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Vascular Plant Inventory for Yosemite National Park

Natural Resource Technical Report NPS/SIEN/NRTR—2011/427

ON THE COVER
View south from Mt. Hoffman (upper left); the Sierra Nevada crest, view south from Virginia Peak (upper right); upper Mariposa Grove of giant sequoias (lower left); Alison E.L. Colwell, Lost Lake, Yosemite National Park.
Photographs by: Peggy E. Moore

Vascular Plant Inventory for Yosemite National Park, California

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Executive Summary

This report describes the contents of a database documenting vascular plant diversity in Yosemite National Park, California. It summarizes the approach used to assemble information and populate the database, describes patterns in the resulting data, and places the park's flora in a regional and state-wide context.

The database, entitled NPSpecies, is the data structure developed by the National Park Service (NPS) Inventory and Monitoring (I&M) program for storing information on the biological diversity within U.S. national parks. It is currently populated with data on vertebrate animals and vascular plants in parks with significant natural resources but is designed to manage species information for all biological taxa for all units of the national park system. For each species in a park's set of records, the database has information on documented occurrence in the park, scientific name, common name, abundance, native status, listing status under the Endangered Species Act, and whether a species is of particular management interest.

The primary purpose of the NPSpecies database is to provide park managers, scientists, educators, and others with information on species occurrence and status within their respective parks to support planning, management, research, and education for the long-term protection of park ecosystems. Populating this database with accurate, well-documented records of vertebrate animals and vascular plants was an important component of the biological inventory phase of the NPS I&M program.

We acquired 15,381 records of existing herbarium specimens documenting 1,545 vascular plant taxa that occur in Yosemite National Park. New field surveys and collecting efforts between 2003 and 2007 added 1,697 herbarium specimens and 27 taxa to the vascular plant list for the park for a total of 1,572 taxa now documented from Yosemite.

The greatest diversity in the vascular flora of Yosemite National Park is among the dicots. There is low diversity among the ferns and their allies, but high conifer diversity. The 171 non-native species are exclusively among the flowering plants and are concentrated among the dicots. The most species-rich families among native and non-native taxa are the sunflower (Asteraceae) and grass (Poaceae) families.

Although there are no federally listed species known to occur within the jurisdiction of Yosemite National Park, 71 taxa have conservation listing status with a government agency and/or the California Native Plant Society. Four of them are listed by the State of California as rare.

Knowledge of the vascular flora of Yosemite is well developed but still not complete. Surveys continue to add taxa to the park list, our understanding of species distributions is still incomplete, and new collections sometimes represent even state records. Occurrence information in Botti (2001) added 134 taxa to the Yosemite National Park species list beyond those we know are documented with herbarium specimens. Among the occurrence records based only on this and other published sources, 29 taxa have been vouchered in the last six years. With more focused efforts, many of these unvouchered taxa could be collected and added to permanent repositories.

The Yosemite flora represents 22% of the species reported for California as of 1993. The flora is comparable to that of Sequoia and Kings Canyon National Parks to the south in the Sierra Nevada, but there are surprising differences. The two areas share 1,168 species and 432 genera in common, but Sequoia and Kings Canyon have 94 genera not documented from Yosemite, and Yosemite has 56 genera not documented from the southern Sierra Nevada parks.

The combination of existing records and recent collecting efforts has brought the proportion of the voucher record dating from the last 40 years to 14%, reflecting the age of most records. Additional plant collecting efforts will be important for new species discoveries, filling gaps in our understanding of species distributions, documenting and preventing extinctions (through conservation planning), and tracking and predicting range expansions and contractions.

Among the most useful aspects of the NPSpecies database on the vascular flora of Yosemite are 1) provision of a species list and evidence supporting each taxon in a shared, accessible format and 2) making accessible the geographic distribution of known specimens using collection localities and, where available, geographic coordinates that can link to mapping products. The work to populate NPSpecies with vascular plant records for Yosemite marks the first time a plant species list has been available for Yosemite National Park to support resources management staff, interpretation and education staff, researchers, and the general public. Among the limitations of NPSpecies is the lack of data by species on group membership (e.g., fern, gymnosperm, monocot angiosperm, dicot angiosperm), life form (e.g., tree, shrub, graminoid), duration (e.g., annual, biennial, perennial), or species origin (e.g., locally endemic, regionally endemic, Nearctic origin, Palearctic origin, etc.). As a result, this type of information must be sought from external sources such as the USDA PLANTS database.

To maintain the usefulness of the database, the National Park Service could establish a protocol for supplementing the data with additional specimens and new published treatments. Among the highest priorities for vouchering are new park records, published but unvouchered taxa, and those that expand the known geographic distribution of species within the park. The nomenclatural standard used for Yosemite National Park, *The Jepson Manual: Higher Plants of California*, is under extensive revision, and there will be an opportunity to update the taxonomy for the park's records once it is published.

Enumerating the vascular flora of a large, complex, and diverse national park is the first step in assessing biological diversity, establishing a baseline to monitor for change, and informing all other efforts that use vascular plant data in protected area management and research. Maintenance of the NPSpecies database will serve all of these needs in multiple ways.

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Dr. Alison E. L. Colwell, U.S. Geological Survey (USGS) and now National Park Service botanist, enthusiastically pursued Yosemite's rarest and heretofore undocumented species from near and far, however remote, hot, high, mucky, steep, or submerged. Dr. Dean Wm. Taylor, the foremost authority on the flora of the central Sierra Nevada, shared his data, knowledge, and insights and brought several issues to Dr. Colwell's attention during her botanical surveys. This directly resulted in several additions to the park flora. The Environmental Careers Organization and the Student Conservation Association provided data and field support, respectively, during data mining and data development phases. Erik Frenzel assisted in quality control and populating portions of the NPSpecies database for Yosemite. Miriam Luchans, Registrar at Yosemite National Park, worked with USGS staff to accession new collections into the National Park Service museum at Yosemite so they could be included in the biodiversity database. Alison Loar and Michelle Flenner, NPS biodiversity database specialists, and the other cooperators at Colorado State University were supportive and efficient in processing data uploads and updates to NPSpecies vascular plant records for Yosemite. The National Park Service Sierra Nevada Network Inventory and Monitoring program funded the Environmental Careers Organization Associate who conducted data mining for vouchers in various herbaria and cost-shared the 2003–2004 rare plant surveys with the USGS Western Ecological Research Center Yosemite Field Station. The Yosemite Fund supported rare plant surveys in selected habitats in 2005 and 2007 resulting in new park, county, and state records that improved our understanding of Yosemite's biotic diversity. The Fund's support also provided for expanding the geographic coverage of the botanical record for Yosemite, adding invaluably to our knowledge of Yosemite plant life. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

1. Introduction

The National Park Service (NPS) established the Inventory and Monitoring (I&M) program in 1992 to provide funding, technical assistance, and coordination for more than 270 parks to complete basic natural resource inventories and to monitor the status and trends of park natural resources. The primary purpose of natural resource inventories is to document the presence of resources in parks, and to assess and document the current condition and knowledge of natural resources in the parks (National Park Service 2009). Beginning in 2000 as part of the Natural Resource Challenge, Congress greatly increased the funding for the NPS I&M Program to accelerate the development and delivery of the basic inventories and to design and implement long-term ecological monitoring programs. Through the Challenge, parks were organized into 32 Inventory and Monitoring Networks where I&M programs are developed and implemented collaboratively among multiple parks.

The Sierra Nevada Network, which comprises Devils Postpile National Monument, Sequoia and Kings Canyon National Parks, and Yosemite National Park in California, identified a number of high-priority inventories in its Biological Inventory Plan (NPS 2001). Since the larger Sierra Nevada Network (SIEN) parks already had substantial existing baseline data, these I&M-funded inventory efforts focused on documenting collections in key herbaria and museums, providing more information on the distribution and abundance of special status or poorly documented taxa, and doing basic inventories for Devils Postpile National Monument. Plant inventories for Yosemite National Park included special status plants (Moore et al. 2005, Colwell et al. 2007) and non-native plants (Klinger and Underwood 2002, Klinger et al. 2006, Kane et al. 2006), and documentation of plant vouchers in key outside institutions. While the I&M program inventories and other recently funded inventories targeted important gaps in Yosemite National Park's natural resource information, most of the data documenting plants in the park come from earlier inventory and research projects.

An important component of the biological inventories was the compilation of species lists and evidence records for vertebrate animals and vascular plants in parks and making those data available through the NPSpecies database, the NPS data structure for storing information on the biological diversity within U.S. national parks. NPSpecies data are served through the NPS Natural Resource Information Portal (http://science.nature.nps.gov/im/datamgmt/IRMA.cfm). NPSpecies is currently populated with data on vertebrate animals and vascular plants in parks with significant natural resources but is designed to manage species information for all biological taxa for all units of the national park system. For each species in a park's set of records, the database has information on documented occurrence in the park, scientific name, common name, abundance, native status, listing status under the Endangered Species Act, and whether a species is of particular management interest (e.g., due to invasiveness, listing status with the state, global or regional rarity). Within the NPSpecies data structure, each species record is supported by evidence in the form of herbarium specimens, references (scientific publications or data sets), and/or observation records that document the occurrence of the species in a park.

The primary purpose of the NPSpecies database is to provide park managers, scientists, educators, and others with information on species occurrence and status within their respective parks to support planning, management, research, and education for the long-term protection of

park ecosystems. Historical and currently accepted scientific names from multiple taxonomic classification systems are cross-referenced within the database using taxonomic standards (e.g., the Integrated Taxonomic Information System [USDA 2009a] and the USDA PLANTS [USDA 2009b] databases) to allow for data integration and sharing across parks and with other agencies and organizations. In addition, parks are able to produce species lists based on the taxonomic authorities that are most accepted in their region and by their partner agencies.

This report describes the contents of the NPSpecies database that documents vascular plant diversity in Yosemite National Park (Yosemite). It summarizes the approach used to assemble information and populate the database, describes patterns in the resulting data, and places the park's flora in a regional and state-wide context.

1.1. Vascular Plant Database for Yosemite National Park

In 2002, the SIEN I&M program funded a data mining effort to gather various forms of evidence with the aim of compiling a vascular plant species list for Yosemite National Park in an updatable database format. Our goals for populating the NPSpecies database with vascular plant data for Yosemite National Park were to:

1) Assemble representative records on herbarium specimens to document the flora
2) Augment specimen records with published accounts of species occurrence
3) Attribute each taxon in the resulting species list with park status, abundance within the park, native status, management priority, and, for non-native species, their status as invasive species

We began the effort to populate the NPSpecies database for Yosemite vascular plants in late 2002 and completed a final version in early 2008. That version included records on herbarium specimens collected in the park through 2005. We then updated the vascular plant data in 2009 with herbarium records of 2006 and 2007 collections.

1.2. Background and Justification

The U.S. national park system protects a broad representation of ecosystems across the country. As a result, national parks play an important role in protecting North American biotic diversity and ecosystem function. That protection makes it incumbent upon the NPS to have a thorough knowledge of the resources within its jurisdiction. However, historically, there has been a paucity of systematic inventories for even major plant and animal groups (Stohlgren et al. 1994). With the pervasive threats of invasive species, contaminants, and climate change, among others, it is increasingly important for national parks to have detailed resource information to monitor for change in ecosystem diversity, structure, and function and to plan for resilience in the face of these threats.

To address the lack of information, the U.S. Congress passed the National Parks Omnibus Management Act in 1998, funding basic natural resource inventories at the more than 270 national park units with significant natural resources. Among the inventories identified, the initial emphasis among biotic inventories was on vertebrates and vascular plants.

The initial step toward these basic inventories was an assessment of whether 90% of vertebrates and vascular plants expected to occur in each park was documented through acceptable lines of

evidence. Acceptable evidence included museum vouchers, published sources, and observation data from reputable sources. The results of these assessments triggered either basic inventory efforts or status assessments for species of special management concern (i.e., rare or exotic taxa). In parallel, parks populated the NPS biodiversity database (NPSpecies) with either existing records documenting species occurrence in parks or results of new inventory efforts. For Yosemite, we concluded evidence was available for 90% of the expected vascular plant taxa, proceeded with its compilation, and set about determining the status of the park's rare plants.

1.2.1. Previous Efforts

The earliest effort to catalog the plants of Yosemite National Park was by Katherine Brandegee, curator of the herbarium at the California Academy of Sciences, San Francisco, and one of the leading authorities at the time on California plants. She summarized a growing species catalog in the journal Zoe in 1891, describing approximately 215 species of trees, shrubs and flowering herbs represented in collections and locations and habitats where those species could be found. *A Yosemite Flora* by Harvey Monroe Hall and Carlotta Case Hall (1912) was a more comprehensive treatment, providing keys and descriptions for 955 vascular plant taxa, omitting only grasses, sedges, and rushes. Their catalog was based on their own extensive observations and collections and on herbarium holdings at the University of California, Berkeley, which included the specimens of such ardent collectors as L. Abrams, K. Brandegee, W. L. Jepson, and J. W. Congdon. They estimated the flowering plants and ferns of Yosemite to number at least 1,200 once the graminoids were included, and they felt any additions were likely to be limited in number and to originate at the lowest foothill or highest alpine elevations. John Thomas Howell of the California Academy of Sciences collected widely throughout the Sierra Nevada for 25 years with the intention of writing a definitive flora of the range (Smith 1989). Howell was a prolific publisher and mentor, but did not manage to accomplish this enormous task.

In spite of these various efforts, there was no comprehensive vascular plant species list for Yosemite National Park prior to 2001 when Stephen Botti completed a comprehensive flora for the park (Botti 2001). He provided keys and species descriptions for 1,427 taxa together with illustrations by Walter Sydoriak, Lesley Randall, and Katherine Hocker to assist in identification. Though thorough and informative, this publication did not provide the park with an updatable species list corroborated by plant voucher information. For over a decade, Dean Wm. Taylor has been developing a meticulous flora of the area in and around Yosemite that documents, through specimen records, the flora of the central Sierra Nevada in Tuolumne, Mariposa, Madera, and Mono counties. When published, this much-anticipated flora will reflect the most recent taxonomic treatments and will be painstaking in its thoroughness. In a complementary way, the NPSpecies database, informed by historic collecting efforts and recent floras, will provide the most concise and accessible species accounting for the park. It is in an easily updatable format, and the species list is linked with collection details and other evidence supporting each entry.

2. Study Area

Yosemite National Park is a 302,768 ha (748,156 acres) natural reserve located in the central Sierra Nevada of California (Figure 1). It ranges in elevation from 640 m (2,100 ft) in the Merced River canyon west of Yosemite Valley to nearly 4,000 m (13,114 ft) at the summit of Mt. Lyell. The park comprises two major watersheds, the Merced River in the south and the Tuolumne River in the north, and completely encompasses the headwaters of each.

2.1. Climate and Geology

Yosemite lies in a Mediterranean-type climate region with warm, dry summers and cool to cold moist winters. The mean minimum temperature in January at Yosemite Valley (1,220 m [4,000 ft] elevation) is -2° C (28° F); the mean maximum in July is 32° C (90° F; Western Regional Climate Center 2009). Precipitation is concentrated in the winter months from October to March with an average total annual precipitation of 95 cm (37.4 in) at Yosemite Valley. Precipitation distribution varies from west to east but can increase with elevation as much as 30 times the lowest elevations due to orographic lift (Dettinger et al. 2004).

During orogenic uplift of the Sierra Nevada, river gradients steepened creating deeply incised river canyons on both the western and eastern slopes (Huber 1981). Subsequent glaciation during the Pleistocene broadened some valleys and further shaped the landscape seen today (Huber 1987). Approximately 64% of the park was glaciated in the most recent glaciation that peaked approximately 20,000 years ago (Alpha et al. 1987; G. Stock, National Park Service, personal communication).

The park lies entirely on the relatively gentle western slope of the Sierra Nevada, the crest of the range defining the eastern park boundary and the beginning of the steep eastern escarpment. Yosemite is famous for massive granitic walls and domes, and granitic rock dominates park geology. The erosional processes that formed the deeply incised landscape also removed 95% of metamorphic rock that once overlaid the intruding plutonic rock (Huber 1987). The result is a sparse, scattered distribution of metamorphics within the park that comprises less than 1.2% of the park area in approximately 10 contiguous or nearly contiguous features. The remaining metamorphics are concentrated along the western boundary in the foothills and along

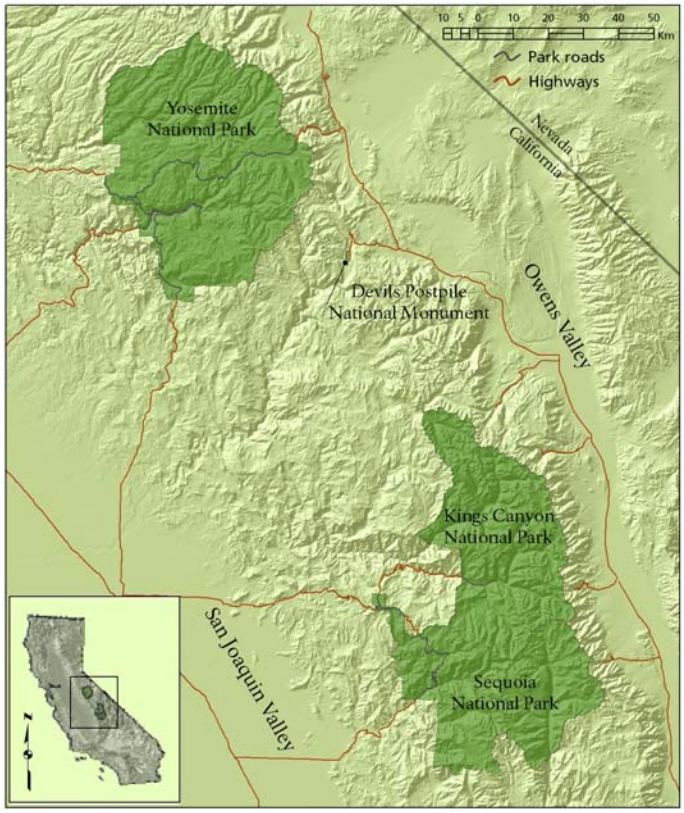

Figure 1. Yosemite National Park location in the central Sierra Nevada, California.

the southeastern and eastern boundaries along the crest (Huber et al. 1989). Metamorphics along the western boundary are largely sedimentary in origin, while the eastern belt is composed of both metasedimentary and metavolcanic rock. Volcanic rock is even less common with Rancheria Mountain (and smaller points north and west), Little Devil's Postpile west of Tuolumne Meadows, and the south side of Merced Pass being notable features (Huber et al. 1989).

2.2. Soils

Entisols (new, undeveloped soils) and Inceptisols (young, slightly developed soils) dominate park soils, particularly at higher elevations, but some Alfisols (high-nutrient soils commonly associated with forests) and Ultisols (old, acidic, heavily leached, low-nutrient soils) have formed at lower elevations along the park's western boundary (U. S. Department of Agriculture 2007). This is probably due to warmer climate, longer weathering, and more mafic rock types at the lower elevations. In spite of extensive glacial activity, most soils are moderately deep to very deep. Soil temperature regimes range from thermic to cryic, decreasing the rate of soil development with increasing elevation. Due to cold temperatures, dry summers and the character of the dominant granitic parent materials, most park soils tend to be coarse textured and weakly developed (Taskey et al. 2009). They generally have a high rock fragment content, low water holding capacity, and low nutrient status. Important exceptions are the soils of wetland meadows (< 3% of the park) which tend to be very deep, well stratified, relatively free of rock fragments, and rich in organic matter (Taskey et al. 2009). At higher elevations (i.e., above 2,300 m [7,500 ft]), non-meadow soils tend to be acidic and have low clay content; at lower elevations and in soils derived from metamorphics, these characteristics vary.

2.3. Vegetation

Two-thirds of Yosemite lies between 2,100 m and 3,050 m (6,890 and 10,000 ft) elevation where the vegetation is predominantly mixed coniferous, montane, and subalpine forests. These forests, as well as lower elevation pine and oak woodlands, are interrupted by sparsely vegetated bedrock slopes and domes, reflecting widespread glacial influence on the landscape.

A total of 215 different plant associations currently are recognized for the park and adjacent areas, 114 at the dominant species or alliance level of classification (Keeler-Wolf et al. 2007). These include an annual grass association in the foothills, montane chaparral types, towering forests of pines and other conifers in the montane zone, extensive upper montane fir and subalpine pine forests, and diminutive cushion plants in the alpine.

3. Methods

We made the decision to emphasize herbarium specimens from the park as the core evidence of park occurrence and to supplement those, where necessary, with published (but unvouchered) occurrences for documenting a vascular plant species list for Yosemite National Park. We did not use unvouchered observation records, the third line of evidence accepted in the NPSpecies database, as the basis for inclusion of a species. This was mainly because relying on specimens and published occurrences would create a list based on evidence that could be revisited and verified. The decision was influenced also by the complexity of the flora, by the complexity of park topography, and by the availability of abundant specimens residing at local and regional herbaria. The complexity of the flora, with taxa numbering over 1,500, made it inevitable that many questions would arise related to taxonomy. The complexity of the topography might bring into question whether particular collection localities fell within the park. Relying on specimen records would provide the opportunity to revisit collection records and specimens as needed to verify collection localities and species determinations.

There are two primary data tables in NPSpecies (which was migrated in 2010 to the NPS Natural Resource Information Portal [NRInfo]) that comprise the key input regarding herbarium records and the species list resulting from all forms of evidence. They are the vouchers table for storing herbarium specimen record information and the species list table for storing the park species list, evidence of occurrence, and status information. We focused on these two tables in compiling the initial set of data to be imported to the database. Secondarily, we populated the data table that stores published sources of park occurrence information.

The most recent state wide nomenclatural standard for California, *The Jepson Manual: Higher Plants of California* (Hickman 1993) is undergoing extensive revision with taxonomic updates according to the latest published work prior to publication of a second edition. Portions of the revision are complete and posted on The Jepson Herbarium web site, portions are in draft, and portions are not yet available. As a result, we used the first edition as the nomenclatural standard for vascular plants in the NPSpecies database.

3.1. Existing Data

3.1.1. Herbarium Records

The greatest resource for assembling a documented list of vascular plant taxa occurring in Yosemite National Park was herbarium specimens residing at local and regional herbaria. We queried electronic databases of institutions with the largest holdings from Yosemite using place names and jurisdictional search terms. These were the databases of University and Jepson Herbaria at University of California, Berkeley; Carl W. Sharsmith Herbarium at San Jose State University; and the National Park Service herbarium at the Yosemite Museum. We filtered the resulting records to limit them to localities within the park or the El Portal Administrative Site, and we filtered records for determinations sufficiently complete to document species occurrence and report it in the current nomenclatural standard for California (Hickman 1993). Within the structure of the NPSpecies database, we cross referenced this nomenclature with the standard for the NPS Inventory and Monitoring program, the Integrated Taxonomic Information System (ITIS 2005–2009).

To supplement specimen records we derived from database queries, we obtained information directly from specimen labels at institutions where collections were not yet stored in electronic format. Most importantly, this included holdings at the California Academy of Sciences (CAS) where we sought vouchers for taxa otherwise documented only in published work (i.e., Botti 2001).

We formatted the resulting herbarium specimen records for the NPSpecies vouchers table. We populated each voucher specimen record with information on park of origin (YOSE in the case of each Yosemite National Park specimen), collector, collection date, collection locality, specimen repository, institutional specimen identification number, and, where available, habitat, elevation, and location coordinates. Under the guidance of NPS botanists, we assigned a sensitivity level to records, designating voucher data availability to individual park staff only, to National Park Service staff only, or to the public. Criteria for limiting population location information to NPS staff were factors making species vulnerable to collection (e.g., rarity; large, showy flowers).

3.1.2. Checklist Fields

From the vouchers table, we extracted unique taxa to assemble a species list for the park and populate the species list table. Within this table for each taxon, we populated attributes in the checklist fields (*Park Status*, *Abundance* within the park, *Native* status, and *Cultivation*) and the management fields. For non-native taxa, management fields include *Weedy* behavior and *Pest* status; for both native and non-native taxa, management fields include *Management Priority*. A final management field for native taxa only indicates whether there is concern over potential exploitation. Standard entries for each of these fields and their definitions are available in Appendix A.

We populated the *Park Status* field with Present in Park when herbarium specimens were collected from park localities or the most recently published flora for the park (Botti 2001) listed occurrences in the park. Because the recent collecting record for Yosemite was so sparse, we accepted records for specimens collected prior to 1950 as evidence, particularly if reinforced by more recent observations (e.g., botanical survey data) or by published information (e.g., Botti 2001). We populated the *Park Status* field with Probably Present if evidence of park occurrence was limited to specimens collected prior to approximately 1950. These taxa were either not included in the most recently published flora for the park (Botti 2001) or may have been listed as probably present in that flora. Older specimens forming the evidence for these taxa did not have determinations or park collection localities that were vague or suspect. We attributed taxa with Historic *Park Status* if the evidence of occurrence was entirely limited to specimens collected in the early 1900s or before. For example, there is a 1922 Carlotta Hall specimen of Cascade rockbrake (*Cryptogramma cascadensis*) from the Fairview Dome area (UC1481770). The species is otherwise unknown from the park, but it is documented from counties north, east, and south of Yosemite. We therefore entered Historic rather than Unconfirmed for *Park Status* and noted that the specimen identification needs to be verified. We entered Unconfirmed in *Park Status* for vouchers of questionable provenance within the current boundaries of Yosemite National Park. For example, an undated specimen of desert sweet (*Chamaebatiaria millefolium*; YOSE 116570) collected by Huss resides at the Yosemite National Park herbarium (YM) and was purportedly associated with the vegetation type mapping project of 1935–1937 but has no

collection locality recorded. In the central and southern Sierra Nevada this species is known only from the east slope of the range outside the park. Its status is Unconfirmed until firmer evidence of park occurrence surfaces. We entered False Report in the *Park Status* field when we uncovered specific evidence that a specimen was misidentified or incorrectly attributed to the park. For example, there is a single specimen of common viburnum (*Viburnum ellipticum*), a rare shrub in California, collected by Enid Michael in 1930 and allegedly from Wawona golf course in the southwest portion of the park. However, the species is known in the Yosemite region only from the vicinity of Highway 168 in Fresno County, and there was evidence of mistaken locality information associated with the 1930 collection.

We reserved the Abundant category in the *Abundance* field for tree species that dominate large acreages in the park. These included red fir and white fir (*Abies magnifica* and *A. concolor*), the common pines (whitebark [*Pinus albicaulis*], lodgepole [*P. contorta* ssp. *murrayana*], sugar [*P. lambertiana*], ponderosa [*P. ponderosa*], western white [*P. monticola*]), and mountain hemlock (*Tsuga mertensiana*). We relied on Botti (2001) for assignments of Common and Uncommon. Where Botti indicated a taxon was common or widespread, we labeled taxa as Common; where Botti indicated a taxon was occasional or uncommon, we labeled taxa as Uncommon. For species not included in Botti (2001) but documented in the park from limited voucher evidence, we categorized them as Rare. Species on the park's 2005 list of special status plant species (National Park Service 2005) constitute the majority of species labeled Rare. Rare was also assigned to any additional taxa Botti indicated occurred only rarely in the park. We assigned Unknown to 13 taxa for which there was insufficient information on the species' distribution and abundance in the park.

We relied on the state-wide flora (Hickman 1993) for assigning native or non-native status to taxa in the *Nativity* field of the species list table.

The species list field *Cultivation* applies to non-native species only and only to those introduced as part of a park's mission or persisting in the natural environment as escapes from cultivation, not those being cultivated for landscape purposes around developments (Appendix A). For non-native vascular plant records, we populated the *Cultivation* field with Cultivated, Persistent, Not cultivated, and Unknown according to definitions in Appendix A. Taxa coded as Cultivated have naturalized outside of current cultivation. In the *CultivationDataSource* field, we cited references that indicated whether species commonly are used in cultivation (i.e., Sunset Books and Sunset Magazine 1997, Bailey 1949) or references that indicated particular species were cultivated locally in the park (i.e., Botti 2001, Gerlach et al. 2003). We entered NA (for not applicable) for scientific names that did not have a *Park Status* of Present or Probably Present and a *Nativity* of non-native according to guidance in Appendix A.

3.1.3. Management Fields

The *Weedy* and *Pest* fields apply to vascular plant records for non-native taxa only. To identify a species as weedy, we used a modified version of the Hickman (1993) glossary definition of 'weed': "a generally alien, generally undesired plant, often adapted to disturbed places, often aggressive, occurring in or near settlements, in fields or gardens, along roadsides, and in relatively undisturbed communities of native plants." Non-native species not considered weedy included small, distinct populations of non-native species that did not appear to be spreading, waif species (not persistent without human intervention and not persisting for more than a few

generations and therefore incompletely naturalized), and persistent historic plantings. Observations of species behavior in this context were based on the experience of the authors with 26 cumulative seasons of botanical survey, vouchering, and management work in Yosemite.

For whether or not a plant species is labeled as a pest in the Yosemite species list, we used the definition of pests from NPS Management Policies (2001b): "living organisms that interfere with the purposes or management objectives of a specific site within a park or that jeopardize human health and safety."

We labeled two groups of species in the *Management Priority* field. For non-natives, we labeled those actively managed as non-native invasive species in Yosemite and those recommended for management priority by Gerlach et al. (2003). In consultation with the park botanist, we labeled native species in this field that are 1) listed as rare, threatened, or endangered by the State of California; 2) listed by the California Native Plant Society; or 3) listed as sensitive by Yosemite National Park.

We labeled species as vulnerable to exploitation in the *Exploitation Concern* field based on desirability to collectors (e.g., orchids, trillium, charismatic bulbs); those listed by the Yosemite National Park law enforcement office as having been the basis for citations issued for illegal collecting; and those in the park's resource protection ranger training materials as vulnerable to collection for purposes of hobby use (e.g., use as ornamentals), of consumption, of medicinal use, and of commercial propagation (B. Waldow, National Park Service, personal communication).

3.1.4. Published Information

We supplemented species occurrence information based on herbarium holdings with published occurrence information from *An Illustrated Flora of Yosemite National Park* published in 2001 (Botti). Botti conducted extensive investigations of herbarium holdings from Yosemite and made extensive field observations to support the 1,427 taxa included in his flora (S. J. Botti, National Park Service, personal communication). Based on this information we supplemented records with *Park Status* of Present in Park in the species list table with additional taxa that lacked voucher records but for which Botti reported observations within the park. We entered Unconfirmed for the species included by Botti (2001) for their proximity to the park (S. J. Botti, National Park Service. personal communication) but for which there are no voucher records confirming park occurrence.

3.2. New Data

Between 2003 and 2007, we used two survey-based approaches to expand knowledge of the park's flora. First, during surveys to determine population status of special status species, we made opportunistic plant collections when encountering new taxa, thereby adding species to the park list (Moore et al. 2005). Second, we implemented directed surveys of uncommon habitats and under-sampled areas specifically seeking new populations of special status species and new park records. These habitats included metamorphic features in a landscape dominated by substrates of granitic origin and mineral springs with their unusual soil and water chemistry.

Surveys to determine population status consisted of relocating populations mapped in the 1980s on U.S. Geological Survey 15-minute (1:62,500) quadrangles, determining population size,

vouchering associated species, and documenting the special status plant population with a voucher if sufficiently abundant and if not previously vouchered (Moore et al. 2005).

Surveys seeking park records and additional special status plant populations within uncommon habitats consisted of searches of as much of the habitat of interest as practicable within the June to September growing season. We located survey areas by identifying metamorphic features on USGS geologic maps of the 15-minute quadrangles covering Yosemite National Park and by using reported locations of mineral springs (Moore et al. 2008). We surveyed water bodies as well when we encountered aquatic species of interest or species rich aquatic communities.

During each of these survey efforts, we collected plant specimens for the purpose of accurate identifications, to document and permanently voucher species from undocumented populations, and to provide permanent records of species distributions in the park. We limited special status plant collections to previously undocumented localities and to stands that numbered at least 25 plants per specimen collected.

Plant collections were inclusive of common and uncommon taxa to better document species distributions. Using this approach increased the probability of obtaining specimens that, upon later identification, were determined to have special status with the park, the state, or the California Native Plant Society or to be park or county records. This was particularly true of cryptic species such as some members in the sedge family (Cyperaceae), aquatic species and some grasses.

We sometimes called upon specialists for determination of some of the more difficult taxa, such as sedges (*Carex* sp.), bent grass (*Agrostis* spp.), dodder (*Cuscuta* spp.), pondweeds (*Potamogeton* spp.), moonworts (*Botrychium* spp.), popcornflower (*Plagiobothrys* spp.) and rock cress (*Arabis* spp.). This improved the quality of the determinations and the value of the specimens in documenting the park flora.

We stored specimen data in tables modeled on the format required by the National Park Service curatorial database, ANCS+, and reformatted it for inclusion in NPSpecies. We created specimen labels directly from these data, using relational database query and reporting tools (Microsoft Office Access 2003, Microsoft Corporation, Redmond, WA). The National Park Service accessioned the mounted and labeled specimens provided by these projects to the museum at Yosemite National Park (Index Herbariorum code YM) with duplicates going to University Herbarium, University of California, Berkeley (UC).

4. Results

4.1. Existing Data

We acquired a total of 15,381 herbarium specimen records documenting 1,545 vascular plant taxa that occur (*Park Status* = present or probably present) in Yosemite National Park. The University and Jepson herbaria at the University of California, Berkeley, (UC/JEPS, 4,912 records) and the National Park Service herbarium at Yosemite National Park (YM, 3,648 records) have the largest number of holdings from the park. The Carl W. Sharsmith Herbarium at San Jose State University also has substantial holdings from Yosemite (912 records). The California Academy of Sciences has a large number of Yosemite holdings; however, as the data were not available at the time in electronic format, we derived a very limited number of records from that collection.

4.1.1. Collection Records

The botanical record for the area now constituting Yosemite National Park began in 1863 with the central Sierra Nevada expeditions of the California Geological Survey and the collections of William Henry Brewer and, later, Henry N. Bolander. Following a gap in the 1870s, the record slowly accumulated with significant contributions every decade through the 1960s (Figure 2). After that period, the rate of specimen accumulation declined. The 1930s had a notable increase in the number of specimens due in part to collections associated with vegetation type mapping efforts (Wieslander 1935).

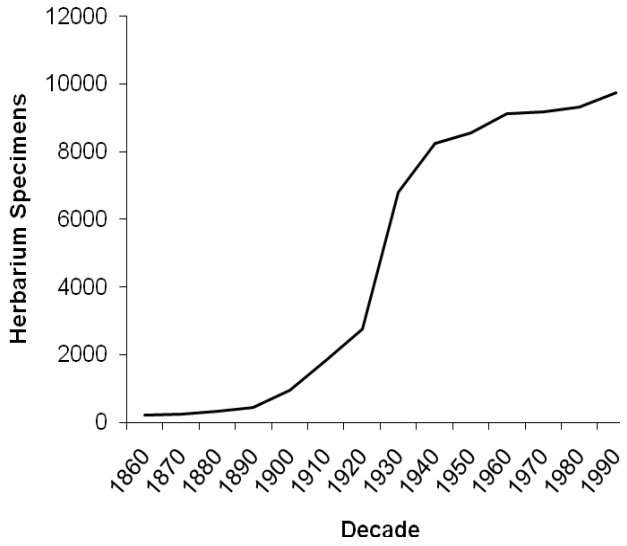

Figure 2. The botanical record for Yosemite National Park, beginning in 1863, shows that specimens accumulated at various herbaria gradually after 1900, increased rapidly in the 1930s and slowed markedly in the 1970s. Figure displays only those specimens with recorded dates.

The largest contribution to our understanding of Yosemite's vascular flora is from historic specimens of individual collectors. These included those of Joseph Whipple Congdon, an attorney by trade, who made extensive collections throughout the Yosemite region between 1880 and 1903; those of Willis Linn Jepson, professor of botany at the University of California, Berkeley, whose extensive botanical explorations throughout California produced 565[1] Yosemite specimens from between 1896 and 1924; and those of Carl W. Sharsmith, botany professor at San Jose State University (California) and Yosemite park naturalist, from whom we have records of 1,738 specimens collected between 1931 and 1991. We have 475 records from Harvey M. Hall,

[1] The 565 W.L. Jepson specimen records in the NPSpecies database clearly do not include all of Jepson's Yosemite specimens that are now posted by the herbarium at the Consortium of California Herbaria web site (http://ucjeps.berkeley.edu/consortium/). With recent updates to the Consortium database, approximately 75% of 1,825 Jepson records listed by the Consortium from Tuolumne, Mariposa, and Madera counties are from Yosemite.

professor of botany at the University of California, Berkeley, and then with the Carnegie Institution of Washington and Stanford University, who made collections in the park between 1900 and 1924. From Enid Michael and Beryl O. Shreiber we have 630 specimen records from the 1920s and 480 specimen records from the 1930s, respectively. Enid Michael was a seasonal ranger naturalist in Yosemite Valley. Beryl Olive Shreiber was with the U.S. Forest Service for a time and later with *Sunset Magazine*.

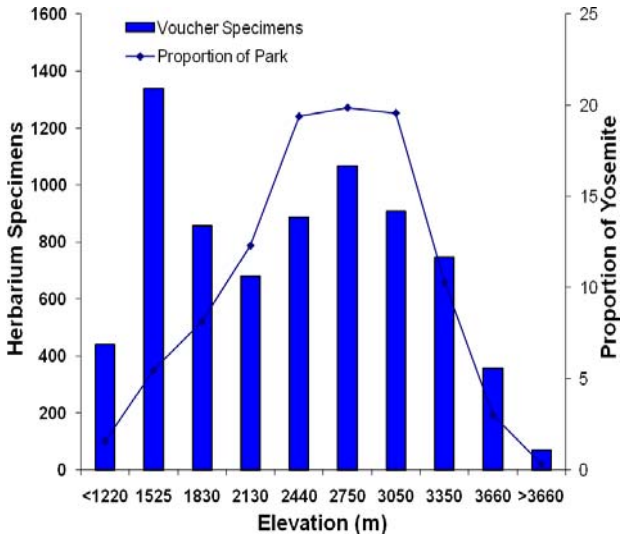

Figure 3. Number of herbarium specimens (bars) and proportion of park area (line) relative to elevation.

Herbert L. Mason, botanist and phytogeographer at the University of California, Berkeley, left a legacy of over 650 specimens collected in the park between 1922 and 1958. Mary V. Hood, who published, along with her husband, A. William Hood, and M. E. Mathias, *Yosemite Wildflowers and their Stories* in 1969, contributed 350 specimens to the museum at Yosemite National Park.

Formally sponsored efforts made sizeable contributions as well such as those of William H. Brewer (31 specimen records obtained thus far) and Henry N. Bolander (150) of the California Geological Survey in the mid 1860s and the state wide Vegetation Type Mapping effort (Wieslander 1935) for which W. B. Augustine, A. Hawbecker, and W. D. Thomas made significant collections in Yosemite between 1935 and 1937 (735 records). More recently, non-native species were extensively documented in 1998 and 1999 for moderate to heavy visitor use areas by a U.S. Geological Survey team led by D. Graham Roy (Gerlach et al. 2003). They obtained 344 specimens with detailed label data documenting 214 taxa, 129 of which were non-native.

Other botanists made valuable contributions toward documenting selected taxa. For example, the willows (*Salix* spp.) are well documented through the efforts of C. R. Ball and George A. Zentmyer, and there is a nearly comprehensive set of sedges (Cyperaceae family) in the work of C. W. Sharsmith.

Recent collection records were sparse for Yosemite National Park; 87% of the records we obtained dated from prior to 1960, 93% from prior to 1970. Only 13% of the voucher record is from after 1960 and prior to 2003 when the U.S. Geological Survey began seeking new park records. However, surveys in 2003 and 2004 found the vast majority of populations reported historically to be extant in the park, supporting our decision to consider taxa reported prior to the last few decades, and not since, to most likely persist.

Collection localities for existing records were well distributed among elevations and largely proportional to the amount of area at various elevations in the park (Figure 3). Exceptions were specimens from the park's lowest elevations, particularly Yosemite Valley at 1,220 m which received tourism and scientific attention beginning in the 1850s. The collection record was fairly well distributed north to south as well. As a result, there were not large gaps in the record in terms of geographic coverage.

4.1.2. Published Records

S. J. Botti (2001) made the greatest contribution toward making the cumulative knowledge about the park flora available outside of academic institutions through his book, *An Illustrated Flora of Yosemite National Park*. The utility of this publication to documenting the flora in the NPSpecies database was that it added 134 taxa to the list beyond those we know are documented with herbarium specimens. Botti directly observed these taxa within the park or may have been familiar with vouchers residing at institutions for which we do not have records.

4.2. New Data

Field surveys and collecting efforts between 2003 and 2007 added 1,697 herbarium specimens, not including duplicates, and 27 taxa to the vascular plant list for Yosemite National Park. In addition, approximately 29 taxa were newly vouchered from these efforts (Dean Wm. Taylor, consulting botanist, personal communication) that were previously known in the park only from published sources (e.g., Botti 2001). Among the additions to the park list, 19 were county records for Mariposa or Tuolumne counties, one was a state record (Yakutat moonwort [*Botrychium yaaxudakeit*]) and one was a newly described species (Yosemite bog-orchid [*Platanthera yosemitensis*], Colwell et al. 2007).

4.3. Vascular Flora of Yosemite National Park

Searches for existing data and completion of recent inventory efforts resulted in five references and 17,078 vouchers being incorporated into NPSpecies to document vascular plant occurrence in Yosemite National Park. Based on a review of this evidence, 1,572 vascular plant organisms[2] are considered Present in Park or Probably Present in Yosemite National Park (Table 1) using the nomenclature of Hickman (1993). Native species number 1,401 among 106 families with the greatest representation also in the sunflower and grass families with 182 (13%) and 105 species (8%), respectively. The figwort (Scrophulariaceae) and sedge (Cyperaceae) families have the next greatest representation among natives with 81 (6%) and 101 species (7%), respectively.

The greatest diversity in the vascular flora of Yosemite National Park is among the dicots. In contrast, there is low diversity among the ferns and their allies (spike-mosses, quillworts, and horsetails). Conifer diversity in Yosemite contributes to California's gymnosperm diversity being second only to that of southeast Asia (Mutke and Barthlott 2005).

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[2] Organisms, as defined by the National Park Service for the NPSpecies database, are biological entities identified by scientific names at the taxonomic rank of species or lower. They differ from a species in that a species is an organism identified by a scientific name at the rank of species but no lower (e.g., not to subspecies or variety). Organisms differ from scientific names in that a scientific name is a name for an organism or group of organisms (e.g., multiple varieties of a species) identified by a name at any taxonomic rank. In practice, more than one scientific name may apply to an organism depending on the nomenclature being applied. The term organism in this context is similar to the term taxon, but the term taxon technically applies to any taxonomic rank.

Non-native species are exclusively among the flowering plants and are concentrated among the dicots.

Table 1. Taxonomic composition of vascular plant taxa ("organisms") occurring in Yosemite National Park, California.

Taxa	Families	Genera	Organisms		
			Native	Exotic	Total
Division					
Lycopodiophyta (spike-mosses, quillworts)	2	2	6	0	6
Equisetophyta (horsetails)	1	1	3	0	3
Pteridophyta (ferns)	7	16	35	0	35
Coniferophyta (conifers)	4	8	19	0	19
Magnoliophyta (flowering plants)					
Class					
Magnoliopsida (dicots)	83	368	1011	115	1126
Liliopsida (monocots)	12	92	327	56	383
Total	**109**	**487**	**1,401**	**171**	**1,572**

There are 63 taxa with *Park Status* of Probably Present. Their occurrence is based on reliable records but these taxa bear some collecting efforts to confirm their presence in the park. There are just 12 taxa with Historic *Park Status*. Among these, we consider the two non-native species, *Cynoglossum occidentale* and *Secale cereal*, to have been waifs; they are uncommon introductions in montane settings, and there have been no subsequent observations. Another species with Historic status is purple fawnlily (*Erythronium purpurascens*) which was reported from the south side of Yosemite Valley by Katherine Brandegee in 1891; there are no extant specimens from Yosemite or any other more recent evidence. Among the angiosperms, there are 35 dicot and 10 monocot species with *Park Status* of Unconfirmed. These all have suspect localities, determinations, or reports.

In terms of abundance, most species are uncommon to rare, some are common, and few are sufficiently abundant that they dominate large areas within the park (Table 2). The 12 abundant gymnosperms are those species occurring over large acreages in the park, including white and red fir (*Abies concolor* and *A. magnifica*), six species of pine (*Pinus*), mountain hemlock (*Tsuga mertensiana*), incense-cedar (*Calocedrus decurrens*), and Sierra juniper (*Juniperus occidentalis* var. *australis*). The single abundant dicot is canyon live oak (*Quercus chrysolepis*), a broad-leaved species that is a common component of lower mixed coniferous forests and that forms closed-canopy forests on the talus slopes lining glacially-carved canyons in the lower elevations of Yosemite. The six rare species among the ferns and their allies consist of three species of moonwort (*Botrychium*), a fern just reaching the northern portion of the park (*Polystichum kruckebergii*), western quillwort (*Isoetes occidentalis*), and a member of the aquatic fern order, Hydropteridales (*Marsilea vestita* ssp. *vestita*). The two rare gymnosperms are Rocky Mountain juniper (*Juniperus communis*) and giant sequoia (*Sequoiadendron giganteum*). The juniper is limited to scattered stands along the Sierra Nevada crest. Giant sequoia is limited to three groves

Table 2. Count of vascular plant organisms by abundance categories at Yosemite among species considered present in the park (not including those considered probably present because those are not categorized by abundance in NPSpecies).

Abundance Category*	Ferns/ Allies	Gymnosperms	Angiosperms		Total
			Dicots	Monocots	
Abundant	0	12	1	0	13
Common	19	2	280	81	382
Uncommon	18	3	637	183	841
Rare	6	2	151	101	260
Unknown	0	0	11	2	13
Total	**43**	**19**	**1,080**	**367**	**1,509**

*Definitions of the *abundance* categories are in Appendix A

in Yosemite. We found insufficient information for 11 of the dicots and two of the monocot species to assign *abundance* categories other than Unknown.

4.3.1. Checklist Fields

Following *Park Status*, *Abundance*, and *Nativity*, the remaining checklist field is *Cultivation*. It applies to non-native taxa only. We know of only three non-native taxa to be cultivated in the park currently and to be naturalized in natural to semi-natural settings as escapes from cultivation. These are garden coreopsis (*Coreopsis lanceolata*), greater periwinkle (*Vinca major*), and purple foxglove (*Digitalis purpurea*). We labeled 12 species as persistent in natural areas as escapes from previous cultivation. Examples of the latter include ox-eye daisy (*Leucanthemum vulgare*), an escaped ornamental, and timothy (*Phleum pratense*), once cultivated in many lower elevation park meadows for hay (Botti 2001).

4.3.2. Management Fields

There are 143 non-native species (84% of the total number of non-native species) labeled as *Weedy*, 49 non-native species (29%) labeled in the *Pest* field, and 36 non-native species (21%) labeled in the *Management Priority* field. Non-native species marked as management priorities include three species of *Centaurea* (the star-thistles and knapweeds, *C. cyanus, C. melitensis, C. solstitialis*), three species of sweet clover (*Melilotus albus*, *M. indicus*, and *M. officinalis*), velvetgrass (*Holcus lanatus*), Himalayan blackberry (*Rubus discolor*), and Kentucky bluegrass (*Poa pratensis*). Species labeled as pests that we did not label as management priorities include species that are fairly invasive in natural communities but appear to have a low level of effects on native ecosystems locally. These include fennel (*Foeniculum vulgare*), yellow salsify (*Tragopogon dubius*), red clover (*Trifolium pratense*), and puncturevine (*Tribulus terrestris*). Species we labeled as weedy but not pests or management priorities include ubiquitous species of disturbed and compacted soils (e.g., pineapple weed [*Chamomilla suaveolens*] and red sand-spurrey [*Spergularia rubra*]), species long established and now seemingly permanent components of native communities (e.g., ripgut grass [*Bromus diandrus*]), and relatively new invaders locally that nevertheless seem ineradicable due to life history or limits on available control methods (e.g., hedgehog dogtail [*Cynosurus echinatus*]).

There are 44 species categorized as vulnerable to exploitation. Among those sometimes collected in large quantities for consumption are bracken fern (*Pteridium aquilinum*) and onions (*Allium* spp.). Those used in hobby or commercial purposes include orchids, lilies, and others with showy flowers (e.g., mountain lady's slipper [*Cypripedium montanum*], Washington lily [*Lilium washingtonianum*], and beardtongue [*Penstemon* spp.]); insectivorous species (e.g., round-leaved sundew [*Drosera rotundifolia*]); and those used medicinally (e.g., California valerian [*Valeriana californica*]).

4.4. Special Status Plant Species

4.4.1. Listed Plant Taxa Occurring in Yosemite

A total of 71 vascular plant taxa documented from Yosemite National Park have conservation listing status with a government agency and/or the California Native Plant Society (CNPS; Appendix B). For each taxon in Appendix B there is at least one voucher documenting park occurrence.

There is no vascular plant species listed under the Endangered Species Act known to occur within the jurisdiction of Yosemite National Park.[3] The park has four species listed by the State of California as Rare. They are Congdon's woolly sunflower (*Eriophyllum congdonii*), Congdon's lewisia (*Lewisia congdonii*), Yosemite onion (*Allium yosemitense*) and Tompkins' sedge (*Carex tompkinsii*). Populations of the woolly sunflower, onion and sedge occur within the park; a population of Congdon's lewisia in Sierra National Forest adjoins the NPS El Portal Administrative Site but no population falls fully within Yosemite National Park jurisdiction.

CNPS lists the four state-listed species and an additional 67 taxa that occur within the park as rare, threatened, or endangered; under review; or as watch list species (Appendix B; CNPS 2009). These include 17 taxa on List 1B, 17 on List 2, two on List 3, and 35 on List 4. List 1B[4] is for taxa that are rare, threatened, or endangered in California and elsewhere, including those that occur only in California. List 2 includes taxa that are rare, threatened, or endangered in California but are more common elsewhere. List 3 is for taxa under review about which more information is needed. List 4 is the CNPS watch list for taxa of limited distribution about which there might be conservation concerns.

[3] Ten species occurring in the park were, until recently, listed by the Sacramento, California, office of the U.S. Fish and Wildlife Service as species of concern, but that was an informal designation that is no longer being maintained (U.S. Fish and Wildlife Service 2009).
[4] CNPS List 1A species are presumed extinct in California.

4.4.1.1. California Natural Diversity Database Listings – Critically Imperiled Globally: NatureServe assesses the conservation status of species and ecosystems across their global range using standard criteria and rank definitions based on rarity, trends, and threats (NatureServe 2009). Based on information assembled by the California Natural Diversity Database (CDFG 2009) of the California Department of Fish and Game, part of the NatureServe natural heritage program, NatureServe also assigns conservation ranks to taxa according to their status within California (NatureServe 2009). These global and state rankings provide context for vascular plant conservation status within Yosemite and are reflected in Appendix B.

Figure 4. Bolander's woodreed (*Cinna bolanderi*) was originally described from a specimen collected in Mariposa Grove of giant sequoias by Henry N. Bolander in 1866. Image courtesy of New York Botanical Garden.

Three species occurring in Yosemite are ranked by NatureServe as critically imperiled globally (global rank = G1) and within the state (state rank = S1) due to extreme rarity (i.e., there are fewer than six occurrences): Tioga Pass sedge (*Carex tiogana*), Bolander's woodreed (*Cinna bolanderi*; Figure 4), and Congdon's lewisia (*Lewisia congdonii*). At the time it was described in 1999 and for some years afterward, Tioga Pass sedge was known from fewer than five localities on calcareous substrates near the Sierra Nevada crest in Mono County (Taylor and Mastrogiuseppe 1999). In 2007, it was collected from a single population west of the crest and within the park by A. E. L. Colwell and D. Grossenbacher. As a result, it is among the rarest species globally, state wide, and in Yosemite National Park. Bolander's woodreed is endemic to the central and southern Sierra Nevada. In the Yosemite region, it is known from approximately four historic localities, but not all of them have been relocated, and the species may not persist at some. A. E. L. Colwell found three additional populations in recent years (Moore et al. 2008). Congdon's lewisia is known from fewer than eight localities in the Kings and Merced river canyons in the central and southern Sierra Nevada.

Figure 5. Upswept moonwort (*Botrychium ascendens*) occupies microhabitats associated with mineralized waters. NatureServe ranks it critically imperiled in California (photograph by Alison E.L. Colwell).

4.4.1.2. California Natural Diversity Database Listings–Critically Imperiled in the State: In addition to the three species with global conservation status of G1, there are seven taxa with state conservation status ranks of S1 (or S1S2 in the case of slender-leaved pondweed) indicating they are critically imperiled in California due to extreme rarity (i.e., there are fewer than six occurrences) or other factors such as declining trend (Appendix B). The first, mountain bent grass (*Agrostis humilis*), is broadly distributed in western North America from Yukon Territory to California but rare in portions of its range (NatureServe 2009). In California, it is known only from the central Sierra Nevada in Alpine, Madera, Mariposa, Mono, and Tuolumne counties. With five new localities found between 2004 and 2007, the species still is known from just seven sites in Yosemite.

Records show upswept moonwort (*Botrychium ascendens*; Figure 5) to be widely scattered and rare across western North America from Alaska to California (NatureServe 2009), but its diminutive size may cause it to be overlooked. Prior to discovery of the new Yosemite locality in 2005 by A. E. L. Colwell, *B. ascendens* was known from just four localities in California (Consortium of California Herbaria 2009).

Mingan moonwort (*Botrychium minganense*) has a scattered distribution across northern North America and the western U.S. but is rare or uncommon where found. It was known from just five California localities prior to the new Yosemite locality found in 2007. A third species of *Botrychium*, Yakutat moonwort (*Botrychium yaaxudakeit*) was known from approximately 7 locations along the southern coast of Alaska and from Montana prior to Colwell's 2005 collection from Yosemite, a new state record. It is not yet listed by CNPS or ranked by CNDDB for the state, but it may be a candidate for a rank of S1.

The fourth species with a state rank of S1, western single-spiked sedge (*Carex scirpoidea* var. *pseudoscirpoidea*) is mostly restricted in California to Mono and Inyo counties in the east central Sierra Nevada where it is known from approximately five localities. However, there is a single Yosemite locality in the vicinity of Mt. Dana (Tuolumne Co.) based on a 1949 Sharsmith specimen and relocation by D. Grossenbacher in 2006. The latter is within two km of the two most frequently collected populations of this variety in the state on the east side of Mt. Dana (Consortium of California Herbaria 2009). Outside California, where the variety is not considered threatened, the range of western single-spiked sedge extends from British Columbia, Washington, and Montana south to New Mexico.

The status of small-flowered fescue (*Festuca minutiflora*) in California is based on few occurrences, mostly above 3,050 m (10,000 ft.) in the central Sierra Nevada (Mono and Inyo cos.) and the White Mountains. In Yosemite, it is known from Mt. Dana and was collected as

early as 1866 by W.H. Brewer. Recent collections from Yosemite added a second park locality (Moore et al. 2008).

Slender-leaved pondweed (*Potamogeton filiformis*) has scattered occurrences across the central and northeastern portions of California, mostly below 2,150 m (7,050 ft.) elevation. In Yosemite, this species was a new park record in 2006 when collected from a pond at 2,878 m (9,500 ft.) by A. E. L. Colwell and D. Grossenbacher.

Figure 6. Snow willow (*Salix reticulata* var. *nivalis*) is restricted to metamorphic substrates at high elevations in the central Sierra Nevada (photograph by Peggy E. Moore).

Snow willow (*Salix reticulata* ssp. *nivalis*; Figure 6) is another species of very limited distribution in the state. There are approximately 14 documented populations in Mono, Inyo, and Tuolumne counties in the central Sierra Nevada where the species is restricted to metamorphic substrates at high elevations. It is much more widespread and abundant in alpine habitats of the Rocky Mountains, Cascade Mountains, and other western ranges from California and Colorado north to British Columbia and Alberta.

4.4.1.3. Park Rarity: There are a number of species with low conservation ranks globally (G5, demonstrably secure to ineradicable) that are, nevertheless, rare in the park. A portion of these are at or near the southern limit of their ranges and occur in Yosemite as small populations isolated from the main species range. As such, they are both vulnerable to extirpation and are potential reservoirs of genetic variation. Examples include shore sedge (*Carex limosa*), California bog asphodel (*Narthecium californicum*), and slender cottongrass (*Eriophorum gracile*).

Conversely, there are a number of species that are globally or regionally rare but are fairly abundant in the park. These include short-leaved hulsea (*Hulsea brevifolia*; 17 populations; Figure 7), slender lupine (*Lupinus gracilentus*; eight populations, most numbering over 3,000 plants each), slender-stemmed monkeyflower (*Mimulus filicaulis*; 17 populations), Sierra podistera (*Podistera nevadensis*; common in the alpine along the crest but under-surveyed), Bolander's clover (*Trifolium bolanderi*; eight populations, six of them numbering over 1,000 plants), and Congdon's sedge (*Carex congdonii*; 10 populations mapped and common in commonly occurring habitat).

Figure 7. Short-leaved hulsea (*Hulsea brevifolia*) is endemic to the central and southern Sierra Nevada (photograph by Peggy E. Moore).

4.4.1.4. U. S. Department of Agriculture, Forest Service Listings: The Pacific Southwest Region of the Forest

Service, U.S. Department of Agriculture, maintains a list of sensitive species based on rarity and threats within California. The Forest Service designates plant species as "Sensitive" that are known or expected to occur on its lands and that are potential candidates for federal threatened or endangered status under the Endangered Species Act of 1973 (as amended, 1988; Powell 2001). Forest Service Region 5 sensitive species occurring in Yosemite are indicated in Appendix B.

Figure 8. Yosemite bog-orchid (*Platanthera yosemitensis*) inhabits wet meadows at middle elevations in Yosemite National Park (photograph by Alison E.L. Colwell, NPS).

4.4.2. Recent Records for Yosemite National Park

During surveys to determine rare plant population status and seek new park records between 2003 and 2007, USGS and NPS botanists collected eight special status plant species not previously known from the park. The additions included two aquatic species (*Potamogeton filiformis*, *Utricularia intermedia*), a diminutive wetland sedge (*Carex tiogana*), and an orchid new to science, Yosemite bog-orchid (*Platanthera yosemitensis*; Colwell et al. 2007; Figure 8). The greatest number of special status plant species added to the park was from surveys of uncommon habitats. Four were from metamorphic features (upswept moonwort [*Botrychium ascendens*], Mingan moonwort [*B. minganense*], Yakutat moonwort [*B. yaaxudakeit*], and Tioga Pass sedge. Four additions were encountered opportunistically in other habitats: slender-leaved pondweed (*Potamogeton filiformis*), flatleaf bladderwort (*Utricularia intermedia*), Yuba Pass willowherb (*Epilobium howellii*), and forget-me-not popcornflower (*Plagiobothrys myosotoides*).

A second set of special status plant taxa added to the species list for Yosemite consists of those newly described since the state-wide flora was published in 1993 (Hickman). This includes Coleman's rein orchid (*Piperia colemanii*) and Sierra starwort (*Pseudostellaria sierra*). The 1993 species description of Coleman's rein orchid included five Yosemite localities (Morgan and Glicenstein 1993); new specimens collected in 2005 and 2007 documented two additional park populations. This minute-flowered orchid of coniferous forest and chaparral is on CNPS list 4 (watch list). The 2002 published description of the perennial herb Sierra starwort (Rabeler and Hartman 2002) listed a Yosemite locality based on two historic specimens; botanists found and vouchered an additional population in 2005. This species is on CNPS list 4 and is currently considered fairly endangered in California (CNPS threat code 0.2).

4.5. Non-native Plant Species

Of the 1,572 taxa considered present or probably present in the park, 171 (11%) among 31 families are not native to California (Hickman 1993). Among the non-natives, representation by family varies from one species in each of 16 different families to 54 (31%) in the grass family (Poaceae). The next most commonly occurring families are the sunflower family (Asteraceae) with 27 species (16%) and the mustard (Brassicaceae) and pink (Caryophyllaceae) families with 12 species (7%) each.

Hickman (1993), the most recent state-wide treatment for California, lists 1,023 non-native species (17%) out of 5,867 total species occurring in the state at the time of publication. The number of plant species introduced to California has increased since that time (Hrusa et al. 2002), still outpacing the rate of introductions to Yosemite (M. Hutten, National Park Service, personal communication).

Two non-native species documented from historic specimens are believed to have been waifs that no longer occur in the park: common houndstongue (*Cynoglossum officinale*) and cultivated rye (*Secale cereale*). One of only two non-native species flagged as having Unconfirmed status in the park, Italian thistle (*Carduus pycnocephalus*), was collected from Lower River Campground in 1998 and has not been encountered again in the park. We consider it a waif and the other unconfirmed non-native, stickwort (*Spergula arvensis*), a spurious record with a locality well outside of the species' range.

4.5.1. Non-native Species Management and Listings

We labeled 143 (84%) of the 171 non-native species as weedy based on their behavior in the park and, of those, 49 (34%) as pests based on their extent in the park, their known invasiveness, and their difficulty to control (Appendix A has definitions for the Management Fields, including *Weedy Plant*, *Pest*, and *Management Priority* fields). We labeled 37 non-native species as a priority for management as of 2009. These include such aggressive invaders as yellow star-thistle (*Centaurea solstitialis*), velvetgrass (*Holcus lanatus*), and cheatgrass (*Bromus tectorum*). The few pest species that are not a current priority for management include such well-established species as creeping bentgrass (*Agrostis stolonifera*), English plantain (*Plantago lanceolata*), and yellow salsify (*Tragopogon dubius*).

The California Invasive Plant Council (Cal-IPC) reviews data on invasive non-native plant species that threaten wildlands and uses formal criteria to categorize them as having High, Moderate, or Limited negative ecological impact in California (Cal-IPC 2006). The rating criteria include ecological impact, invasive potential, and distribution. As of the 2007 update of the Cal-IPC list, 200 species are included among the three categories (Cal-IPC 2006, 2007). Thirty-eight of those listed by Cal-IPC occur in Yosemite, 16 with a rating of Limited, 18 with a rating of Moderate, and four with a rating of High (Appendix C).

At the national level, NatureServe assesses the impact of invasive non-native species based on ecological impact, current distribution and abundance, trend in distribution and abundance, and general management difficulty (NatureServe 2009). Using criteria within each of these categories, species are ranked as high, medium, low, or insignificant. Mean ranks spanning two rank categories are common, e.g., high/medium. Some of the highest I-Ranks, e.g., cheatgrass (*Bromus tectorum*) are due to wide distribution across the U.S., the variety and conservation value of invaded habitats, continued range expansion, and complexities involved with management. Species with lower I-Ranks, e.g., redstem filaree (*Erodium cicutarium*), tend to be widely distributed, with lower impacts to ecosystem structure and native species habitat, and with low probability of successful control. Mean ranks spanning more than two adjacent categories, e.g., High/Low for wild oat (*Avena fatua*) and shortpod mustard (*Hirschfeldia incana*), indicate assessment results vary among assessment criteria.

5. Discussion

5.1. Patterns in the Vascular Flora of Yosemite National Park

Among the 1,572 taxa considered present or probably present in Yosemite, there are 487 genera among 109 families and 57 orders. This represents 63% of the families, 40% of the genera and 22% of the species reported for California as of 1993 (Hickman; Table 3) from a land area representing just 0.7% of the state.

Table 3. Vascular plant diversity within Yosemite National Park at the family, genus, and species (or below) levels compared with that reported in Hickman (1993) for the State of California.

Location	Families	Genera	Vascular Plant Organisms[1]
Yosemite National Park	109	487	1,572
California	173	1,222	7,036

[1]Organism count for Yosemite is limited to taxa with Park Status=Present in Park or Probably Present.

The distribution of plant taxa among groups is similar for Yosemite and the State of California in ferns and gymnosperms but differs slightly for dicots and monocots (Table 4). Yosemite has 43 fern taxa (including fern allies, the horsetails, lycopods, and quillworts), 19 gymnosperms, 1,126 dicotyledonous taxa, and 383 monocots considered present or probably present. The proportion of the flora among fern and gymnosperm taxa is comparable to California in general (Hickman 1993). However, monocots make up a slightly greater proportion of the Yosemite flora compared to the state (24% versus 16%), and the dicots make up a slightly lower proportion (72% versus 81%; $X^2_{3,\,0.05} = 7.81$, $p < 0.05$). Other mountainous regions can support high proportions of monocots as well (Rawat and Adhikari 2005).

Table 4. Distribution of plant taxa among groups for Yosemite National Park and the State of California. Figures in parentheses indicate percentage of flora each group represents.

	Ferns/Allies	Gymnosperms	Angiosperms	
			Dicots	Monocots
Yosemite taxa	43 (3)	19 (1)	1,126 (72)	383 (24)
California taxa	108 (2)	67 (1)	5,705 (81)	1,156 (16)

The most species-rich families in Yosemite include the sunflower, grass, sedge, figwort, pea and rose families (Table 5). The sunflower and grass families are the largest families in California as well (Hickman 1993). The sunflower, grass, and pea families are among the five most species rich plant families in the world (Stevens 2001+). The three most species-rich families in Yosemite (grass sunflower, sedge) can be the most species rich in other montane environments as well (Rawat and Adhikari 2005).

Table 5. The 15 most species-rich families in the vascular flora of Yosemite National Park. Organism numbers represent the number of taxa at the lowest taxonomic level recognized in Hickman (1993) nomenclature.

Family Scientific Name	Family Common Name)	Genus Number	Organism Number
Asteraceae	Sunflower	73	209
Poaceae	Grass	45	159
Cyperaceae	Sedge	9	102
Scrophulariaceae	Figwort	16	88
Fabaceae	Pea	10	76
Brassicaceae	Mustard	24	67
Rosaceae	Rose	17	53
Onagraceae	Evening primrose	7	45
Polygonaceae	Buckwheat	6	45
Caryophyllaceae	Pink	13	43
Liliaceae	Lily	17	42
Polemoniaceae	Phlox	10	37
Juncaceae	Rush	2	36
Ranunculaceae	Buttercup	11	35
Hydrophyllaceae	Waterleaf	7	30

Among the sunflower and grass families, non-native species contribute 13% and 34% of the species richness, respectively. The sedge family in Yosemite consists almost entirely of native species (99%), largely in the genus *Carex* (77 taxa or 75% of the sedge family occurring in Yosemite). The buckwheat family owes its diversity to the profusion of species in the genus *Eriogonum* (18 organisms or 45%).

In terms of diversity among life forms, there are 36 tree taxa, 157 shrubs (including subshrubs), four vines, 1,030 forbs (non-grass-like herbs), 301 graminoids (grass or grass-like monocotyledonous herbs [e.g., Cyperaceae, Juncaceae, and Poaceae]), and 44 ferns and their allies in Yosemite National Park (Table 6). One species, western poison oak (*Toxicodendron diversilobum*), may take the form of a tree, shrub, or vine but is most commonly a shrub, so we classified it as a shrub for the purpose of Table 6. Approximately half of the tree taxa are gymnosperms. Among the remaining trees, four are willows (Salicaceae) and five are oaks (Fagaceae). Among shrubs, 16% are in the rose family (Rosaceae), 11% in the sunflower family (Asteraceae), and 11% in the willow family (Salicaceae).

5.2. Patterns in the Non-native Plant Collection Record

The earliest non-native plant specimen collections from Yosemite, among the records we obtained, date from the 1890s. John Baptist Lembert, who did commercial collecting in Yosemite for specimens to sell to museums, collected annual beard grass (*Polypogon monspeliensis*) from Yosemite Valley in 1895. Willis Linn Jepson, curator of the herbarium at the University of California, Berkeley, collected black-eyed susan (*Rudbeckia hirta* var.

Table 6. Taxonomic and life form diversity of vascular plants in Yosemite National Park, California.

Taxonomic and Life Form Categories	Present in Park	Probably Present	Total
Taxonomic diversity			
Total taxa (including varieties and subspecies)	1,509	63	1,572
Full species (not including varieties and sspp)	1,411	51	1,462
Families	109	0	109
Life form diversity			
Tree taxa	36	0	36
Shrub taxa	154	3	157
Vine taxa	4	0	4
Perennial forb taxa	661	29	647
Annual forb taxa	363	20	383
Perennial graminoid taxa	230	9	239
Annual graminoid taxa	60	2	62
Fern/allies taxa	43	1	44

pulcherrima, a garden escape) at Big Meadow in 1896. Some of the most common and widespread Mediterranean annuals introduced to California in the mission period were among the earliest non-natives collected in Yosemite. F. T. Bioletti collected *Bromus madritensis* ssp. *rubens*, *B. hordeaceus*, *Erodium cicutarium*, and *Vulpia myuros* var. *hirsuta* in Yosemite Valley in 1900. Jepson obtained specimens of *Bromus japonicus* and *Poa pratensis* ssp. *pratensis* from Yosemite Valley in 1909, and Le Roy Abrams collected *Bromus secalinus* and *Bromus tectorum* from Yosemite Valley in 1911.

Of the 150 non-native plant taxa documented with vouchers, 10% had arrived and were vouchered by 1921 (Figure 9). One third were vouchered by 1930 and half by 1961. However, the increase of 74% in 1998 and 1999, with focused efforts to collect non-native species and accession them to a herbarium, may reflect the lack of collecting efforts in the 1950s, 1960s, and 1970s more than a sharp increase in the occurrence of non-native species in the 1990s. To some degree, herbarium specimens may only loosely reflect the timing of introductions to the park.

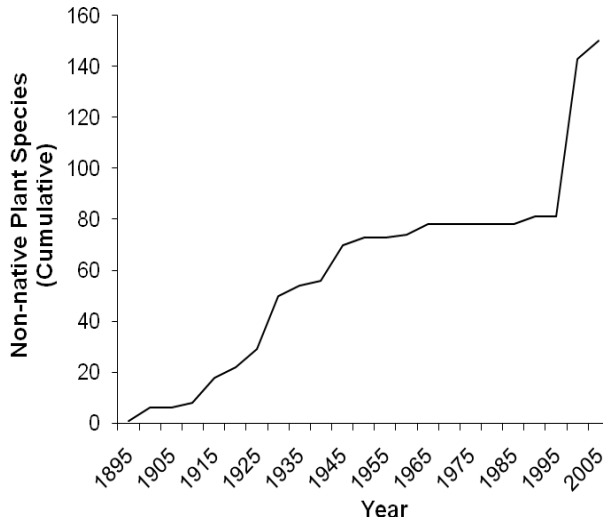

Figure 9. Cumulative number of non-native plant species documented from Yosemite National Park with herbarium specimens between 1895 and 2006.

The most commonly collected, and therefore perhaps the most widespread non-native species, include cheatgrass, redtop (*Agrostis gigantea*), red sand-spurrey (*Spergularia rubra*), and sheep sorrel (*Rumex acetosella*; Table 7).

Table 7. The most commonly collected non-native plant taxa among herbarium specimens from Yosemite National Park.

Scientific Name	Common Name	Herbarium Specimens
Bromus tectorum	cheatgrass	18
Phleum pratense	timothy	17
Agrostis gigantea	redtop	13
Spergularia rubra	red sand-spurrey	13
Rumex acetosella	sheep sorrel	12
Erigeron strigosus	prairie fleabane	11
Bromus secalinus	rye brome	11
Bromus hordeaceus	soft brome	11
Poa pratensis ssp. *pratensis*	Kentucky bluegrass	10
Bromus diandrus	ripgut brome	10
Agrostis stolonifera	creeping bentgrass	9
Vulpia myuros var. *hirsuta*	rat-tail fescue	8
Polygonum convolvulus	black bindweed	8
Holcus lanatus	common velvetgrass	8
Avena barbata	slender wild oat	8
Cynosurus echinatus	hedgehog dogtail	7
Polygonum arenastrum	common knotweed	7
Leucanthemum vulgare	oxeye daisy	7
Sisymbrium altissimum	Jim Hill mustard	7
Cerastium glomeratum	sticky mouse-ear chickweed	6
Cirsium vulgare	bull thistle	6
Polygonum persicaria	lady's thumb	6
Setaria viridis	green bristlegrass	6
Chenopodium botrys	Jerusalem oak	6

5.3. Comparison with Sequoia and Kings Canyon National Parks

Yosemite, in the central western Sierra Nevada, and Sequoia and Kings Canyon National Parks (350,169 ha [865,286 acres]; two adjoining parks administered together and with one set of NPSpecies records), in the southwestern Sierra Nevada (Figure 1), each have over 100 families and over 1,500 organisms documented from within their boundaries (Table 8).

Table 8. Vascular plant diversity within Yosemite National Park at the family, genus, and species (or below) levels compared with results for Sequoia and Kings Canyon National Parks.

	Families	Genera	Vascular Plant Organisms[1]
Yosemite National Park	109	487	1,572
Sequoia and Kings Canyon National Parks	115	525	1,552

[1]Organism counts for Yosemite and Sequoia and Kings Canyon are limited to taxa with Park Status = Present in Park or Probably Present.

Yosemite and Sequoia and Kings Canyon share 103 families in common. Sequoia and Kings Canyon have representatives documented from 12 families not represented in Yosemite (Agavaceae, Aspleniaceae, Azollaceae, Cannabaceae, Juglandaceae, Moraceae, Myrtaceae, Platanaceae, Polygalaceae, Punicaceae, Saururaceae, and Sterculiaceae). *Yucca whipplei* (Agavaceae) occurs in the foothills of Sequoia and Kings Canyon on metamorphic substrates not found at Yosemite's low elevations. The native California black walnut (*Juglans californica*, Juglandaceae) occurs in the lower elevations of Sequoia and Kings Canyon. Yosemite has little appropriate habitat for this species but it occurs in the park's low-elevation administrative site in El Portal though is yet to be vouchered. Western sycamore (*Platanus racemosa*, Platanaceae) is common at lower elevations in the Kaweah and Kings River watersheds of Sequoia National Park but rare in the Yosemite region and does not occur in the park. Moraceae is represented by naturalized edible fig (*Ficus carica*), a native of the Mediterranean region, and Punicaceae is represented by naturalized pomegranate (*Punica granatum*), a native of southeast Europe and the Himalayan Mountains. Edible fig is naturalized just outside Yosemite, 20 km (12 mi) west of the park in the Merced River canyon but not yet within the park. Of the two ferns documented only for Sequoia and Kings Canyon, one is an aquatic (*Azolla filiculoides* in Azollaceae, the mosquito fern family), and the other is a rare member of the spleenwort family (Aspleniaceae), *Asplenium septentrionale*, that inhabits crevices in granite at higher elevations. Yerba mansa in the lizard's-tail family (*Anemopsis californica*, Saururaceae) was collected in Sequoia and Kings Canyon but is more typical of moist alkaline sites in more arid portions of the state.

Yosemite has representatives documented from six families not represented in Sequoia and Kings Canyon (Cabombaceae, Haloragaceae, Hippuridaceae, Marsileaceae, Myricaceae, and Nymphaeaceae). Each of these is represented by a single native species, five of them aquatics. The non-aquatic is Sierra sweetbay (*Myrica hartwegii*, Myricaceae) which is a rare, riparian shrub. Most of the aquatics have long been known from Yosemite, including watershield (*Brasenia schreberi* in Cabombaceae), yellow pond-lily (*Nuphar lutea* ssp. *polysepala* in Nymphaeaceae), and mare's-tail (*Hippuris vulgaris* in Hippuridaceae). The water-milfoil (*Myriophyllum sibiricum*, Haloragaceae) and hairy waterclover (*Marsilea vestita* ssp. *vestita*, Marsileaceae) are based on recent collections.

Sorensen's Similarity Index (QS) is a measure of similarity between two samples where 0 = no overlap and 1 = complete overlap or identical composition (Sorensen 1948). At the family level, QS = 0.920 when comparing Yosemite and Sequoia and Kings Canyon. The two areas share 431 genera in common (QS = 0.854). Sequoia and Kings Canyon have 94 genera not documented

from Yosemite. Most of those genera are in the largest families, Asteraceae and Poaceae, and most are native. Yosemite has 56 genera not documented from Sequoia and Kings Canyon.

In terms of species overlap, Yosemite and Sequoia and Kings Canyon share 1,168 taxa between them (QS = 0.748). In addition to differences detailed above, there are differences in species representation among shared genera. They generally appear proportional to diversity among families, with a greater number of species differences among the more species-rich families.

Yosemite and Sequoia and Kings Canyon have a high degree of overlap in habitats, elevational range, geologic history, rock and soil types, and plant communities. We would not have been surprised with a greater similarity in species occurrence. Regarding differences, Yosemite has more northern floristic influences, and several species reach their southern limit in Yosemite (e.g., Douglas-fir [*Pseudotsuga menziesii*]). Each park has local endemics and disjunct populations not documented from the other park or parks. The very low representation of low elevation foothill habitat at Yosemite accounts for some of the discrepancies. Distribution of non-natives, phytogeography, and completeness of documentation of both natives and non-natives account for other discrepancies.

5.4. Documentation of the Flora

The relatively small proportional increase, between 2003 and 2007, in the vouchered vascular flora of Yosemite National Park (27/1,572 = 1.7%) from nearly 1,700 new herbarium specimens from under-represented and under-surveyed habitats reflects the degree to which the previous collection record documented the vascular flora. This is largely due to the collecting efforts of numerous botanists who left herbarium specimens housed where they would be curated for posterity. The accumulation of specimens over time and from across the landscape now makes it possible to seek patterns in the flora as a whole, to re-examine collections with advances in taxonomic knowledge, to study distribution patterns, and to identify gaps in our knowledge about species distributions.

At the same time, knowledge of the vascular flora of Yosemite is still not complete. Surveys continue to add taxa to the park list, both native and non-native, our understanding of species distributions is still incomplete, and new collections sometimes represent state records. Botti (2001) added 134 taxa to the list beyond those we know are documented with herbarium specimens. Among the occurrence records based only on published sources, 29 taxa have been vouchered in the last six years. With more focused efforts, many of these unvouchered taxa could be collected and added to permanent collections.

Several efforts provide evidence that strategies used during collecting efforts determine the character of the resulting specimens. The majority of records of non-native species occurring in Yosemite stems from USGS efforts in 1998 and 1999 to record non-native species in anthropogenically disturbed areas (e.g., campgrounds, developments, roadsides, and trailsides) and permanently document their occurrence with herbarium specimens (Figure 8). These efforts resulted in 344 specimens documenting 129 non-native species. In addition, survey and collecting efforts in 2005 and 2007 that focused on uncommon habitats documented 18 taxa not previously collected in Yosemite over the course of the nearly 150-year record. So, there are benefits to thematic collecting as well as general collecting.

Prior to recent efforts, documentation of the Yosemite flora was becoming somewhat dated with only 7% of the voucher record dating from after 1970 and before our contemporary efforts. The most recent collecting efforts have brought the proportion of the voucher record dating from after 1970 to 14%. Documenting a flora with collections that are relatively current and complete serves to keep floristic information current and to track changes such as new invasive species (Hrusa et al. 2002). Prather et al. (2004a) eloquently make the case for maintaining the currentness of herbarium holdings with plant collecting efforts. Well documented, recent collections are important in new species discoveries, filling gaps in our understanding of species distributions, documenting and preventing extinctions (through conservation planning), and tracking and predicting range expansions and contractions (Prather et al. 2004a). The decline in plant collecting in the U.S. (Prather et al. 2004b) serves as a warning that these opportunities are being lost with each passing year.

5.4.1. Utility of the NPSpecies Database

Among the most useful aspects of the NPSpecies database on the vascular flora of Yosemite are 1) provision of a species list and evidence supporting each taxon in a shared, accessible format and 2) making accessible the geographic distribution of known specimens using collection localities and, where available, geographic coordinates that can link to mapping products. The work to populate NPSpecies with vascular plant records for Yosemite marks the first time a plant species list has been available for Yosemite National Park to support resources management staff, interpretation and education staff, researchers, and the general public. A list based on evidence together with voucher details, however, provide a deeper understanding of the park flora beyond just a list of taxa. Managers and others have ready access to the justification for each taxon on the list together with information on approximate abundance, native versus non-native status, invasiveness, and management priority. The rich history of collections from the park is now available in a single location.

In the NPSpecies database, nomenclature is standardized within and among parks and is updatable. The standard among parks is that of ITIS (USDA 2009a), the Integrated Taxonomic Information System, to which every species list is matched within NPSpecies. The standard nomenclature within parks is ITIS or the locally recognized nomenclature selected by the park and in which the park species list is expressed. With changes in nomenclature, evidence in the form of vouchers or published occurrences can be linked to updated names where appropriate.

Among the limitations of NPSpecies is the lack of data by species on group membership (fern/fern allies, gymnosperm, monocot angiosperm, dicot angiosperm), life form (tree, shrub, vine, herb/forb, graminoid, fern), duration (annual, biennial, perennial), or species origin (e.g., locally endemic, regionally endemic, Nearctic origin, Palearctic origin, Africotropical origin, etc). As a result, this type of information must be sought from external sources such as the USDA PLANTS database (USDA 2009b) in order to attribute taxa in the database, and it must be done external to NPSpecies. This may be addressed to some extent with the upcoming revision of NPSpecies when it will be integrated into an on-line natural resource information portal with links to ITIS and the USDA PLANTS database.

5.5. Recommendations

To maintain the usefulness of the database, we recommend that the National Park Service establish a protocol for supplementing the data with additional specimens and published treatments. The highest priorities may be specimens that document additions to the park flora or that voucher taxa when information on their occurrence has been limited to published accounts. The second priority may be specimens that expand the known geographic distribution of species within the park. Specimens mounted and labeled according to professional standards and submitted to an indexed herbarium[5] following NPS guidelines will serve as the most permanent records. Currently, these guidelines include assignment of a National Park Service accession number (accession numbers are assigned for groups of specimens) and a NPS catalog number (individual catalog numbers are assigned to each herbarium sheet) in coordination with National Park Service curatorial staff. At the time specimens are submitted to the National Park Service herbarium at the Yosemite Museum (YM), the museum requests that collection data be provided in the format of the curatorial database. This information includes accession number, catalog number, scientific name, collector, collection number, date of collection, locality, habitat, elevation, specimen description, who identified the specimen and the date, park name, county, state, geographic coordinates, and native/non-native status.

There are a number of specimens with records in NPSpecies for which determinations need to be verified. Sometimes a single specimen serves as the sole evidence of park occurrence for a species. When the park is outside the normal species' range or other factors cast serious doubt on the validity of a record, we noted in the species record that verification is needed. Dr. D. W. Taylor provided determinations needed for specimens residing at the National Park Service herbarium at Yosemite; those remaining are largely at the University Herbarium and Jepson Herbarium. The taxa with the most questionable determinations or provenance have Unconfirmed entries in the *Park Status* field. Arranging for these specimens to be revisited would serve to resolve these issues.

At this time, the NPS curatorial database (ANCS+) and NPSpecies do not share a common format, and we recommend efficiencies be sought in providing data to each while minimizing data reformatting. At this time there is no automated import function in the online or desktop versions of NPSpecies for general users to get data in from the ANCS+ database. However, the NPSpecies support office offers the service to accept ANCS+ data in spreadsheet (.csv, xls, etc) or database format (mdb, dbf, etc), convert those data to the desktop NPSpecies format in Microsoft Access, and then import those data into the online version of NPSpecies.

The Jepson Manual: Higher Plants of California (Hickman 1993) was the nomenclatural standard for the initial version, described in this report, of vascular plant data uploaded to NPSpecies for Yosemite National Park. With the extensive revisions underway for the upcoming second edition of *The Jepson Manual*, upon publication, the National Park Service will have the

[5] Indexed herbaria are included in the Index Herbariorum (IH), a guide to worldwide herbaria numbering over 3,900 that document the earth's plant and fungal diversity. Only those collections that are permanent scientific repositories are included in IH. New registrants must demonstrate that their collection is large (usually 5,000 specimens minimum), accessible to scientists, and actively managed. Each institution is assigned a permanent unique identifier in the form of a four to eight letter code, a practice that dates from the founding of IH in 1935. YM is the code for the herbarium at Yosemite National Park. More information can be found at www.nybg.org.

option of updating the nomenclature in NPSpecies for the Yosemite plant species list. Doing so will update the species list to the latest scientific understanding of species taxonomic relationships. In many cases, the taxonomy will then more closely follow that of recently published volumes of the Flora of North America (FNA; Flora of North America Editorial Committee 1993+) as well. In a minority of cases, taxonomic treatments may differ from those in FNA.

Enumerating the vascular flora of a large, complex, and diverse national park is the first step in assessing biological diversity, establishing a baseline to monitor for change, and informing all other efforts that use vascular plant data in protected area management and research. These efforts may include rare plant population inventory and monitoring, wetland condition assessment, vegetation type mapping, and non-native plant management. In an era of unprecedented change associated with habitat loss, contaminants, nutrient deposition, and climate change, it is more important than ever to document the building blocks of ecosystem structure and function. Maintenance of the NPSpecies database will serve all of these needs in multiple ways.

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Appendix A. NPSpecies Database Metadata

The following fields and definitions apply to the species list stored in the NPSpecies database. Entries in the Label column in bold are field names; entries in regular type face are acceptable values within that field.

Label	Definition	Comments
Park Status	The current status of each species in each park.	Applicable only to organisms with the *Local List* checkbox checked. The possible values reflect a combination of confidence, and availability and currency of verifiable evidence in NPSpecies.
Present in Park	Species' occurrence in park is documented and assumed to be extant.	Extremely high confidence that the species is currently in the park. A current, verifiable reference, voucher or observation is included in NPSpecies.
Probably Present	Park is within species' range and contains appropriate habitat. Documented occurrences of the species in the adjoining region of the park give reason to suspect that it probably occurs within the park. The degree of probability may vary within this category, including species that range from common to rare.	Very high confidence that the organism is currently in the park. Verifiable evidence may exist in NPSpecies, but is not considered current enough to elevate the status to Present in Park. Efforts should be made to obtain current, verifiable evidence in NPSpecies to elevate the *Park Status* to “Present in Park”. If reasonable efforts to obtain current, verifiable evidence are unsuccessful, then the *Park Status* should be changed to Unconfirmed, Historic, Encroaching or False Report as applicable.
Unconfirmed	Included for the park based on weak ("unconfirmed record") or no evidence, giving minimal indication of the species' occurrence in the park.	Any confidence from very low to high that the organism is currently in the park. Verifiable evidence may exist in NPSpecies, but it is not considered sufficient enough to elevate the status to Probably Present, nor current enough to elevate the status to Present. Efforts should be made to obtain current, verifiable evidence in NPSpecies to elevate the *Park Status* to “Present in Park”. If reasonable efforts to obtain current, verifiable evidence are unsuccessful, then the *Park Status* should be changed to Historic, Encroaching or False Report as applicable.
Encroaching	The species is not documented	Extremely low confidence that the organism

Label	Definition	Comments
	in the park, but is documented as being adjacent to the park and has potential to occur in the park.	is currently in the park, but extremely high confidence that the organism is currently adjacent to the park. Verifiable evidence may exist in NPSpecies documenting the occurrence in the park, but it is not current. Potential invasive organisms are good candidates for this *Park Status* designation, either before they enter a park or after they have been eliminated from a park.
Historic	Species' historical occurrence in the park is documented, but recent investigations indicate that the species is now probably absent.	Extremely low confidence that the organism is currently in the park. Verifiable evidence exists in NPSpecies, but is not current. Extinct, extirpated or eliminated species are candidates for a Historic *Park Status* designation.
False Report	Species previously reported to occur within the park, but current evidence indicates that the report was based on a misidentification, a taxonomic concept no longer accepted, or some other similar problem of interpretation.	Extremely low confidence that the organism is currently in the park. Evidence exists in NPSpecies, but it cannot be sufficiently verified.
NA	Not Applicable - Park-Status does not apply to the scientific name for the park.	The NA value prevents null values from appearing in NPSpecies and applies to 2 primary situations: 1) An outdated scientific name that is not used in the locale of the park for an organism, but is in NPSpecies for a park because of the inclusion of vouchers, observations or names linked to references. Note that outdated names are reconciled in NPSpecies with the nomenclature of Hickman (1993). 2) Vouchers, observations or names linked to references have not been identified at the species level or lower, but are included in NPSpecies with the name of a higher taxonomic rank than the species level. The

Label	Definition	Comments
		name of the higher level taxonomic rank will disappear from NPSpecies if the evidence of the respective name is identified to the species level or lower, and is changed appropriately in NPSpecies.
Abundance	The current abundance of each organism in each park.	Applicable only to organisms with the *Local List* checkbox checked and a *Park Status* of "Present". The values attempt to balance abundance with suitable habitat, and temporal/behavioral considerations. In practice, the entered value should apply (although there are numerous exceptions) to the abundance in the most suitable habitat of the organism, and at the time that the organism is engaged in its principle behavior in (e.g., breeding, migrating, hibernating, etc.), or most important behavior to, the park. A future generation of NPSpecies will address the coding of *Abundance* (and associated *Residency*) to separate out the temporal and behavioral aspects. The Data Source field for *Abundance* is available to provide a citation that specifically addresses abundance in more detail.
Abundant	**Animals:** May be seen daily, in suitable habitat and season, and counted in relatively large numbers. **Plants:** Large number of individuals; wide ecological amplitude or occurring in habitats covering a large portion of the park.	
Common	**Animals:** May be seen daily, in suitable habitat and season, but not in large numbers. **Plants:** Large numbers of individuals predictably occurring in commonly encountered habitats but not those covering a large portion of the park.	
Uncommon	**Animals:** Likely to be seen	

Label	Definition	Comments
	monthly in appropriate season/habitat. May be locally common. **Plants:** Few to moderate numbers of individuals; occurring either sporadically in commonly encountered habitats or in uncommon habitats.	
Rare	**Animals:** Present, but usually seen only a few times each year**. Plants:** Few individuals, usually restricted to small areas of rare habitat.	
Occasional	**Animals:** Occurs in the park at least once every few years, but not necessarily every year. **Plants:** Not applicable.	
Unknown	Abundance unknown.	
NA	Not Applicable – Abundance does not apply to the scientific name in the park.	All names on a park's list that do not have a *Park Status* of Present should have an *Abundance* of NA.
Residency	Current residency classification for each ANIMAL species in each park.	Applicable only to ANIMALS with the *Local List* checkbox checked and a *Park Status* of "Present". The values attempt to balance temporal and behavioral considerations. In practice, the entered value should apply (although there are numerous exceptions) to the residency of the organism at the time that the organism is engaged in its principle behavior (e.g., breeding, migrating, hibernating, etc.) in, or most important behavior to, the park. A future generation of NPSpecies will address the coding of Residency (and associated *Abundance*) to separate out the temporal and behavior aspects. The Data Source field for Residency is available to provide a citation that specifically addresses Residency in more detail.

Label	Definition	Comments
Breeder	Population reproduces in the park.	
Resident	A significant population is maintained in the park for more than two months each year, but it is not known to breed there.	
Migratory	Migratory species that occurs in park approximately two months or less each year and does not breed there.	
Vagrant	Park is outside of the species' usual range.	
Unknown	Residency status in park is unknown.	
NA	Not Applicable – Residency does not apply to the scientific name in the park.	All names on a park's list that do not have a *Park Status* of Present should have a *Residency* of NA.
Nativity	*Nativity* classification for each organism for each park.	Applicable only to organisms with the *Local List* checkbox checked. If the park-status of an organism is not "Present in Park", then nativity represents the nativity if the organism were eventually confirmed in the park.
Native	The organism is native, or would be native, to the park (either endemic or indigenous).	
Non-Native	The organism is not native, or would not be native, to the park (neither endemic nor indigenous).	Cultivated organisms as defined under the *Cultivation* field are also considered non-native.
Unknown	Nativity is unknown relative to the park.	
NA	Not Applicable	Applies to names that do not represent organism names for the locale of the park.

Label	Definition	Comments
Cultivation	Cultivation classification for each non-native organism in each park.	Applicable only to organisms with the *Local List* checkbox checked, a *Park Status* of "Present" or "Probably Present" and a *Nativity* of Non-Native. *Cultivation* is intended to distinguish between non-native organisms that were introduced as part of a park's mission, and non-native organisms that occur in the park naturally. *Cultivation* was not intended to apply to organisms that are cultivated for landscape purposes and have not persisted into the natural environment, for example plants in gardens or terrariums, or animals in enclosures. In general, NPSpecies was not intended to include controlled, "domestic" organisms.
Cultivated	A non-native species that is currently cultivated in the park.	
Persistent	A non-native species that persists in the park (either reproducing or non-reproducing) from a previous cultivation in the park.	
Not Cultivated	A non-native species that is not currently cultivated in the park.	
Unknown	A non-native species for which the cultivation in the park is currently unknown.	
NA	Not Applicable – Cultivation does not apply to the non-native scientific name in the park.	All names on a park's list that do not have a *Park Status* of Present or Probably Present and a *Nativity* of Non-native should have a *Cultivation* of NA.
Management Fields	Information related to the management of organisms at a park such as *Weedy* Plant, *Pest*, *Management Priority* and Exploitation Concern.	Applicable only to organisms with the *Local List* checkbox checked.
Weedy Plant?	Yes/No field for plant species only. Plant species are considered "weedy" or	The definition of *Weedy Plant* has been found to be too general to be of use from both an ecological and managerial

Label	Definition	Comments
	"invasive" if they (a) occur almost exclusively in disturbed habitats, (b) relatively recently occupied natural habitats in competition with native species, or (c) occur across a broad range of ecological conditions.	perspective. The *Pest* field was added to provide a more narrow definition that was specifically oriented to management. No similarly narrow counterpart to the ecological aspects of the definition of *Weedy Plant* is currently in NPSpecies.
Pest?	Yes/No if a species is a "pest" in the park. "Pests are living organisms that interfere with the purposes or management objectives of a specific site within a park, or that jeopardize human health and safety." (NPS Management Policies 2001. Section 4.4.5.1)	Organisms identified by the park's Chief of Natural Resources or Invasive Species Management Team, or addressed in a park's Resource Management Plan or APCAM database are good candidates for having *Management Priority* checked in NPSpecies.
Management Priority?	Yes/No flag if a species is a management priority in the park.	Organisms identified by the park's chief of Natural Resources or addressed in a park's Resource Management Plan are good candidates for having *Management Priority* checked in NPSpecies.
Exploitation Concern	Yes/No if a species is an exploitation concern in the park.	Organisms identified by a park's law enforcers or contained within the Critical Incident Report System database are good candidates for having the *Exploitation Concern* checked in NPSpecies.

Appendix B. Special Status Vascular Plant Species Occurring in Yosemite National Park

Voucher records document 72 vascular plant taxa in Yosemite National Park that are currently listed by the State of California, the California Natural Diversity Database, the Forest Service and/or the California Native Plant Society.

Scientific Name	Common Name	Family	CNPS List.Threat Code[1]	CA	NatureServe/ CNDDB[2]	USFS[3]
Agrostis humilis	mountain bent grass	Poaceae	2.3		G4/S1.3	
Allium tribracteatum	three-bracted onion	Liliaceae	1B.2		G2/S2.2	FSS
Allium yosemitense	Yosemite onion	Liliaceae	1B.3	Rare	G2/S2.3	FSS
Arabis repanda var. *greenei*	Greene's rock cress	Brassicaceae	4.3		G5T2/S2.3	
Astragalus kentrophyta var. *danaus*	Sweetwater Mountains milk-vetch	Fabaceae	4.3		G5T2T3/ S2S3	
Bolandra californica	Sierra bolandra	Saxifragaceae	4.3		G3/S3.3	
Botrychium ascendens	upswept moonwort	Ophioglossaceae	2.3		G2G3/ S1.3?	FSS
Botrychium minganense	Mingan moonwort	Ophioglossaceae	2.2		G4/S1.2	FSS
Botrychium yaaxudakeit[4]	Yakutat moonwort	Ophioglossaceae			G2	
Bulbostylis capillaris	hair-leaf sedge	Cyperaceae	4.2		G5/S3.2	
Camissonia sierrae ssp. *alticola*	Mono Hot Springs evening-primrose	Onagraceae	1B.2		G3T2/S2.2	FSS
Camissonia sierrae ssp. *sierra*	Yosemite evening-primrose	Onagraceae	4.3		G3T3/S3.3	
Carex buxbaumii	Buxbaum's sedge	Cyperaceae	4.2		G5/S3.2	
Carex congdonii	Congdon's sedge	Cyperaceae	4.3		G3/S3.3	
Carex davyi	Davy's sedge	Cyperaceae	4.3		G3/S3.3	
Carex incurviformis var. *danaensis*	Mount Dana sedge	Cyperaceae	4.3		G4G5T3/ S3.3	
Carex limosa	shore sedge	Cyperaceae	2.2		G5/S3?	

Appendix B. Special Status Vascular Plant Species Occurring in Yosemite National Park (continued)

Scientific Name	Common Name	Family	CNPS List.Threat Code[1]	CA	NatureServe/ CNDDB[2]	USFS[3]
Carex praticola	meadow sedge	Cyperaceae	2.2		G5/S2S3	
Carex scirpoidea var. *pseudoscirpoidea*	single-spiked sedge	Cyperaceae	2.2		G5T5/S1.2	
Carex tahoensis	Tahoe sedge	Cyperaceae	4.3		G5/S3	
Carex tiogana	Tioga Pass sedge	Cyperaceae	1B.3		G1/S1.2	FSS
Carex tompkinsii	Tompkins' sedge	Cyperaceae	4.3	Rare	G3/S3.3	
Ceanothus fresnensis	Fresno ceanothus	Rhamnaceae	4.3		G3/S3.3	
Cinna bolanderi	Bolander's woodreed	Poaceae	1B.2		G1/S1.2	
Clarkia australis	Small's southern clarkia	Onagraceae	1B.2		G2/S2.2	FSS
Claytonia megarhiza	fell-fields claytonia	Portulacaceae	2.3		G4G5/S2S3	
Cordylanthus rigidus ssp. *brevibracteatus*	short-bracted bird's beak	Scrophulariaceae	4.3		G5T3/S3.3	
Cryptantha glomeriflora	Truckee cryptantha	Boraginaceae	4.3		G3Q/S3.3	
Cypripedium montanum	mountain lady's-slipper	Orchidaceae	4.2		G4/S4.2	FSS
Draba praealta	tall draba	Brassicaceae	2.3		G5/S2.3	
Epilobium howellii	Yuba Pass willowherb	Onagraceae	4.3		G4/S4	FSS
Eriophorum gracile	slender cottongrass	Cyperaceae	4.3		G5/S3.3	
Eriophyllum congdonii	Congdon's woolly sunflower	Asteraceae	1B.2	Rare	G2/S2.2	FSS
Eriophyllum nubigenum	Yosemite woolly sunflower	Asteraceae	1B.3		G2/S2.3	FSS
Festuca minutiflora	small-flowered fescue	Poaceae	2.3		G5/S1.3	
Fritillaria pinetorum	pine-woods fritillary	Liliaceae	4.3		G4/S3.3	
Hulsea brevifolia	short-leaved hulsea	Asteraceae	1B.2		G3/S3.2	FSS
Ivesia unguiculata	Yosemite ivesia	Rosaceae	4.2		G3/S3.2	
Jensia yosemitana	Yosemite tarweed	Asteraceae	3.2		G2G3/ S2S3	
Juncus hemiendytus var.	Center Basin rush	Juncaceae	4.3		G5T4/S3.3	

Appendix B. Special Status Vascular Plant Species Occurring in Yosemite National Park (continued)

Scientific Name	Common Name	Family	CNPS List.Threat Code[1]	CA	NatureServe/ CNDDB[2]	USFS[3]
abjectus						
Lewisia congdonii	Congdon's lewisia	Portulacaceae	1B.3	Rare	G1/S1.3	FSS
Lewisia disepala	Yosemite lewisia	Portulacaceae	1B.2		G2/S2.2	FSS
Lupinus gracilentus	slender lupine	Fabaceae	1B.3		G3/S3	FSS
Lycopus uniflorus	northern bugleweed	Lamiaceae	4.3		G5/S3.3	
Mimulus filicaulis	slender-stemmed monkeyflower	Scrophulariaceae	1B.2		G2/S2.2	FSS
Mimulus inconspicuus	small-flowered monkeyflower	Scrophulariaceae	4.3		G3/S3.3	
Mimulus laciniatus	cut-leaved monkeyflower	Scrophulariaceae	4.3		G3/S3.3	
Mimulus pulchellus	Pansy monkeyflower	Scrophulariaceae	1B.2		G2G3/ S2S3.2	FSS
Minuartia obtusiloba	alpine sandwort	Caryophyllaceae	4.3		G5/S3.3	
Myrica hartwegii	Sierra sweet bay	Myricaceae	4.3		G3G4/S3S4	
Piperia colemanii	Coleman's piperia	Orchidaceae	4.3		G3/S3.3	
Plagiobothrys myosotoides	forget-me-not popcornflower	Boraginaceae	4.3		G4Q/S3.3	
Plagiobothrys torreyi var. *torreyi*	Yosemite popcornflower	Boraginaceae	1B.2		G4T2Q/ S2.2	
Platanthera yosemitensis	Yosemite bog-orchid	Orchidaceae	1B.2		G2/S2.2	
Podistera nevadensis	Sierra podistera	Apiaceae	4.3		G3/S3.3	
Polystichum kruckebergii	Kruckeberg's sword fern	Dryopteridaceae	4.3		G4/S3.3	
Potamogeton epihydrus ssp. *nuttallii*	Nuttall's pondweed	Potamogetonaceae	2.2		G5T5/ S2.2?	
Potamogeton filiformis	slender-leaved pondweed	Potamogetonaceae	2.2		G5/S1S2	
Potamogeton robbinsii	Robbins' pondweed	Potamogetonaceae	2.3		G5/S2.3?	
Pseudostellaria sierrae	Sierra starwort	Caryophyllaceae	4.2		G3G4/ S3S4	
Rhynchospora alba	white beaked-rush	Cyperaceae	2.2		G5/S3.2	
Salix reticulata ssp. *nivalis*	snow willow	Salicaceae	2.3		G5/S1.3	
Scirpus subterminalis	water bulrush	Cyperaceae	2.3		G4G5/ S2S3	

Appendix B. Special Status Vascular Plant Species Occurring in Yosemite National Park (continued)

Scientific Name	Common Name	Family	CNPS List.Threat Code[1]	CA	NatureServe/ CNDDB[2]	USFS[3]
Sparganium natans	small bur-reed	Typhaceae	4.3		G5/S3.3	
Stellaria obtusa	obtuse stellaria	Caryophyllaceae	4.3		G5/S3.3	
Trifolium bolanderi	Bolander's clover	Fabaceae	1B.2		G3/S3.2	FSS
Triglochin palustris	marsh arrow-grass	Juncaginaceae	2.3		G5/S2.3	
Triteleia lugens	Coast Range triteleia	Liliaceae	4.3		G3/S3.3	
Utricularia intermedia	flatleaf bladderwort	Lentibulariaceae	2.2		G5/S2.2	
Utricularia minor	lesser bladderwort	Lentibulariaceae	4.2		G5/S3.2	
Veronica cusickii	Cusick's speedwell	Scrophulariaceae	4.3		G5/S3.3	
Wyethia elata	Hall's wyethia	Asteraceae	4.3		G3/S3.3	

[1]California Native Plant Society codes include the list number and threat rank separated by a period
CNPS List 1B: Rare, threatened, or endangered in California and elsewhere
CNPS List 2: Rare, threatened, or endangered in California, but more common elsewhere
CNPS List 3: More information is needed about these plants (Review List)
CNPS List 4: Limited distribution (Watch List)
CNPS Threat Rank 0.1: Seriously endangered in California
CNPS Threat Rank 0.2: Fairly endangered in California
CNPS Threat Rank 0.3: Not very endangered in California

[2]California Department of Fish and Game, Natural Diversity Database (CNDDB) global and state rankings:
The global rank (G-rank) is a reflection of the overall condition of an element throughout its global range.
G1 = Fewer than 6 viable element occurrences (EOs) OR fewer than 1,000 individuals OR less than 2,000 acres
G2 = 6-20 element occurrences OR 1,000-3,000 individuals OR 2,000-10,000 acres
G3 = 21-80 element occurrences OR 3,000-10,000 individuals OR 10,000-50,000 acres
G4 = Apparently secure; this rank is clearly lower than G3 but factors exist to cause some concern; i.e., there is some threat, or somewhat narrow habitat
G5 = Population or stand demonstrably secure to ineradicable due to being commonly found in the world
T: Subspecies receive a T-rank attached to the G- or S-rank. With the subspecies, the G-rank reflects the condition of the entire species, whereas the T-rank reflects the global/state situation of just the subspecies or variety. For example: *Camissonia sierrae* ssp. *alticola*. This plant is ranked G3T2. The G-rank refers to the whole species range, i.e., *Camissonia sierrae*. The T-rank refers only to the global condition of ssp. *alticola*.
Expressing the rank as a range of values, e.g., S2S3, indicates the rank is somewhere between S2 and S3.
?: Adding a ? to the rank, e.g., S2?, indicates more certainty than S2S3, but less than S2.
Q: Appending Q to a rank indicates there are taxonomic questions associated with the taxon.

The state rank (S-rank) is assigned much the same way as the global rank, except state ranks in California often also contain a threat designation attached to the S-rank.

S1 = Less than 6 EOs OR less than 1,000 individuals OR less than 2,000 acres
S1.1 = very threatened
S1.2 = threatened
S1.3 = no current threats known
S2 = 6-20 EOs OR 1,000-3,000 individuals OR 2,000-10,000 acres
S2.1 = very threatened
S2.2 = threatened
S2.3 = no current threats known
S3 = 21-80 EOs or 3,000-10,000 individuals OR 10,000-50,000 acres
S3.1 = very threatened
S3.2 = threatened
S3.3 = no current threats known
S4 = Apparently secure within California; this rank is clearly lower than S3 but factors exist to cause some concern; i.e. there is some threat, or somewhat narrow habitat. No threat rank.
S5 = Demonstrably secure to ineradicable in California. No threat rank.

[3]FSS: Included on the U.S. Department of Agriculture, Forest Service, Pacific Southwest Region (Region 5) Regional Forester's Sensitive Species List, 2006
[4]*Botrychium yaaxudakeit*, a new state record, is not yet listed by CNPS or other entities

Appendix C. Invasive Non-native Vascular Plant Species Documented from Yosemite National Park with California Invasive Plant Council Threat Ratings or NatureServe U.S. Invasive Species Impact Ranks

Species	Common Name	Family	Park Abundance	Cal-IPC Rating[1]	I-Rank[2]
Agrostis stolonifera	creeping bentgrass	Poaceae	Common	Limited	Medium/Low
Avena barbata	slender wild oat	Poaceae	Common	Moderate	NA
Avena fatua	wild oat	Poaceae	Common	Moderate	High/Low
Brassica nigra	black mustard	Brassicaceae	Uncommon	Moderate	High/Low
Brassica rapa	field mustard	Brassicaceae	Uncommon	Limited	NA
Bromus diandrus	ripgut brome	Poaceae	Uncommon	Moderate	NA
Bromus hordeaceus	soft brome	Poaceae	Uncommon	Limited	NA
Bromus japonicus	Japanese brome	Poaceae	Uncommon	Limited	NA
Bromus madritensis ssp. *rubens*	red brome	Poaceae	Uncommon	High	NA
Bromus tectorum	cheatgrass	Poaceae	Uncommon	High	High
Centaurea melitensis	tocalote	Asteraceae	Uncommon	Moderate	Medium
Centaurea solstitialis	yellow star-thistle	Asteraceae	Uncommon	High	High/Medium
Cirsium vulgare	bull thistle	Asteraceae	Common	Moderate	Medium
Cynodon dactylon	bermudagrass	Poaceae	Rare	Moderate	Medium/Low
Cynosurus echinatus	hedgehog dogtailgrass	Poaceae	Uncommon	Moderate	Medium/Low
Dactylis glomerata	Orchardgrass	Poaceae	Common	Limited	Medium/Insignificant
Digitalis purpurea	foxglove	Poaceae	Uncommon	Limited	Medium/Insignificant
Erodium cicutarium	redstem filaree	Geraniaceae	Uncommon	Limited	Medium/Low
Festuca arundinacea	tall fescue	Poaceae	Rare	Moderate	High/Medium
Foeniculum vulgare	fennel	Apiaceae	Rare	High	Medium/Low
Geranium dissectum	cutleaf geranium	Geraniaceae	Uncommon	Moderate	NA

Appendix C. Invasive Non-native Vascular Plant Species Documented from Yosemite National Park with California Invasive Plant Council Threat Ratings or NatureServe U.S. Invasive Species Impact Ranks (continued)

Species	Common Name	Family	Park Abundance	Cal-IPC Rating[1]	I-Rank[2]
Hirschfeldia incana	shortpod mustard	Brassicaceae	Uncommon	Moderate	High/Low
Holcus lanatus	common velvetgrass	Poaceae	Uncommon	Moderate	High/Medium
Hypericum perforatum	klamathweed	Hypericaceae	Uncommon	Moderate	High/Medium
Hypochaeris glabra	smooth catsear	Asteraceae	Uncommon	Limited	NA
Hypochaeris radicata	rough catsear	Asteraceae	Uncommon	Moderate	High/Low
Leucanthemum vulgare	ox-eye daisy	Asteraceae	Uncommon	Moderate	Medium/Low
Lolium multiflorum	Italian ryegrass	Poaceae	Uncommon	Moderate	NA
Marrubium vulgare	white horehound	Lamiaceae	Uncommon	Limited	Medium/Low
Medicago polymorpha	California burclover	Fabaceae	Uncommon	Limited	NA
Plantago lanceolata	English plantain	Plantaginaceae	Common	Limited	High/Low
Raphanus sativus	radish	Brassicaceae	Uncommon	Limited	NA
Rumex acetosella	sheep sorrel	Polygonaceae	Common	Moderate	Medium/Low
Rumex crispus	curly dock	Polygonaceae	Common	Limited	Low/Insignificant
Saponaria officinalis	bouncingbet	Caryophyllaceae	Uncommon	Limited	Low/Insignificant
Sinapis arvensis	charlock	Brassicaceae	Uncommon	Limited	Low/Insignificant
Verbascum thapsus	woolly mullein	Scrophulariaceae	Uncommon	Limited	Medium
Vinca major	big periwinkle	Apocynaceae	Uncommon	Moderate	Medium

[1]California Invasive Plant Council (Cal-IPC) Invasive Plant Inventory listing category definitions:

High: These species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically.

Moderate: These species have substantial and apparent—but generally not severe—ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.

Limited: These species are invasive but their ecological impacts are minor on a statewide level or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic.

Additional information on Cal-IPC ratings available at www.cal-ipc.org

[2]Information on NatureServe I-Ranks available at www.natureserve.org/explorer; NA = Not yet assessed

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