Merced River watershed, as it has for a century. As is the case with any nexus of human activity, the typical threats to vegetation are found here: overuse of unusual habitats that harbor unusual species and introduction of alien species.

Notable Trees

The unusually deep soils here have fostered the growth of some notable tree specimens. When W.L. Jepson visited Merced Lake in 1909 as part of a 150-person Sierra Club outing, he remarked on

Right. remains of a stand of aspen at Merced Lake backpacker's camp noted by W.L. Jepson on a Sierra Club trip in 1909. Above, a champion white fir, likely noted by Jepson on that same visit, still stands beside the trail west of the High Sierra Camp. A stone stairway has been constructed across its base to avoid damage by the heavy stock use this trail sees. This strategy appears to be working as intended but the optimal situation for this and the other enormous white firs next to the trail in the vicinity would be to reroute the trail farther from this grove of trees.

a "beautiful" stand of aspen there. Currently there is a healthy stand of small-diameter aspen along the trail a kilometer west of the High Sierra Camp and a senescing stand of very large aspen in and around the Backpackers Camp, which we assume is the stand Jepson referred to in the above quote. Most of the trunks in this stand have fallen over and the rest look diseased. Aspen are relatively short-lived trees and their stands naturally go through cycles of growth and senescence, but it should be noted that surface hydrology changes (e.g., drying out of the soil) possibly induced by the devegetation caused by the campground may have had an impact on this stand of trees.

Impacts of Human Activity

The High Sierra Camp at Merced Lake has surprisingly few impacts on vegetation outside of its immediate perimeter. The caveat for this statement is that at the time of our visit, Merced Lake was in flood, so we could not observe shoreline impacts closely, but they appeared to be limited to a shore perimeter trail. The only severely degraded riparian site noted was a sandy area of about 50 meters in length between the old barn and the river, where the campers apparently congregate to swim.

The employees of the Merced High Sierra Camp have demarcated walkways within the camp with stones and native vegetation (notably: pinewoods horkelia (*Horkelia fusca*), prettyface (*Tritelea ixioides*), Western needlegrass (*Achnatherum occidentale*) and silver bird's-foot trefoil (*Lotus argophyllus*) is regenerating in the intervening spaces very nicely from what the staff referred to as a 'dustbowl' in previous decades. In the paths themselves, in the spring, grows *Plagiobothrys torreyi* var. *diffusus*, an ephemeral annual native plant that colonizes disturbed sandy areas (a flood-follower). A few non-native species such as hairy rupturewort (*Herniaria hirsuta*), purple sandspurry (*Spergularia rubra*) and Kentucky bluegrass (*Poa pratensis*), occur in the paths and behind the cabins. The density of Kentucky bluegrass behind the tent cabins suggests that it may have been planted there at one time to create a lawn. These non-natives don't ap-

Left, paths demarcated by Merced Lake High Sierra Camp staff turned a long-standing dustbowl into a native plant regeneration zone. Right, the density of non-native Kentucky bluegrass behind the tent cabins suggests that grass-seeding may have been practiced at some time in the past.

pear to be colonizing beyond the human use area.

The DNC horse corral is in a wooded conifer area with thick duff and few understory herbs and has no invasive species around it. The DNC stock are no longer allowed to graze the fen & wet meadow across the trail to the south of the corral and this meadow now supports a nice diversity of typical native species, although no rare species were found there (possibly the lack of special status species in this meadow is a lingering result of past grazing or perhaps it is natural).

The NPS horse corral contained several non-native species that had not previously been documented from this area: shepherd's purse (*Capsella bursa-pastoris*), Jerusalem oak (*Dysphania* (*Chenopodium*) *botrys*), orchard grass (*Dactylis glomerata*), cheeseweed (*Malva pauciflora*), pineapple weed (*Matricaria matricarioides*), annual bluegrass (*Poa annua*), Kentucky bluegrass (*Poa pratensis*) and burning nettle (*Urtica urens*). These finds represent significant range and elevation extensions for these species, which are otherwise typically found in locations below 4,000 feet. These species could have been introduced on the hooves or gear of the pack animals from locations where they are already established such as the Yosemite Valley Stables area, or they could have arrived in the intestines of the animals if the animals had consumed these species at lower elevations. These species do not appear to be colonizing locations away from the corral at the current time, but they have the potential to the adversely impact surrounding plant communities if they do.

The pack stock were fed processed grain at the corral before being turned out to forage. The spilled grain is an attractive nuisance for wildlife as birds, rodents and deer are clearly accustomed to coming into the corral to scavenge it and were there nightly during our survey. Rodents were occupying the grain storage shed in the Merced Lake Ranger Cabin.

The nearby meadow that the stock are allowed to graze in was not observed to have the above-mentioned species of weeds, but was inundated at the time of visitation and should therefore be reinspected for non-natives at a later calendar date (in August or September). The grazing meadow could not be assessed for special status species at the time of visit because it was inundated. The MRP Meadow Report discusses the condition of this meadow in September 2010 – no special status species were observed there on that date (Ballenger 2011).

The NPS horse corral impacts only a small area. However, several new species of non-natives were documented from this site. None appear to be moving away from the corral but vigilance is important, as this is a potential point source of non-native species which could have a large impact if they colonize the surrounding area.

Left, the large, sunny, vernally moist gravel site between the barn and the dining hall in Merced Lake High Sierra Camp was the best potential habitat of Mono Hot Springs evening primrose in the area. That species was not found here, possibly due to historically high human impact at the site. However, the native species, Torrey's popcornflower (at right), colonizes similar habitats and was found here in abundance.

It was the intention of the survey crew to conduct surveys in Merced Lake for aquatic special status species, but the unusually high water proved too cold for more than a brief look in one spot, even with wet suits. Western quillwort (*Isoetes occidentalis*) very likely occurs in Merced Lake but should be surveyed for when water levels are at their lowest and water temperature is at its highest.

The rare plant Mono Hot Springs evening primrose (*Camissonia sierrae* ssp. *alticola*) was sought by this survey, but not found, at Merced Lake. A 1909 collection by W.L. Jepson lacked specific details on location, stating only "Merced Lake", so despite the failure of this survey to find this species, it cannot yet be said to be extirpated as there is much potential habitat surrounding the lake for this tiny plant that was not surveyed. However, the best potential habitat observed was in the campus of the Merced High Sierra Camp, so it is possible this species did occur there prior to permanent human habitation and was extirpated by trampling. This species was also sought in appropriate habitat in Echo Valley and along the "high water trail" from Little Yosemite Valley (the route Jepson would have used to travel to Merced Lake in 1909) but was not found. This plant should be sought again in the Merced Lake area in future years in mid-June to early July.

There are falls of water elsewhere finer, there are more stupendous rocks, more beetling cliffs, there are deeper and more awful chasms, there may be as beautiful streams, as lovely meadows, there are larger trees. It is in no scene or scenes the charm consists, but in the miles of scenery where cliffs of awful height and rocks of vast magnitude and of varied and exquisite coloring, are banked and fringed and draped and shadowed by the tender foliage of noble and lovely trees and bushes, reflected from the most placid pools, and associated with the most tranquil meadows, the most playful streams, and every variety of soft and peaceful pastoral beauty."

– Frederick Law Olmsted, 1865.

Little Yosemite Valley & Vernal Falls

Results of Survey from Merced Lake to Happy Isles

Drs. Colwell and Taylor walked this section of the Merced River on July 12 and on 16, 2010. This route, also largely a high human impact area, was surveyed for expected special status plants (Appendix 3) and a species list of all plants observed was created. Special status plants encountered were mapped and data collected according to standard methods for special status species. Where special status plants had been reported by earlier studies, but not yet mapped, targeted surveys were done. The locations of special status species in this section are shown on portions of two maps: Little Yosemite Valley Map and on the left half of Merced Lake Vicinity Map.

Discussion of Special Status Species Occurrences

Special status species in this section were associated with humid or wet environments of three types:

1) Spray zone of waterfalls

2) Seepage areas

3) Slow-flow, deep-water section of river

These habitats are small in size, so the plants specialized for them tend to have small populations. These same areas are attractive to wildlife and humans so suffer a relatively greater burden of trampling, and greater opportunity for invasive species to be transported here. The Mist Trail, Yosemite's most popular hike, is built right through such habitats, which is exactly what makes this trail both attractive to visitors and a tricky place to manage for special status species.

The most problematic site on the Mist Trail is the spray zone of Vernal Falls. The area is heavily infested with non-native invasive species. Velvet grass (*Holcus lanatus*) and Kentucky bluegrass (*Poa pratensis*) constitute a significant amount of the vegetation cover, crowding out native species. Bristly dogtail grass (*Cynosurus echinatus*) is also established there and will likely continue to increase. The ability of non-native invasives to invade this site is excacerbated by visitor trampling off trail onto moist ground and vegetation, creating spots of bare ground for new arrivals to establish in. This spot would be a difficult place to treat invasives, but treatment should be considered because: a) Waterfall spray zones are a rare habitat and home to uncommon species, and b) Vernal Falls is a prominent natural feature that is degraded by unrestricted foot-traffic and deserves to look its best to the many eyes that see it.

Educational signage about the plants of this specialized habitat and better physical barriers to leaving the trail in this section may curtail off-trail damage caused by photographers seeking a different angle or hikers looking for a place to take a bathroom break. This location is a high-visibility, high-visitation showcase of one of Yosemite's wonders and therefore the

Special status species wood saxifrage (*Saxifraga mertensiana*) (top) and Sierra false coolwort (*Bolandra californica*) (bottom) were observed along the trail in the spray zone.

Invasive velvet grass is now a dominant species in the spray zone at Vernal Falls. In addition, social trails destroy vegetation in this rare habitat and open up ground for colonization by more non-native species.

Below right, a granite slope with water sheeting across it, with the Merced River above Little Yosemite Valley in the background. The specialized plant community on the rock in the foreground is the usual habitat of the special status species Yosemite tarweed, three-way sedge and cut-leaf monkeyflower. These species also occasionally form small colonies on Yosemite Valley floor, the seeds likely having been swept into the valley during floods. Below left, three-way sedge grows in a vernally inundated section of path behind the Ranger Club, marked by pink flagging.

condition of the vegetation at this site should be addressed.

In contrast, as the Mist Trail passes Nevada Falls, it skirts around the spray zone. Invasive species and trampling are not nearly as serious a problem here as they are at Vernal Falls. A specimen of *Kobresia bellardii* was collected by Freda Detmer (a wetland specialist) in 1929 at the base of Nevada Falls, and this is the only specimen ever collected in Yosemite. We inspected the area around the base of the falls and found none of the 'bog' habitat that Freda described on her label. It is possible that either past hydrologic alterations done to Nevada Falls or a rockfall removed a bog site, or that Freda

was referring to Lost Lake at the base of Half Dome.

Seepage areas on rock slabs, rock faces, across gravel slopes occurred regularly from the base of the Mist Trail to Merced Lake. Most were in good condition, even when adjacent to the trail (due to smart trail construction) but a few showed damage from pack stock leaving the trail in search of water. Seepage sites typically contained the following special status species: Bolander's tarweed (*Jensia bolanderi*), Yosemite woolly sunflower (*Eriophyllum nubigenum*), cut-leaf monkeyflower (*Mimulus laciniatus*), Bolander's saxifrage (*Bolandra californica*). However, the diminuitive densetuft hairsedge (*Bulbostylis capillaris*) which is found in such habitats in so many places in the Tuolumne River Canyon, was not observed, despite being targeted in these sites.

Trampling Impacts

In Little Yosemite Valley the riverbank is degraded where the trail meets a flat section of river as hikers like to access the water here to cool off. In this section is where a submerged aquatic special status species observed in the Merced River, Western quillwort (*Isoetes occidentalis*), was found, as was an emergent aquatic special status species, common mare's-tail (*Hippuris vulgaris*). This species had been observed in the slow-moving section of the river beside Little Yosemite Valley Ranger Station during aquatic habitat surveys in 2008. More extensive surveys for this species were not undertaken in 2010 due to fast-flowing, cold water. This species may occur in other spots of the river between Little Yosemite Valley and the headwaters wherever there is still water 2 meters or more in depth.

The camp and ranger station in Little Yosemite Valley are in an appropriately dry site somewhat distant from the river where they are not in the immediate vicinity of special status plant populations. The nearest special status plant population to the campground and ranger station, at

Many trailside seepages between Little Yosemite Valley and Merced Lake contain the diminutive annual Yosemite tarweed (*Jensia yosemitensis*). The moist soil at a few of these sites is disturbed by deep hoofprints left by horses going to water.

0.25 km distance, is a population of Sierra sun cups (*Camissonia sierrae* ssp. *alticola*). This population, last observed by Steve Botti in the 1980s, was found and mapped. It is on a flat, vernally moist, granite gruss opening near a trail to Half Dome. The site appears undisturbed, although several festoons of fresh orange flagging tape were tied on trees adjacent to the site, apparently to mark a cross-country route. The flagging was removed because it was unmarked. An increase in off-trail traffic through this open site (for instance, if there is a popular climb behind this site) could easily impact this rare plant, as its patch size is only five meters in diameter.

The unusual quaking bog at Lost Lake, which contains the special status plant species bugleweed (*Lycopus uniflorus*) and lesser bladderwort (*Utricularia minor*) as well as many other unusual species, remains little visited and consequently is in good condition (a well-worn social trail to climbing routes bypasses closely this lake), but this fragile habitat should be monitored for an increase in off-trail use.

At the east end of Echo Valley, about one kilometer west of Merced Lake is a small, ephemeral mineral spring located three meters below the trail. Mineral springs in Yosemite are an unusual habitat that frequently harbor species of plants specialized for highly mineralized wet soils, some of which are special status species. This particular spring is undisturbed by trail traffic but does not harbor special status species.

A mineral spring also occurs in the trail itself between Merced and Washburn

Lakes, 2 kilometers west of the Merced Lake Ranger Station (This location is not displayed on the Merced Lake Map as it occurs to the east of the map extent. The GPS coordinates are: UTM Zone 11/289896/4178076 NAD83) (Moore et al. 2007). This spring arises on the north side of a switchback and flows into the trail. The trail at this spot should be routed away from this mineral spring. The reasons are: a) mineral springs are heavily used by wildlife seeking salt, b) special status plant species typical of mineral springs may have existed here prior to the trail's construction, and c) the mineral spring makes the trail muddy, contributing to erosion.

In Echo Valley the trail goes through wet bottomland and is in need of either reinforcing work to bring it above the water table or a reroute around the wet area. These sections of trail are muddy and have multiple paths. The problem is exacerbated by the high volume of pack stock traffic through Echo Valley. No special status species were observed in this section in 2010.

Candidate Special Status Species

Nevada City buckwheat (*Eriogonum prattenianum* var. *prattenianum*) was surveyed in this river section. This is a candidate for special status, as one of two previously documented occurrences in the park was in the vicinity of Merced Lake (the other is on the South Fork of the Merced River upstream of Wawona). Our surveys confirmed that this species is widespread from Bunnell Point to above Merced Lake, with scattered populations on rocky canyon slopes on the north side of the Merced River down to the water's edge (but, oddly, it was not observed on the south slope). The Merced Lake map indicates several populations but not all that occur here. The population found near the High Sierra Camp appears to be stable, and it has even colonized the stonework of the trail near Merced Lake. This species is not threatened by human activity in the area as it prefers rock ledges and cracks in rock faces and there is much secure habitat of this sort in the area. This species will remain on the candidate list pending further taxonomic study to determine the limits of its range in the central Sierra Nevada.

Special Status Species

The population of redray alpinegold (*Hulsea heterochroma*) at Twin Bridges recorded (but not vouchered) by Steven Botti

At left, a mineral spring at the upper end of Echo Valley is located only a few meters below the trail (the vantage point from which the photo was taken), but since its flow is away from the trail, the plant habitat, which is highly restricted to the salt water perimeter, is unaffected by the trail traffic, although it is riddled with wildlife tracks. At right, a mineral spring west of Washburn Lake flows into and is diverted by the trail (creating reddish mud) and the result is loss of use to mineral spring specialist plants and wildlife and poor trail quality.

Above, Nevada City buckwheat, which prefers granite crevices, colonizes stonework in trail near Merced Lake. Left, Nevada City buckwheat thrives in a granite crack next to power cable at Merced Lake High Sierra Camp.

(2000) was not found. Instead, a large population of Yosemite tarweed (*Jensia yosemitana*) was found in approximately the same perimeter as the mapped redray alpinegold. Twin Bridges is not typical habitat for redray alpinegold, which is a foothill chaparral species, but this is typical habitat for Yosemite tarweed, so we suspect that there was a past name error in the rare plant records. A species of tarweed (*Madia* sp.) that could not be identified in the field was also mapped on the north slope above twin bridges, within the perimeter of the Yosemite tarweed. This species is on loan to an expert for identification.

> *Yosemite was all one glorious flower garden before plows and scythes and trampling, biting horses came to make its wide open spaces look like farmers' pasture fields. Nevertheless, countless flowers still bloom every year in glorious profusion on the grand talus slopes, wall benches and tablets, and in all the fine, cool side-canyons up to the rim of the Valley, and beyond, higher and higher, to the summits of the peaks. Even on the open floor and in easily-reached side-nooks many common flowering plants have survived and still make a brave show in the spring and early summer.*
>
> - John Muir, 1912.
>
> From: *The Yosemite*.

Yosemite Valley

Results of Yosemite Valley Surveys

The floor of Yosemite Valley had been surveyed for rare plants using GPS technology when this study was started. To survey the entire valley floor was beyond the scope of this project, so survey emphasis was placed on the river banks, meadows and developed areas. Targeted surveys were done by Drs. Colwell and Taylor and by Park Botanist Lisa Acree over the course of the season. Gridded surveys in a few areas known to harbor special status species were done by Dr. Colwell and field assistants. In addition, the Merced River Plan Meadow survey project crew alerted this project staff when they found special status species in their plots and these data were incorporated into these maps.

The two maps titled: Yosemite Valley – East Portion and Yosemite Valley – West Portion display the results of these surveys. No special status species (exceptions were landscaping subjects discussed below), were found in campgrounds, housing areas or other intensively developed areas. Nearly all special status species were found in ares with at least brief inundation: meadows, oxbow cutoffs or some other feature remaining from old river channels or flood events. Nearly all major wetland areas had at least one special status species occupant, but usually not the same one. Occurrence of special status species was widely distributed and was highly patchy. Possible reasons for this pattern are discussed below.

Note: Torrey's popcornflower (*Plagiobothrys torreyi* var. *torreyi*) is shown on the Yosemite Valley- East Portion map in Ahwahnee Meadow, in the vicinity of the site of the original collection from which this subspecies was described. This variety of Torrey's popcornflower has since been found to be widespread in Yosemite Valley and its taxonomic relationship to the more widespread *Plagiobothrys torreyi* var. *diffusus* is currently under review, so we did not include additional populations on the Yosemite Valley or Little Yosemite Valley maps in order to preserve clarity.

Discussion

The natural role of the Merced River in Yosemite Valley is as an agent of cleansing and renewal. Regular floods clear out duff, debris, and understory vegetation. This provides clearings for sun-loving species to thrive. It also exposes mineral soil for seeds to germinate and establish new populations without competition for light from above. Nutrients are redistributed by the force of the floodwater and are introduced by the settling of suspended solids as the floodwaters slow and spread across the floodplain. Seeds of species from higher elevations are washed down and planted with the sediment settling. Therefore, patches of species uncharacteristic of this elevation, both common and rare, establish themselves in the moist soils and flooded swales left by the flooding, at least for the short term. It is expected that some of these will appear and disappear with the normal river processes. The following species marked on the Yosem-

Far left, Cutleaf monkeyflower (*Mimulus laciniatus*) ordinarily prefers seepages on rock faces, but in 2010 individuals were found scattered in pine-needle covered duff of a recently burned forested bottomland, shown at right. These plants were likely established via seed introduced from more typical upstream sites by recent floodwaters. Such populations may only last a few years until outcompeted by other vegetation, or they may establish permanently.

ite Valley – East Portion and Yosemite Valley – West Portion maps are likely the result of presumptive introductions from higher elevations by flooding: Buxbaum's sedge (*Carex buxbaumii*), stream orchid (*Epipactis gigantea*), Northern bugleweed (*Lycopus uniflorus*), cutleaf monkeyflower (*Mimulus laciniatus*) and lesser bladderwort (*Utricularia minor*).

This was also doubtless the case for the Sierra sun cups (*Camissonia sierrae* ssp. *sierrae*) collected on a "granite sand drift" in Royal Arches Meadow the year after a flood (W.L. Jepson #10478, 1924). Royal Arches Meadow was surveyed thoroughly for this special status species in 2010, but the habitat is now a densely vegetated wetland, and inappropriate for this small annual plant that prefers sandy soil in sun. We conclude that this population was probably established in an ephemeral habitat (a sunny sandbar) from a source population up Tenaya Creek and that it was extirpated due to natural succession processes in a channel that was cut off from the main channel of Tenaya Creek (either by natural meander processes or by creation of roadbed or ditching). Sierra sun cups may therefore turn up again on

View of Royal Arches Meadow. Decades ago a floodchannel of Tenaya Creek with gravel bars, now a densely-vegetated seasonal wetland with a large stand of tule bulrush.

sandbars elsewhere in Yosemite Valley left by recent or future floods. In contrast, Buxbaum's sedge is found in most wet meadows in Yosemite Valley, at the lower end of its known elevation in the Sierra Nevada, suggesting that it has found a suitably cold and moist habitat in Yosemite Valley and has become established. The primary lesson from this pattern of distribution is that it is important to maintain the flood processes (e.g., both flooding and river meandering) in Yosemite Valley as they, in turn, maintain natural habitat and generate species diversity.

Adverse Impacts: Changed Hydrology

Most of Yosemite Valley is riparian floodplain, and, from interpretation of 19th century descriptions and photos, we understand that much more flooding occurred and much more riparian vegetation such as willow thickets covered the valley floor (Ballenger, 2011 unpublished). Extensive human impacts in the form of wetland draining, such as removal of natural dams, ditching and piping have been documented throughout Yosemite Valley (Ernst 1943, Milestone 1978) and although some of these have since been removed, others remain. The cumulative effect these impacts has had on special status species is a reduction in the available habitat. As can be seen from the Maps (Yosemite Valley – East Portion, Yosemite Valley – West Portion), most special status species sites are located in, or at the margin of, wetlands. These wetland areas were more extensive prior to the drying and draining activities of the past 150 years.

The flora of the valley floor was reasonably well known by the end of the 19th century, so we infer that impacts to special status species have mostly been in the form of extirpation of individual populations of species rather than extirpation of special status species entirely from the valley. A case in point is the mountain lady slipper (*Cypripedium montanum*), of which remain in Yosemite Valley two depauperate patches of plants: one patch of 7 small individuals downstream of Pohono Bridge and two small patches between the Curry Stables and Tenaya Creek. One of these was of two small, non-flowering individuals, either juveniles or weak adults. The second patch had two individuals, one with one stem setting one fruit, but all of the leaves of that stem had been chewed off by deer. This section of woods is converting to pine & cedar forest from oak woodland, with consequent drying and needle accumulation on the ground. These conditions are not optimal for mountain lady's slipper and a prescribed burn should be considered for this area. Also, the level of browsing by deer should be considered a potential adverse impact on rare native species in Yosemite Valley. A larger population was buried by the Happy Isles Rockfall in 1997, and a single individual near the Happy Isles boardwalk disappeared since 1980 for unknown reasons. Additional populations that may have existed in Yosemite Valley in earlier times went undocumented, but since this species prefers shady forest at the margin of wetlands, it was likely more abundant prior to the drying and 'coniferization' of Yosemite Valley as a result of

Left, Buxbaum's sedge rings a seasonal pool of water in Stoneman Meadow. Right, stream orchid thrives next to a boardwalk that replaced a social trail in Stoneman Meadow. The combination of restored hydrology that increases meadow wetness and reduction in foot traffic by hardening surfaces in high traffic areas improves habitat quickly.

Left, Sierra laurel does very well as a shaded ground-cover in the Ahwahnee Hotel parking lot. Right, narrowpetal wakerobin under shrubs along the front walk of the hotel

changed hydrology. The current surviving patches are not thriving where they occur, as they now occupy forest with closing conifer canopy and drying soil.

Hydrologic impacts are thus the greatest threat to survival of most special status species in Yosemite Valley. An illustration of this point is the hydrologic restoration of flows through Happy Isles fen which have caused Stoneman Meadow to become a wetter habitat. The two special status species found here - Buxbaum's sedge (*Carex buxbaumii*) and stream orchid (*Epipactis gigantea*) - occupy wet parts of the meadow and appear to now be spreading, although follow-up surveys will be necessary to confirm this.

Impacts of Landscaping on Special Status Species

Historically it was accepted practice to transplant wild plants to landscaping. Consequently, much of the original landscaping at The Ahwahnee and Tecoya housing are natives transplanted from elsewhere in Yosemite Valley and the park. A few that are park special status plants continue to exist as landscaping at the Ahwahnee Hotel: Sierra laurel (*Leucothoe davisiae*) in the visitor parking lot, narrow-petal wakerobin (*Trillium angustipetalum*) next to the front entrance walk and behind cabin #7 and western bladderpod (*Staphylea occidentalis*) near the swimming pool, and narrow-petal wakerobin is also found behind the Ranger Club. These species, by surviving this long, have proven to be good local landscaping plants. These species should not necessarily be discouraged from local landscaping due to their special status. The current accepted practice for producing native species is for local seeds/cuttings to be harvested by a permitted park staff or contractor, grown out at an approved nursery and brought back into the park and planted near to the place of origin of the starting material. This process is designed to minimize movement of pests, pathogens and non-local races of natives. Native species for landscaping should not be placed near wild populations with which they could hybridize if they did not come from that area. The western bladderpod, for instance, does not occur in the park closer than the Arch Rock Entrance Station. Therefore, there is no possibility

Left, a patch of this species, in foreground behind Ranger Club, is likely planted. Some park special status plant species are also excellent subjects for native landscaping. Below, narrow-petal wakerobin is a special status species of moist, shady sites.

Above, wall hawkweed got established briefly between a road and a bikepath before being detected and eradicated. Right, detail of plants. Alien species arrive in Yosemite Valley at a rate of almost two new species per year.

that a planting at The Ahwahnee would hybridize with native plants and thus this planting is not a problem. Developing guidance for residents and park cooperators on best practices for native plant landscaping and a suggested species list would be helpful.

Impacts of Invasive Species on Special Status Plants

Opportunities for introduction of non-native species are commensurate with the number of vectors (human, livestock, wildlife) coming into an area, and Yosemite Valley, with by far the highest visitor use, consequently has the highest number of non-native species of any area of the park. As mentioned above, approximately 1.7 new non-native plant species establish in Yosemite Valley every year. In the course of surveys for this project, a species previously unknown in California, wall hawkweed (*Hieracium murorum*), a native of Europe, was observed growing in the Tecoya Housing area between a footpath and Ahwahnee Drive. This species belongs to a genus known for aggressive weeds. This species was therefore designated a high priority invasive and quickly eradicated by the invasive management crew.

Landscaping in Yosemite Valley also provides an avenue of entry for non-natives. Surveys for this project revealed a number of other worrisome non-natives in residential areas in Yosemite Valley: stinky Bob (*Geranium robertianum*), Italian lords and ladies (*Arum italicum*), and sweet violet (*Viola odorata*). These species were spreading between yards and are known to be invasive elsewhere, so should be monitored for spreading outside of landscaping. This has happened already in one case: the Ahwahnee Hotel has one specimen of a weedy non-native orchid broadleaf helleborine (*Epipactis helleborine*) in its landscaping. This species is known to be an aggressive invader in western states and surveys in nearby forested areas revealed that it had spread beyond the landscaping. Those plants were treated with herbicide and will be subjected to follow-up treatments, although there is now an established seedbank in the vicinity of the Ahwahnee, so it may require re-treatment

Above, candystick (*Allotropa virgata*) is blooming in foreground, next to pink flag. The moist habitat of forested riverbanks and old oxbow swales is the only place where this moisture-loving special status species is found. 'Trail creep' from high foot traffic squeezes this narrow-diameter habitat. Left, a view of the entire eight meters square patch of this plant (flags mark candystick stalks).

for years. The Ahwahnee landscaping staff agreed to remove the finished blooms from the plants in their landscaping before the seeds matured, but the optimal solution would be to remove the plant itself.

In some cases it is unclear whether a species is native or non-native. This is the case for woolgrass (*Scirpus cyperinus*) which occurs in the meadow opposite the Chapel. This is the only known location of this species in California. The first collection was made in Yosemite Valley in 1976 by J.T. Howell (52233), and the species was listed in the Flora of California (Hickman 1993) as a non-native, since the recentness of the first collection is taken as an indication of it being newly introduced. However, for wetland plants, which are traditionally under-collected, this is not necessarily indicative of anything besides lack of prior data. Botanists in Washington State (Peter Zika, pers. comm.) report that this species, also recently documented there, is spreading quickly into wetlands of the Columbia River, which is behavior typical of an invasive species. At this point the species remains a 'candidate' for special status. If proved to be native it would be moved onto the special status species list. If proved to be non-native, it would be put on the list of non-natives to be eradicated. For the time being, it will be monitored.

Impacts of Trampling

One of the significant challenges for rare flora in Yosemite Valley is trampling of individual plants in areas which attract a lot of pedestrian traffic. Replacing social trails with hardened surfaces such as boardwalks has worked well in meadow settings and additional locations in Yosemite Valley (e.g., on the east side of Ahwahnee Meadow) would benefit from this approach. For example, a boardwalk replaced a social trail through Stoneman Meadow which ran through a population of stream orchid (*Epipactis gigantea*). The individuals next to or under the boardwalk are now released from trampling impacts and are flourishing.

> *…there are two considerations which should not escape attention. First; the value of the district in its present condition as a museum of natural science and the danger – indeed the certainty – that without care many of the species of plants now flourishing upon it will be lost…Second; it is important that it should be remembered that in permitting the sacrifice of anything that would be of slightest value to future visitors to the convenience, bad taste, playfulness, carelessness, or wanton destructiveness of present visitors, we probably yield in each case the interest of uncounted millions to the selfishness of a few individuals.*
>
> – Frederick Law Olmsted, 1865.

Yosemite Valley to El Portal

The field crew, led by Heather Smith, surveyed longitudinally along both banks of the Merced River from Pohono Bridge to El Portal in late September when the Merced River had dropped to safe levels. They had previous experience mapping Sierra sweetbay (*Myrica hartwegii*) and other likely target species for this section while working in Wawona. Immediately prior to the start of this survey, they were shown examples of mountain lady's slipper (*Cypripedium montanum*) and tanoak (*Lithocarpus densiflorus* var. *echinoides*), also known from this section of river.

Results of Yosemite Valley to El Portal Survey

Sierra sweetbay was not observed on this section of river (see discussion of this species in Appendix 2). No tanoak other than that already known from the south side of the river opposite the junction of Highway 140 and Big Oak Flat Road was observed. (Note: On the Yosemite Valley West map, this point is missing.) The other special status species observed by the crew in this section of river, California sunflower (*Helianthus californicus*), was observed in this same site on the sunny, sandy beach on the north side of the river.

The Yosemite Valley to El Portal section is a possible location of the historic collections of Sierra sweetbay and the likely location of the historic collections of Pacific yew (*Taxus brevifolia*) mentioned above, but these species were not discovered by this survey. Western bladderpod (*Staphylea bolanderi*) was observed but not mapped on the south bank of the Merced River from the Arch Rock to Windy Point.

Right, Western bladderpod (*Staphylea bolanderi*) flowers. Below, Western bladderpod is a small tree in moist, cool spots. Several individuals occur at the Arch Rock Entrance Station and on the south slope of the canyon from the El Portal trailer park to Cold Canyon. The lone specimen in Yosemite Valley at the Ahwahnee Hotel is likely a transplant.

Discussion

At the bottom of Yosemite Valley, the Merced River flows gently for a short distance before hurtling into a narrow granite chasm. The river is steep and dangerous in this section, the channel cascading over large boulders, both water-smoothed and sharply-angled from recent falls. The sides of the chasm are steep and deeply shaded on the south side. There grows dense forest and enticing rocky slopes covered in mosses and flowers in the spring, but are inaccessible to botanists until the fall when the water level in the river has dropped. Few specimens are known from the south slope, most botanists having contented themselves with inspecting the

area with binoculars from Highway 140. Thus, although special status species may well exist that are overlooked, they are also well-protected from human impacts there.

Although Highway 140 parallels this section of river and is a heavily-travelled route, relatively few travelers venture off of the road in this section. Although the relatively uncommon California nutmeg (*Torreya californica*) is found along this side of the river in abundance, from Arch Rock to the Big Oak Flat junction, few other special status species had been reported from this side of the river in this section. A contributing factor to the relative lack of special status species in this river section is the high frequency of rockfall here. Areas of active rockfall in Yosemite and in general tend to lack rare species - only those species sturdy enough and fast-growing enough to survive frequent rockfalls remain.

> *The Yosemite National Park is perhaps the most delightful region in all the world for the study of plant life. The wide variety of conditions here found, ranging from the hot and dessicated slopes of the brush-clad foothills to the cold, bleak summits above timber-line, the abode of glaciers and perpetual snow, gives to the flora an exceedingly diverse and interesting character.*
>
> - Harvey Monroe Hall, 1912.
>
> From: *A Yosemite Flora.*

El Portal Administrative Site

Results of El Portal Surveys

The El Portal segment of the Merced River was surveyed for special status species using GPS technology between 2003 and 2009 (Moore et al. 2010) and was further surveyed for these species in 2011. An undescribed species of *Collinsia* occurring in the El Portal Administrative Area has been mapped and added to the special status plant list.

Discussion

At the western park boundary, the main fork of the Merced River emerges from a narrow gorge cut deep into its granite canyon and enters a region of metamorphic rock strata, primarily composed of Cretaceous plutonic rocks (Bass Lake Tonalite) and Paleozoic sedimentary rocks (Quartzite of Pilot Ridge) (Bateman and Krauskopf 1987). In this section, which occurs from Parkline to Briceburg, the Merced River has been able to carve a wider canyon through which it flows with a gentler gradient, with its widest points occurring in El Portal. The highly fractured metamorphosed rocks produce steep, unstable slopes with deeper, finer-textured soils than does the granite that dominates upriver. Small outcrops of calcareous substrates and heavy metal-rich spring seeps are scattered through the area, creating a variety of habitats with unusual soil chemistry. The lower gradient flows and wider channel of the river have added to the habitat complexity of this section by allowing formation in this section of river some braided river channels and bottomland habitats with alluvial soils.

The variety of soils present in this area, in combination with dramatic variations in moisture levels and amount of light in the two-thousand foot deep canyon of this river segment results in a great diversity of plant species found within this relatively small area. For instance, the foothill vegetation communities find habitat at their upper range limits in this area in hotter sites, where they grow juxtaposed with montane vegetation types in cooler sites. Thus, many foothills species have their only occurrence within the park boundary in this canyon. More importantly, the segment of the river from Parkline to Briceburg is a large part of the known range of several species endemic to this region. These species appear to be largely or wholly restricted to metamorphic rock formations (found here and in Kings Canyon). Those which occur within El Portal are: Yosemite onion (*Allium yosemitense*), Tompkins sedge (*Carex tompkinsii*), Condgon's woolly sunflower (*Eriophyllum congdonii*), Congdon's lewisia (*Lewisia congdonii*), and a new species of blue-eyed Mary (genus *Collinsia*) which has not yet been formally published (Michael Park, pers. comm.). These are all park special status species (the new *Collinsia* is currently under the name *Collinsia linearis*) and the first four species are state-listed and CNPS-listed. These species all grow within or adjacent to areas of prehistoric and current human use. However, because a large part of their habitat consists of rocky ridges and slopes, little of their preferred habitat has been impacted directly. Indirect impacts to these species

The unique chemistries of the local rocks combined with the steep walls near the river support a community of specialized plants. At left, a rocky overhang created by a road-cut oozes heavy-metal laden salts brightened by the green fuzz of the rare copper moss (*Mielichhoferia elongata*) (Inset). In California, copper moss is found only in the Merced River Canyon and in Kings Canyon, two places where its preferred habitat (mineralized seepages) is abundant. Yosemite does not yet assign 'special status' to any non-vascular plants, but rare mosses and lichens are frequent in this segment of canyon.

occur largely through encroachment by invasive non-native plants, mainly annual grasses. Where the canyon slopes are stable enough to allow these grasses to accumulate fibrous root mats and thatch that stabilize the soil further, these grasses are able to crowd out special status species and provide sites for other invasive species to grow, furthering the cycle of habitat conversion. However, a portion of the slopes in the area are not stable enough to allow buildup of organic thatch, and in such places many native species adapted to the 'stably unstable' talus or mineral soil slopes continue to survive.

The El Portal Map shows distributions of special status species in El Portal. One

Congdon's woolly sunflower (*Eriophyllum congdonii*) (inset) prefers steep talus slopes, both natural and man-made. For this reason, it has not had to compete with human infrastructure for most of its habitat. On Foresta Road, just upriver of the El Portal Maintenance Complex, it grows in unstable talus above and below the road, down to the river's edge. Also in this site, a new species of blue-eyed Mary (not officially published yet) also inhabits the roadside talus. Both species are restricted to these metamorphic rock types and are found only in Mariposa County.

In foreground, Tompkins sedge (*Carex tompkinsii*), a state-listed species which does very well with wildfire, is no match for invading groundcovers. This population of Tompkins sedge has been smothered by English ivy and periwinkle spreading from a yard in Old El Portal.

notices first that most special status species are found on rocky slopes and ridges. The exception is Tompkins' sedge, which occurs on steep slope habitat but also occurs in river channel forest and in the shady slopes among houses in El Portal and Rancheria Flat. Periodic low intensity fire appears to be a positive influence on this species as it has responded well to controlled burns and wildfire around El Portal and elsewhere.

The riparian vegetation of El Portal, in contrast to the slope vegetation, has been affected in larger measure by historic human use. Placement of railroad and highway corridors near the river and subsequent protection of this infrastructure from flooding have restricted the frequency and extent of rejuvenating flood cycles, changed water tables by impounding water flow in some areas and causing drying in others. Placement of buildings in riparian habitat has also reduced the total area of this habitat and reduced the opportunity for natural channel meander to occur.

Any loss of special status species in the riparian setting early in the development of El Portal went undocumented. Tompkins' sedge is the only current special status species to occur in the riparian forest setting and was likely more abundant in this setting previously. Valley oak (*Quercus*

Below, an oxbow channel of the Merced River was obstructed by early development in Old El Portal. At right, the wetland downstream in this same oxbow still harbors wetland herbs and trees, but is also choked with invasive species, such as the Himalayan blackberry in the foreground.

Left, native bottomland vegetation (oaks, pines, shrubs and annual herbs) was left intact to the west of the NPS Resources building erected in 2007 and it continues to flourish. Right, non-native landscaping species installed in 2007 to the east of the same building includes a lawn which requires fertilizer and supplementary watering and which has introduced non-native invertebrates (e.g., slugs and earthworms) to the site. Non-native London plane trees (*Platanus* X *acerifolia*) are known to have interbred with native California sycamore elsewhere in California. Hybridization with native sycamore is not an issue in El Portal, as the native species is not present in this canyon, however the potential for this non-native sycamore to establish itself in this area is a concern.

lobata) is currently under consideration for special status as it is found in a single population in Yosemite, in El Portal. This oak population is discussed in the Condition Assessment in Appendix 1.

Occupants and users of El Portal are doing several things that currently maintain health of special status species in the area and these practices should be continued and expanded:

- NPS crews are removing noxious weeds such as Himalayan blackberry, French broom, sweet pea and tree-of-heaven that crowd out natives in the riparian areas.
- NPS crews have largely succeeded in removing the noxious weed star-thistle from the sunny slopes above Rancheria where it was crowding out other species. This effort should be continued to its completion so that star thistle will not threaten special status species, such as brownies (*Mimulus douglasii*).
- NPS staff conduct understory burning around El Portal that reduces thatch built up by non-native grasses and provides for recruitment of fire-adapted species such as Tompkins' sedge.
- Town occupants and NPS facilities tend to leave native vegetation around buildings intact and tend to minimize landscaping that requires additional watering (e.g., few lawns).
- Town occupants and NPS facilities tend to utilize native species for landscaping purposes. NPS and town occupants propagate some local stock from seed and cuttings for local restoration purposes.

> *Banks of heartsease and beds of cowslips and daisies are frequent, and thickets of alder, dogwood and willow often fringe the shores."*
>
> – Frederick Law Olmsted, 1865.

Wawona

Results of the Surveys in Wawona

The developed areas within Wawona (the Wawona Hotel, the residential area, Camp Wawona, Wawona golf course, and Wawona Campground) were surveyed over several days in July by Drs. Taylor and Colwell. Special status species occurrences were mapped or those which were frequently encountered were noted for followup surveying in September by field crews. The members of the field crew were shown examples of each special status species they would encounter in each area and were trained on data collection, then they did gridded surveys on their own in the residential areas, and linear surveys along the river course.

Discussion

In 2010, several special status species were found in natural vegetation at the margins of human habitation and several appear to be holding their own within the residential area itself: Yosemite sedge (*Carex sartwelliana*), California sunflower (*Helianthus californicus*), yellow-and-white monkeyflower (*Mimulus bicolor*), narrowpetal wakerobin (*Trillium angustipetalum*), and Hall's mules-ears (*Wyethia elata*). These can be seen in many locations. The first is likely present because residents moved it from surrounding forests into their yards. The latter three appear to be species that are fire and/or disturbance adapted, and thus are pre-adapted for survival in the vicinity of human habitation.

The South Fork of the Merced River, in the stretch that encompasses Wawona, flows over a relatively low gradient and thus displays a meandering, open channel, abutted by pine-oak woodland and meadows. The substrate rock in this area is granite, which has decomposed into sandy gravel, creating characteristically

Hall's mules-ears in Wawona Campground. This native species is naturally found in disturbed areas, so does well at the margins of human habitation. The upper edge of its range edges into Yosemite in Wawona.

sandy bottomland. Sandy bottomland is relatively well-drained and thus seasonally dry with resulting lower vegetation cover in the vicinity of Wawona. Special status species that occur here tend to be those adapted to drier foothill habitats, finding a foothold within Yosemite's borders in this area. There are pockets of moister habitats where water flow of streamlets has built up deep organic soils over millennia and created wet meadows, such as the lower end of Wawona Meadow, now largely under the golf course.

The benign terrain of Wawona led to its early settlement by Galen Clark (1840). Early visitors to the Mariposa "Big Tree" Grove stayed at his cabin, now an abandoned site adjacent to the Wawona Golf Course. Those visitors included botanists, who made botanical collections in the area, some of which then became the 'type specimen' from which new species were described. This means that the vicinity of the Galen Clark Cabin is the 'type locality' for several species and is therefore valued by scientists as the most appropriate site to make fresh collections. Herbarium specimens from the late nineteenth century that are merely labeled "Clark's cabin" are inferred to come from the Wawona area.

The benign environment of this area also attracted various subsequent human uses (orchards, cattle range, air landing strip) that continue today in the form of a residential area, summer camp complex, hotel complex and golf course. Continuous human occupation has led to reduction in meadow and riparian habitat, and could possibly have led to the extirpation of some special status species, but none can be confirmed from comparison of historical records with extant species lists. Historical records do suggest that mountain ladyslipper (*Cypripedium montanum*) occurred at several additional sites in Wawona to what is known today and that it may have been negatively affected by illegal collecting in the early 20th century.

The major contributing factor to survival of these species within the ongoing human habitation footprint area is that impacts on surrounding vegetation (watering, introduction of landscaping plants or lawns, and trampling) are kept to a minimum by the occupants and users of Wawona.

Impacts to Special Status Species

The greatest potential threat to the health of special status species populations in Wawona is competition for habitat by non-native species. One significant potential source of this problem was observed while surveying the Wawona residential area: landscaping ornamentals have been planted that have potential to or are already escaping from yards on private land into surrounding park land. The park high priority weed foxglove (*Digitalis purpurea*) is cultivated by several homeowners. This species establishes easily from the many seed it produces and is the focus of eradication efforts in the Mariposa Grove. There were also several new records for the park of non-native species found in the Wawona Residential Area by this survey, some of which are worrisome: Scotch broom (*Cytisus scoparius*), an ornamental shrub which is a noxious weed in other western states is producing offspring on land adjacent to some homes in Wawona. Common bugle (*Ajuga reptans*), a mint-family ground cover herb native to Europe and escaped from cultivation throughout the United States, was found adjacent to one home in Wawona. Common bugle is not yet reported as established in California, but it reproduces vigorously from lateral roots and its proximity to the Merced River provides an opportunity for it to spread through the river system. Yel-

The non-native English daisy is a weed in the Wawona Golf Course lawn.

Left, special status species yellow-and-white monkey-flower does well at the forested west margin of the golf course where a recent prescribed burn occurred. Right, narrowpetal wakerobin patches behind the 'rough' in shaded spots kept clear of brush on the west side of the golf course.

lowflag iris (*Iris pseudacoris*) is a wetland ornamental, a native of Eurasia and Africa, that is known to be invasive in eastern U.S. wetlands. It appears to have been planted in a stream drainage by a homeowner in Wawona. Finally, Oregon-grape (*Berberis aquifolia*) has been planted by several homeowners and is establishing itself up and down drainages in Wawona. This plant is marketed by nurseries as a California native plant but is not native to the Sierra Nevada. Its Sierra Nevada native relative, California barberry (*Berberis dictyota*) occurs naturally downstream of Wawona in the river channel but has not been utilized as a landscaping plant in Wawona itself. Resident education on risky landscape plantings would go a long way towards solving this problem. A "Good Neighbor" handbook that sets out horticultural guidance & resources for park residents and neighbors is becoming a common practice for land management agencies with urban neighbors. For park partners, a more interactive approach would be warranted, e.g., working more closely with park concessions to develop a list of attractive local native landscaping plants and one for those to be avoided.

The golf course is also a potential point source of non-natives for this area. The following new records for the park were found in the course of this survey: English daisy (*Bellis perennis*), a European weed common in lawns but otherwise unknown in Yosemite was found on fairway 2. The marsh meadow foxtail grass (*Alopecurus geniculatus*), a native of Europe was found in wet areas of the fairways; catnip (*Nepeta cataria*), an aggressively spreading medicinal herb, was found in the unmowed margin between the golf course and the river. A species list for the golf course was provided to the golf course staff and is found in Appendix 4. The golf course staff is already doing spot removal of non-natives that they recognize, but a cooperative invasive management plan would focus time and effort efficiently and reduce the chances of other non-natives arriving by this entry point. The golf course staff, by keeping brush cleared at the margin of the course, are maintaining habitat for special status species narrowpetal wakerobin and yellow-and-white monkeyflower, both of which were found there in 2010.

The location of the historic site of the Wawona Arboretum (built by the 9th Cavalry) at the confluence of Big Creek and the South Fork Merced River was investigated. Documents describing this project suggested that the arboretum consisted of infrastructure and signage posted on existing vegetation only and that the project was abandoned before exogenous plants were transplanted to the site. A ground verification concurred that although remnants of infrastructure still exist at the site, no non-native or unusual native species occur at the site.

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Appendix I

Condition Assessment of Valley Oaks (*Quercus lobata*) in El Portal

Background

Valley oak (*Quercus lobata*) is a keystone tree species in floodplain riparian habitats of California. Its presence is tied to a high water table, as valley oaks occur where the water table is 30 m deep or less (Tyler 2006). Endemic to California, valley oak populations have experienced a widespread decline throughout the state. This decline is due primarily to loss of habitat, and similar declines have been observed for many low elevation native species, as foothill areas below about 3,300 feet have experienced the greatest loss of riparian vegetation of any region in the Sierra Nevada (U.C. Davis 1996). The California Native Plant Society has listed the valley oak plant community, or *Quercus lobata* Alliance, as rare and threatened throughout its range (Sawyer et al. 2009).

Valley oak riparian and woodland areas comprise critical habitat of high value to wildlife (Howard 1992). In general, riparian environments support more species and greater numbers of wildlife than any other habitat type in the Sierra Nevada (U.C. Davis 1996). Collectively, valley oak riparian forests in California support 67 nesting bird species- more than any other California habitat for which data are available (Gaines 1980). The ecological significance of riparian habitat at lower elevations in Yosemite is accentuated by its Mediterranean climate, where water is extremely limited during hot summer months. In the Merced River Canyon, valley oaks provide forage for deer, acorns for birds, rodents and bears, and food storage and nesting sites for acorn woodpeckers.

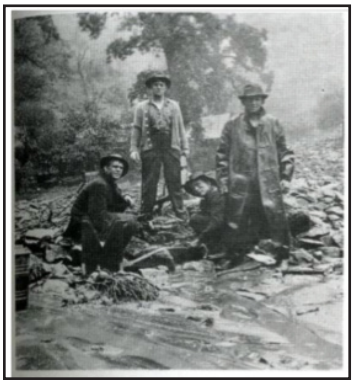
Yosemite is home to one valley oak population, located at the El Portal Administrative Site. This population lies at the eastern boundary for the species in the Merced River Canyon, with the nearest population to the west occurring at Indian Flat 3 miles to the west, a few more scattered downstream in the Merced River Canyon and most populations occurring in the Central Valley 50 miles to the west.

The nucleus of the El Portal valley oak population is the El Portal Road, located adjacent to the existing fuel storage facility and El Portal Post Office. The population extends west in the floodplain to Middle Road, and east in the river cut-off channel toward the gas station. Additional oaks occur a short distance up the hillside in El Portal, though botanists suspect that the oaks in these drier uphill habitats could be hybrids between valley oaks and adjacent upland oak species (a common phenomenon in oaks). These upland oaks exhibit slight differences in morphological characteristics from the core population, such as slightly hairy terminal buds, although genetic studies have not been done to confirm a hybrid status. These drier-habitat oaks are not part of the population that is an outstandingly remarkable value, as they are not strongly river-dependent or river-related.

Condition at the time of 1987 designation

Anderson (2005) estimated that urbanization and land conversion destroyed about 90% of valley oak stands in California that existed prior to European contact. In the Sacramento River System, researchers estimate that about 1.5 percent of original valley oak acreage remains (Hehnke 1979).

Two views of 1913 El Portal flood in core valley oak habitat. (Law 1993).



Left, vehicular traffic within dripline of a tree will compact soil and possibly injure trees. Right, a recently fallen valley oak was in the 80–100 cm dbh size class and was 117 years old when it died. (Photo on left by Mike Osborne.)

The valley oak population in El Portal was an exception to this extensive loss, though the population did sustain moderate impacts from rural development such as the construction of the terminus of the Yosemite Valley Railroad in El Portal in the 1930s.

Current Condition: Oak researchers use four traditional methods to evaluate the condition and structure of oak woodlands—age structure, size structure, comparative analysis of historic and current photos, and comparative analysis of on-the-ground surveys. Each method has limitations and merits. One of the most useful tools to examine the condition and long-term viability of the El Portal valley oak population is the size distribution of existing individual trees (Tyler 2006). While the size of oaks does not necessarily reflect the age of oaks, it is generally true that the largest individuals are probably old and the youngest individuals are generally small, but it is not always the case that the smallest trees are young. Regardless, the size of oaks is a good indicator of reproductive capabilities (Tyler 2006). A healthy population would generally have all size classes present, but would have a higher number of smaller individuals than larger individuals.

The core El Portal valley oak population contains 38 individual trees, with sizes ranging from 1-140 cm diameter at breast height (see Figure 1). Five valley oaks in the smallest size class were removed within the past five years during a restoration project, and are thus not reflected in the figure. The distribution of the El Portal valley oak population in a variety of age classes, with more young trees than old trees, is of particular importance. The greatest problem facing those who manage valley oak woodlands is lack of sapling recruitment (Howard 1992). In a review of published studies on the demography and recruitment of California oak trees, nearly all of the valley oak inventories found valley oak seedlings and saplings to be uncommon or absent (Tyler 2006). The El Portal population is exemplary in that it contains a relatively well-rounded distribution of age-classes.

Local development continues to limit valley oak establishment in potential habitat in El Portal. The unpaved parking lots across Foresta Road from the railroad engine have expanded under the drip line of mature oaks, some areas within the core oak population have been graded,

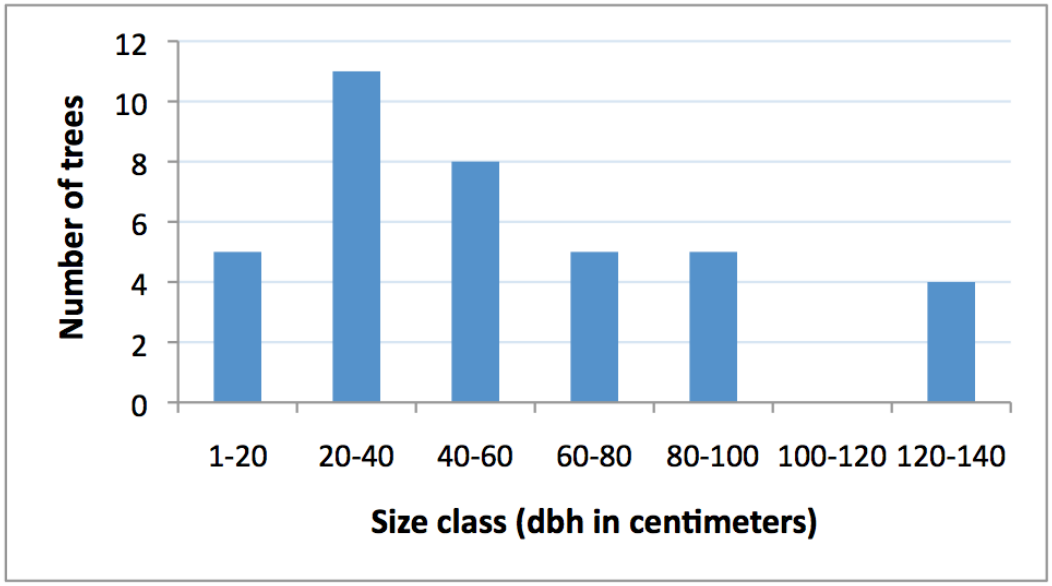


Figure 1. Size class distribution of core valley oak population in dbh (diameter at breast height). [Note: Five trees in the smallest size class are not reflected in this figure, as they were removed in the last five years.]

and small numbers of young oaks have been removed for a variety of reasons. The valley oak understory is in some places kept clear of understory vegetation that would protect young trees from browsing or trampling. Also, an invasion of non-native Himalayan blackberry makes much understory area inhospitable for seedling recruitment. Despite these issues, the core population retains sufficient integrity as a vegetation community, and is classified as valley oak woodland in the park wide vegetation map for Yosemite.

As summarized by McClaran (1986), successful oak recruitment requires a combination of events including abundant acorn production, sufficient rainfall, and limited competition for light and water from neighbors. Mature trees are sensitive to over watering, pruning, grade changes, and asphalt covering the root system (Rossi 1908). In El Portal, long-term stability of the valley oak population would be enhanced by protection of habitat in the vicinity of valley oak trees and especially under the drip line of existing oak trees, removal of invasive plants and protection (from browsing by deer and from mowing) with stakes and wire cloth tubes, and cultivation of new recruits.

A significant requirement for survival of this population of valley oaks, a high water table, continues to be met in El Portal as the root systems of mature oaks are likely connected to the Merced River water table, which remains stable.

Appendix 2

Condition Assessment of Sierra Sweetbay (*Myrica hartwegii*) in Wawona

Sierra sweetbay (*Myrica hartwegii* A. Chevalier) is a shrub in the myrtle family (Myricaceae), a small family of shrubs and small trees, found in both temperate and tropical regions, which typically contain aromatic resins. Sierra sweet bay is no exception - rubbing the leaves between the fingers releases a spicy odor, an excellent field identification clue. The myrtle family is neither large nor prominent in our flora, it is represented in North America by only two genera, the monospecific sweet-fern (*Comptonia peregrina)* in the eastern U.S. and by seven *Myrica* species across the U.S., two of which occur in California: California wax-myrtle (*Myrica californica*), found from Washington state through the Coast Ranges of California, and Sierra sweet bay, which is found only in the central Sierra Nevada (Bornstein 1997). Sierra sweetbay appears to be most closely related to bog myrtle (*Myrica gale*), a circumboreal species whose range extends only as far south as the Cascade Mountains of Washington and Oregon. These two species would likely have diverged as a result of isolation from each other caused by glaciation or volcanic events.

The California Native Plant Society listed Sierra sweet bay on its Inventory of Rare and Endangered Plants in 2010, with an assigned rarity level of 4.3. The 4 indicates 'limited distribution (Watch List)', given because of the restricted area within which this species occurs (El Dorado, Madera, Mariposa, Tuolumne Counties only) and because it has been documented from fewer than ten drainages within that area. The 0.3 indicates 'not very endangered in California', and is given because most known populations receive some sort of protection on public land and those on private land are not threatened by large-scale development. (CNPS 2011)

Sierra sweetbay, along with Indian rhubarb, thrives in a boulder-filled side channel of the South Fork, away from the main current.

Sierra sweetbay lines a straight segment of river at the normal high water line n here.

Two of the known occurrences are partly in Yosemite National Park: 1) the Big Creek population that follows Big Creek from Fish Camp (Sierra National Forest) to its confluence with the South Fork of the Merced River and from there down the South Fork possibly as far as the confluence with the main stem of the Merced River (see Wawona Map and Wawona Campground Map), and 2) the South Fork of the Tuolumne River population that begins some miles upstream of the western park boundary in Yosemite and crosses into the Stanislaus National Forest, continuing downstream for an unknown distance. With these two populations, Yosemite contains a significant portion of the known range and known populations of this species.

Existing Documentation

Sierra sweet bay has been very well documented over time within Yosemite and herbarium records have been made throughout its occurrence on the South Fork of the Merced River (Consortium of California Herbaria 2011). The survey for this species, conducted in July and September 2010, confirmed that it continues to occur in much of its historically documented range, as an intermittent stand consisting of several hundred individuals, along Big Creek from where Big Creek enters the park near the South Entrance Station to the mouth of Big Creek at the Merced River. It continues from this confluence downstream on the South Fork to nearly the park boundary, and possibly occurs beyond the park boundary, although surveys for this study did not include areas outside the park. Sierra sweet bay was not observed to occur on the South Fork of the Merced River upstream of the mouth of Big Creek to the wilderness boundary upstream of Wawona. The lack of its occurrence in this section is possibly due to its not having been able to colonize upstream from Big Creek. The stretch of river upstream of Wawona to the wilderness boundary appears to be similar habitat to that which occurs from the Wawona Campground downstream, yet Sierra sweet bay has not be observed there. The stretch of river in the vicinity of Wawona itself appears

Above right, are female inflorescences, the fruits beginning to ripen in the fall. Below are male catkins, dried up and detached from the plant in early summer after pollen has been released, caught on a branch near a pair immature cone-like female inflorescences. Note differences in leaf shape between these two individuals.

sunnier and sandier than the habitats in which this species is found, so is perhaps not optimal habitat for this species.

In *The Flora of Yo Semite*, Katherine Brandegee states "*Myrica hartwegi*, a rather rare wax-myrtle, though not found in the valley grows on the Merced below it" (Brandegee 1891). This historic report by a respected botanist caused us to survey for this species on the main stem of the Merced River from the lower end of Yosemite Valley to El Portal. However, we did not find Sierra sweet bay in the main stem of the Merced River. It could occur below the confluence of the main stem and with the South Fork at Savage's Trading Post in the Stanislaus National Forest, which would also fulfill the Brandegee location description, but was not surveyed for in that location for this report. Therefore it cannot currently be discerned from historic records as to whether Sierra sweet bay never occurred on the main stem of the Merced River within the park boundary, or was extirpated from that section. Our observations suggest that this species prefers protected banks along third order streams which contain large boulders and shaded shorelines. In contrast, the section of the main stem of the Merced River immediately below Yosemite Valley is high volume, and it fluctuates in flow height a great deal, leaving the shady, boulder-dense banks far from the water's edge in late summer. It appears to not be the preferred habitat for Sierra sweet bay, so if Sierra sweet bay did occur here at one time, it did not likely occur in large numbers.

A hazard tree was felled onto Sierra sweetbay plants. The bushes will likely just grow up around it, unless floods cause scouring to wash individuals away on the upstream side.

Sierra sweetbay is a deciduous (loses its leaves in winter) and dioecious (individual plants are either male or female) summer-flowering shrub. Its flowers are not showy because it is wind-pollinated. Its fruits offer no obvious reward to animals, so are

A Sierra sweetbay was cut away with a machete or axe, presumably by a camper wishing to access the water.

Foot traffic is the major ongoing effect in the vicinity of the Wawona Campground. Other segments of this species' habitat are minimally affected by human traffic. At right, dense footprints texture a sandbar downstream of Wawona Campground, surrounding a patch of small Sierra sweetbay stems.

likely dispersed by physical means, such as water currents. It is strictly riparian, found only along stream and small river borders at the normal high water mark from about 250-1800 m.

Dioecious wind-pollinated species are particularly vulnerable to reproductive problems if populations fall too low. This is because male and female plants must be in sufficient proximity that wind can transport pollen between them. If the distance between males and females is great, or the sex ratio in a given spot is too skewed toward one of the sexes, then the amount of the seed crop will drop. It is clear that within Yosemite, Sierra sweet bay individuals expand vegetatively by spreading underground rootstocks, often developing very large clones (5 meters or more diameter) of a single sex. It is possible that pieces of the roots or stems can function as vegetative propagules when washed downstream, as is the case with willows and poplars, but this is unconfirmed for Sierra sweet bay. During our survey of the Wawona population, we found that there was rough parity between males and females overall in the population, with slight local disparity prevalent. Individual clones, when growing intermixed in a large thicket, could be distinguished from each other by the flower sex and by individual variation in the shape and color of the leaves and the stature of the shrub. Seed set was not assessed.

Current Condition of the Habitat

Big Creek has had a significant portion of its flow diverted upstream from the park, according to the Madera County General Plan, which states:

> Merced River flows in the amount of 6,000-acre feet a year into Lewis Creek, a tributary of the Fresno River. Madera Irrigation District's Big Creek (50 cfs) diversion to Lewis Creek is based on water rights for the Madera Canal and Irrigation Company. The water is diverted December 1st – July 15, beginning with 50 cfs in Big Creek, which is reduced to 20 cfs by April. The diversion is set in November. In dry years, the water is released down Big Creek.

This water diversion has an unknown effect on the Sierra sweet bay, but may be

Bay thrives in close proximity to the campground where the riverside is less attractive to bathers.

neutral or beneficial in that it keeps stream flows more even, reducing flood scour of the creek banks. The specific effects of flooding on habitat or dispersal of Sierra sweet bay have not been studied.

Surveys of Sierra sweetbay in the vicinity of the Wawona Campground revealed a low level of adverse effect from human impact. The most frequent and ongoing impact is foot traffic, as social trails are worn through its habitat along the river, and sandbars attract distributed foot traffic. Other adverse effects observed in September 2010: just downstream of the campground the stems of a Sierra sweetbay individual were cut with a sharp implement. One instance of a hazard tree felled on top of some Sierra sweetbay individuals was also observed. However, these impacts do not sum to a significant adverse effect on the population.

The overall condition of Sierra sweet bay on the South Fork of the Merced River in Yosemite National Park is of a large and thriving population. There is no reason to believe that it has not remained more or less in its natural condition.

Appendix 3

Yosemite Special Status Plants Documented in Merced River Corridor

FAMILY	SCIENTIFIC NAME	STATE STATUS	CNPS STATUS	PARK STATUS
Aristolochiaceae	*Asarum lemmonii*			SSP
Asteraceae	*Eriophyllum congdonii*	Listed	1B	SSP
Asteraceae	*Helianthus californicus*			SSP
Asteraceae	*Hulsea heterochroma*			SSP
Asteraceae	*Senecio clarkianus*			SSP
Asteraceae	*Wyethia elata*		4	SSP
Boraginaceae	*Plagiobothrys torreyi* var. *torreyi*		1B	SSP
Cyperaceae	*Bulbostylis capillaris*		4	SSP
Cyperaceae	*Carex buxbaumii*		4	SSP
Cyperaceae	*Carex canescens*			SSP
Cyperaceae	*Carex fissuricola*			SSP
Cyperaceae	*Carex sartwelliana*			SSP
Cyperaceae	*Carex tompkinsii*		4	SSP
Ericaceae	*Leucothoe davisiae*			SSP
Ericaceae	*Vaccinium parvifolium*			SSP
Fagaceae	*Lithocarpus densiflorus* var. *echinoides*			SSP
Fagaceae	*Quercus lobata*			SSP
Hippuridaceae	*Hippuris vulgaris*			SSP
Hydrophyllaceae	*Phacelia tanacetifolia*			SSP
Isoetaceae	*Isoetes occidentalis*			SSP
Lamiaceae	*Lycopus uniflorus*		4	SSP
Lamiaceae	*Scutellaria bolanderi* ssp. *bolanderi*			SSP
Liliaceae	*Erythronium purpurascens*			SSP
Liliaceae	*Narthecium californicum*			SSP
Liliaceae	*Trillium angustipetalum*			SSP
Myricaceae	*Myrica hartwegii*			SSP
Onagraceae	*Camissonia sierrae* ssp. *alticola*		1B	SSP
Onagraceae	*Camissonia sierrae* ssp. *sierrae*		4	SSP
Orchidaceae	*Cypripedium montanum*		4	SSP
Orchidaceae	*Epipactis gigantea*			SSP
Orchidaceae	*Piperia colemanii*		4	G3

ELEV L	ELEV H	HABITAT TYPE
1100	1900	Shady wet places along creeks, north-facing river banks; Yosemite Valley, Wawona
500	1900	Sunny rockys slopes on metamorphic talus; next to river in El Portal
1600	2000	Meadows, seeps, streambanks, seasonally inundated areas; Wawona
300	2500	Chaparral, openings in yellow pine forest, Yosemite Valley, 5 miles above Nevada Fall
1400	2700	Damp montane meadows; Wawona
1000	1400	Open woodland, forest; Wawona
1200	3400	Moist meadows and flats, forest edges; Yosemite Valley
1000	2000	Meadows and seeps, meadow habitats, vernally moist gravel pans; Yosemite Valley
1200	3300	montane and subalpine fens ; Coastal Prairie, Yellow Pine Forest, Red Fir Forest, Lodgepole Forest, Subalpine Forest, Meadows and seeps , wet conditions in meadow habitats. Yosemite Valley
1000	3200	Lake margins, drainages in wet meadows; historic collection from Clark's Wawona
1500	3500	Meadow slopes and flats, among rocks, wet areas, spray zones; Nevada Falls
1200	2600	Moist forest openings and meadow borders; Wildcat Creek
1200	1800	Canyon slopes and river bottomlands under conifer-oak woodland canopy; El Portal area
1300	2600	Moist, shaded drainage bottoms along creeks and rivers; Yosemite Valley
1400	2500	Moist, shaded drainage bottoms along creeks and rivers; Merced River Wawona area
600	2000	Dry shady forest conditions in slope habitats; Merced River below Yosemite Valley
720		Deep soil on slopes and in valleys. Known from a few majestic specimens in El Portal.
0	2600	Lakes, ponds, springs, rivers. Little Yosemite Valley
1000	2000	Habitat variable, occurs in slope habitats; Bridalveil Falls, Yosemite Valley
1500	2500	Mountain lakes and rivers; In Merced River Little Yosemite Valley
1600	2000	Moist areas, marshes, near springs; Merced River banks from El Portal up
300	2000	Gravelly soils, stream & riverbanks, meadows in oak or pine woodland; Wawona
1500	2700	Open forests, meadows, rocky places; Yosemite Valley - possibly extinct
700	2600	Fens, seeps; occurs under wet conditions by streams and waterfalls; Bridalveil Falls
100	2000	Shaded bottomlands; Wawona, Yosemite Valley
300	1500	Stream and riverbanks; Along Merced below Wawona
2000	2350	On vernally moist gravel and sand pans; Merced Lake
500	1300	Granite gravel seepage areas; Yosemite Valley
200	2200	Deep humus and shade of canyon bottoms; Wawona & below Yosemite Valley
1500	2600	Moist conditions in meadows, streambank habitats & cliff basins; Yosemite Valley
1200	2300	Chaparral, lower montane coniferous forest. Little Yosemite Valley

Yosemite Special Status Plants Documented in Merced River Corridor

FAMILY	SCIENTIFIC NAME	STATE STATUS	CNPS STATUS	PARK STATUS
Poaceae	*Cinna bolanderi*		1B	SSP
Poaceae	*Glyceria borealis*			SSP
Portulacaceae	*Lewisia congdonii*	Listed	1B	SSP
Potamogetonaceae	*Potamogeton epihydrus* ssp. *nuttallii*		2	SSP
Saxifragaceae	*Bolandra californica*		4	SSP
Saxifragaceae	*Saxifraga mertensiana*			SSP
Saxifragaceae	*Saxifraga oregana*			SSP
Scrophulariaceae	*Antirrhinum leptaleum*			SSP
Scrophulariaceae	*Collinsia linearis*			SSP
Scrophulariaceae	*Cordylanthus rigidus* ssp. *brevibracteatus*		4	SSP
Scrophulariaceae	*Lindernia dubia* var. *anagallidea*			SSP
Scrophulariaceae	*Mimulus bicolor*			SSP
Scrophulariaceae	*Mimulus inconspicuus*		4	SSP
Scrophulariaceae	*Mimulus laciniatus*		4	SSP
Scrophulariaceae	*Mimulus pulchellus*		1B	SSP
Scrophulariaceae	*Penstemon azureus* ssp. *angustissimus*			SSP
Scrophulariaceae	*Penstemon heterophyllus* var. *purdyi*			SSP
Staphyleaceae	*Staphylea bolanderi*			SSP
Typhaceae	*Sparganium natans*		4	SSP

ELEV L	ELEV H	HABITAT TYPE
1670	2440	Montane stringer meadows and fens; Wawona & Little Yosemite Valley
800	1250	Marshes and shallow lake borders; Yosemite Valley
500	2800	Lower montane coniferous forest, metamorphic cliffs; El Portal
400	1900	Freshwater marshes, tanks; Yosemite Valley
2000	3000	Lower and upper montane coniferous forest, mesic, rocky shaded places; Lyell Fork Merced River
1000	2500	Mossy rocks, cliffs; Yosemite Valley
150	2500	Meadows and seeps; occurs under wet conditions in meadow habitats; Yosemite Valley & Little Yosemite Valley
300	2100	Small washes, shallow ditches, disturbed areas, in foothill woodland, yellow pine forest; historic collection from Wawona
200	2000	Rocky, metamorphic substrates of broad-leaved upland forest, chaparral, cismontane woodland; El Portal & Wawona
1100	2500	North side Yosemite Valley, dry sandy roadside full sun, 1 mi E Cascade Creek Sharsmith 6465 8 Sept 1957
500	1600	Exposed margins of lakes and ponds, mudflats; Yosemite Valley
360	2100	Occurs under vernally moist conditions; usually in nonwetlands, but occasionally found on wetlands & river bottomlands; Wawona
160	2000	Chaparral, cismontane woodland, lower montane coniferous forest, mesic, shady areas; mouth of Moss Creek
900	2000	Chaparral, lower and upper montane coniferous forest, mesic areas of granitic substrate, vernally moist seepage areas; Yosemite Valley
600	2000	Lower montane coniferous forest, vernally mesic meadows; Yosemite Valley
300	700	Chaparral, Yellow Pine Forest, Sagebrush Scrub, Foothill Woodland;occurrs under dry conditions in slope habitats. Yosemite Valley.
50	1600	Chaparral, Foothill Woodland, Yellow Pine Forest; occurs under dry conditions in slope habitats. Yosemite Valley
300	1400	Chaparral, Foothill Woodland, Yellow Pine Forest; occurs in shaded canyon habitats; Merced River Canyon in El Portal
2000	2500	Freshwater wetlands, in lake-margin and edge habitats, tanks in meadows; tributaries of Merced River

Appendix 4

Plant List for Wawona Golf Course

Family	Scientific Name	Common Name
Apiaceae	*Anthriscus caucalis*	bur-chervil
Apiaceae	*Heracleum lanatum*	cow parsnip
Apiaceae	*Osmorhiza chilensis*	mountain sweet-cicely
Apiaceae	*Sanicula crassicaulis*	Pacific sanicle
Apiaceae	*Torilis nodosa*	knotted hedge-parsley
Aristolochiaceae	*Asarum hartwegii*	Hartweg's wild-ginger
Asteraceae	*Adenocaulon bicolor*	American trailplant
Asteraceae	*Antennaria argentea*	silvery everlasting
Asteraceae	*Artemisia douglasiana*	mugwort
Asteraceae	*Bellis perennis*	English daisy
Asteraceae	*Chrysothamnus nauseosus* ssp. *albicaulis*	white-stemmed common rabbitbrush
Asteraceae	*Cirsium andersonii*	Anderson's thistle
Asteraceae	*Cirsium vulgare*	bull thistle
Asteraceae	*Crepis capillaris*	smooth hawksbeard
Asteraceae	*Hieracium albiflorum*	white hawkweed
Asteraceae	*Hypochaeris glabra*	smooth cat's ear
Asteraceae	*Lactuca serriola*	prickly lettuce
Asteraceae	*Senecio triangularis*	arrowhead butterweed
Asteraceae	*Solidago canadensis* ssp. *elongata*	Canada goldenrod
Asteraceae	*Solidago* sp.	unknown goldenrod
Asteraceae	*Sonchus asper* ssp. *asper*	prickly sow thistle
Asteraceae	*Taraxacum officinale*	common dandelion
Asteraceae	*Tragopogon dubius*	yellow salsify
Asteraceae	*Wyethia angustifolia*	narrow-leaved mule-ears
Asteraceae	*Wyethia helenioides*	whitehead wyethia
Betulaceae	*Alnus rhombifolia*	white alder
Boraginaceae	*Myosotis micrantha*	small-flowered forget-me-not
Boraginaceae	*Plagiobothrys torreyi* var. *torreyi*	Torrey's popcorn flower
Brassicaceae	*Capsella bursa-pastoris*	shepherd's purse
Brassicaceae	*Rorippa nasturtium-aquaticum*	water cress
Campanulaceae	*Heterocodon rariflorum*	few-flowered heterocodon
Caprifoliaceae	*Sambucus mexicana*	blue elderberry
Caryophyllaceae	*Cerastium arvense*	field chickweed
Caryophyllaceae	*Cerastium glomeratum*	mouse-ear chickweed
Caryophyllaceae	*Herniaria hirsuta* ssp. *cinerea*	grey herniaria
Caryophyllaceae	*Stellaria longipes* var. *longipes*	meadow starwort

Life Form	Native?
Annual herb	Non-native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Annual herb	Non-native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Non-native
Shrub	Native
Perennial herb	Native
Perennial herb	Non-native
Perennial herb	Non-native
Perennial herb	Native
Annual herb	Non-native
Annual herb	Non-native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Non-native
Annual herb	Non-native
Perennial herb	Non-native
Perennial herb	Non-native
Perennial herb	Native
Perennial herb	Native
Tree	Native
Annual herb	Non-native
Annual herb	Native
Annual herb	Non-native
Perennial herb (aquatic)	Native
Annual herb	Native
Tree, Shrub	Native
Perennial herb	Native
Annual herb	Non-native
Annual herb	Non-native
Perennial herb	Native

Plant List for Wawona Golf Course

Family	Scientific Name	Common Name
Chenopodiaceae	*Chenopodium album*	white goosefoot
Cornaceae	*Cornus sericea* ssp. *sericea*	red osier dogwood
Cupressaceae	*Calocedrus decurrens*	incense cedar
Cyperaceae	*Carex amplifolia*	big-leaf sedge
Cyperaceae	*Carex bolanderi*	Bolander's sedge
Cyperaceae	*Carex mariposana*	Mariposa sedge
Cyperaceae	*Carex nudata*	torrent sedge
Cyperaceae	*Carex senta*	swamp sedge
Dennstaedtiaceae	*Pteridium aquilinum* var. *pubescens*	bracken
Dryopteridaceae	*Athyrium filix-femina* var. *cyclosorum*	subarctic lady-fern
Dryopteridaceae	*Cystopteris fragilis*	brittle bladder fern
Equisetaceae	*Equisetum arvense*	field horsetail
Ericaceae	*Arctostaphylos viscida* ssp. *mariposa*	Mariposa manzanita
Fabaceae	*Lathyrus latifolius*	perennial sweet pea
Fabaceae	*Lathyrus nevadensis* var. *nevadensis*	Sierra Nevada pea
Fabaceae	*Lathyrus sulphureus*	Brewer's pea
Fabaceae	*Lotus purshianus* var. *purshianus*	Spanish clover
Fabaceae	*Lupinus bicolor*	miniature lupine
Fabaceae	*Lupinus latifolius*	broad-leaf lupine
Fabaceae	*Lupinus polyphyllus*	meadow-lupine
Fabaceae	*Trifolium breweri*	Brewer's clover
Fabaceae	*Trifolium dubium*	shamrock
Fabaceae	*Trifolium pratense*	red clover
Fabaceae	*Trifolium wormskioldii*	cows clover
Fabaceae	*Vicia americana* var. *americana*	American vetch
Geraniaceae	*Erodium cicutarium*	red-stemmed filaree
Grossulariaceae	*Ribes roezlii var. roezlii*	Sierra gooseberry
Hydrophyllaceae	*Nemophila menziesii*	baby blue eyes
Hydrophyllaceae	*Nemophila parviflora* var. *parviflora*	small-flowered nemophila
Hypericaceae	*Hypericum formosum* var. *scouleri*	Scouler's St. Johnswort
Iridaceae	*Iris missouriensis*	western blue flag
Juncaceae	*Juncus bufonius*	toad rush
Juncaceae	*Juncus effusus* var. *exiguus*	common bog rush
Juncaceae	*Luzula comosa*	hairy wood rush
Lamiaceae	*Mentha spicata* var. *spicata*	spearmint
Lamiaceae	*Nepeta cataria*	catnip
Lamiaceae	*Stachys albens*	cobwebby hedge-nettle
Liliaceae	*Chlorogalum pomeridianum* var. *pomeridianum*	common soaproot

Life Form	Native?
Annual herb	Non-native
Shrub	Native
Tree	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Tree, Shrub	Native
Perennial herb	Non-native
Perennial herb	Native
Perennial herb	Native
Annual herb	Native
Annual herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Annual herb	Non-native
Perennial herb	Non-native
Perennial herb	Native
Perennial herb	Native
Annual herb	Non-native
Shrub	Native
Annual herb	Native
Annual herb	Native
Perennial herb	Native
Perennial herb	Native
Annual herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Non-native
Perennial herb	Non-native
Perennial herb	Native
Perennial herb	Native

Plant List for Wawona Golf Course

Family	Scientific Name	Common Name
Liliaceae	*Dichelostemma multiflorum*	wild hyacinth
Liliaceae	*Smilacina racemosa*	large false-solomon's-seal
Liliaceae	*Trillium angustipetalum*	narrow-petaled wakerobin
Liliaceae	*Triteleia ixioides*	pretty face
Liliaceae	*Veratrum californicum* var. *californicum*	California corn lily
Malvaceae	*Sidalcea glaucescens*	waxy checkermallow
Onagraceae	*Circaea alpina* ssp. *pacifica*	Pacific enchanter's nightshade
Onagraceae	*Epilobium glaberrimum* ssp. *glaberrimum*	smooth willowherb
Orchidaceae	*Goodyera oblongifolia*	rattlesnake plantain
Oxalidaceae	*Oxalis albicans* ssp. *pilosa*	radish-root woodsorrel
Pinaceae	*Pinus ponderosa*	ponderosa pine
Plantaginaceae	*Plantago lanceolata*	English plantain
Poaceae	*Achnatherum lemmonii*	Lemmon's needlegrass
Poaceae	*Aira caryophyllea*	silver hairgrass
Poaceae	*Bromus diandrus*	ripgut brome
Poaceae	*Bromus tectorum*	cheatgrass
Poaceae	*Calamagrostis canadensis*	Canada reedgrass
Poaceae	*Cynodon dactylon*	bermuda grass
Poaceae	*Dactylis glomerata*	orchard-grass
Poaceae	*Elymus glaucus*	blue wildrye
Poaceae	*Festuca occidentalis*	western fescue
Poaceae	*Festuca rubra*	red fescue
Poaceae	*Glyceria elata*	tall mannagrass
Poaceae	*Lolium perenne*	English rye-grass
Poaceae	*Poa annua*	annual blue grass
Poaceae	*Poa pratensis*	Kentucky blue grass
Poaceae	*Poa palustris*	fowl blue grass
Poaceae	*Vulpia myuros* var. *myuros*	rattail fescue
Polemoniaceae	*Linanthus ciliatus*	whisker-brush
Polemoniaceae	*Navarretia divaricata* ssp. *divaricata*	mountain navarretia
Polemoniaceae	*Phlox gracilis*	annual phlox
Polygonaceae	*Polygonum bistortoides*	western bistort
Polygonaceae	*Rumex acetosella*	common sheep sorrel
Polygonaceae	*Rumex crispus*	curly dock
Ranunculaceae	*Actaea rubra*	red baneberry
Ranunculaceae	*Aquilegia formosa*	western columbine
Ranunculaceae	*Delphinium gypsophilum*	gypsum-loving larkspur
Ranunculaceae	*Ranunculus occidentalis*	western buttercup
Ranunculaceae	*Ranunculus orthorhynchus*	straight-beaked buttercup

Life Form	Native?
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Tree	Native
Perennial herb	Non-native
Perennial herb	Native
Annual herb	Non-native
Annual herb	Non-native
Annual herb	Non-native
Perennial herb	Native
Perennial herb	Non-native
Perennial herb	Non-native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Non-native
Annual herb	Non-native
Perennial herb	Non-native
Perennial herb	Non-native
Annual herb	Non-native
Annual herb	Native
Annual herb	Native
Annual herb	Native
Perennial herb	Native
Perennial herb	Non-native
Perennial herb	Non-native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native

Plant List for Wawona Golf Course

Family	Scientific Name	Common Name
Rhamnaceae	*Ceanothus integerrimus* var. *integerrimus*	deer brush
Rosaceae	*Fragaria virginiana*	mountain strawberry
Rosaceae	*Geum macrophyllum*	large-leaf avens
Rosaceae	*Horkelia tridentata* ssp. *tridentata*	three-toothed horkelia
Rosaceae	*Malus sylvestris*	domestic apple
Rosaceae	*Potentilla glandulosa*	gland cinquefoil
Rosaceae	*Prunus persica*	peach
Rosaceae	*Prunus virginiana*	black cherry
Rosaceae	*Rubus discolor*	Himalaya-berry
Rosaceae	*Rubus laciniatus*	cut-leaved blackberry
Rubiaceae	*Galium aparine*	common bedstraw
Rubiaceae	*Galium bolanderi*	Bolander's bedstraw
Rubiaceae	*Galium triflorum*	sweet-scented bedstraw
Rubiaceae	*Kelloggia galioides*	kelloggia
Salicaceae	*Populus balsamifera* ssp. *trichocarpa*	black cottonwood
Salicaceae	*Salix lasiolepis*	arroyo willow
Salicaceae	*Salix lucida* ssp. *lasiandra*	shining willow
Scrophulariaceae	*Digitalis purpurea*	purple foxglove
Scrophulariaceae	*Mimulus bicolor*	yellow and white monkeyflower
Scrophulariaceae	*Mimulus guttatus*	common yellow monkeyflower
Scrophulariaceae	*Mimulus torreyi*	Torrey's monkeyflower
Scrophulariaceae	*Veronica americana*	American speedwell
Scrophulariaceae	*Veronica arvensis*	corn speedwell
Taxodiaceae	*Sequoiadendron giganteum*	giant sequoia
Violaceae	*Viola glabella*	pioneer violet
Violaceae	*Viola purpurea* ssp. *quercetorum*	goosefoot yellow violet

Life Form	Native?
Shrub	Native
Perennial herb	Native
Perennial herb	Native
Perennial herb	Native
Tree	Non-native
Perennial herb	Native
Tree	Non-native
Tree	Native
Shrub	Non-native
Shrub	Non-native
Annual herb	Native
Perennial herb	Native
Annual herb	Native
Perennial herb	Native
Tree	Native
Tree, Shrub	Native
Tree	Native
Perennial herb	Non-native
Annual herb	Native
Perennial herb	Native
Annual herb	Native
Perennial herb	Native
Annual herb	Non-native
Tree	Native
Perennial herb	Native
Perennial herb	Native


NATIONAL
PARK
SERVICE