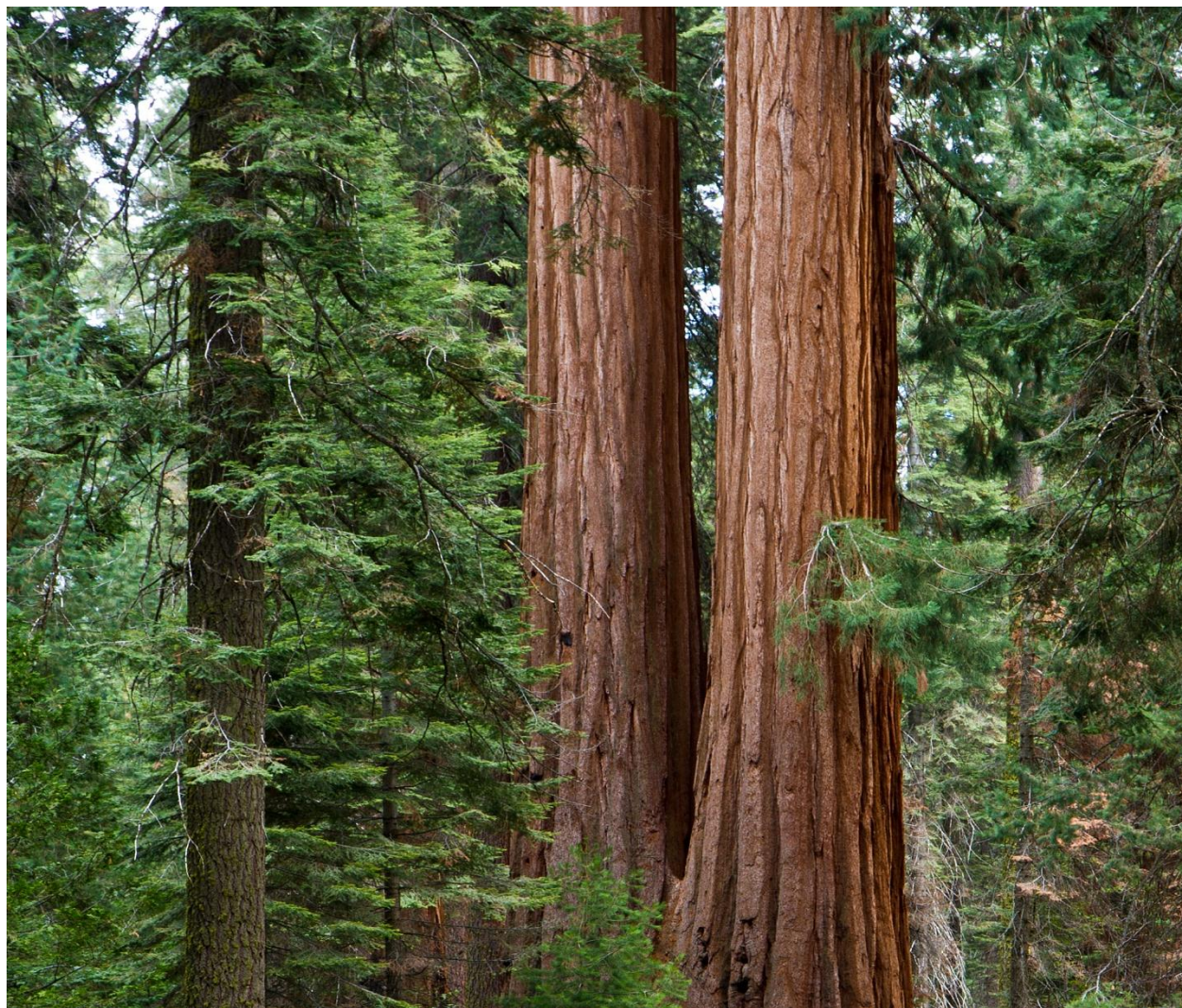




A Natural Resource Condition Assessment for Sequoia and Kings Canyon National Parks

Appendix 23 - Non-native Plants

Natural Resource Report NPS/SEKI/ NRR—2013/665.23



ON THE COVER

Giant Forest, Sequoia National Park
Photography by: Brent Paull

A Natural Resource Condition Assessment for Sequoia and Kings Canyon National Parks

Appendix 23 - Non-native Plants

Natural Resource Report NPS/SEKI/ NRR—2013/665.23

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Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

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This document contains subject matter expert interpretation of the data. The authors of this document are responsible for the technical accuracy of the information provided. The parks refrained from providing substantive administrative review to encourage the experts to offer their opinions and ideas on management implications based on their assessments of conditions. Some authors accepted the offer to cross the science/management divide while others preferred to stay firmly grounded in the presentation of only science-based results. While the authors' interpretations of the data and ideas/opinions on management implications were desired, the results and opinions provided do not represent the policies or positions of the parks, the NPS, or the U.S. Government.

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Scope of Analysis

Non-native (exotic, introduced, alien) species are non-indigenous species, such as plants, animals, and microbes, which have been introduced to new areas beyond their native ranges, and refer only to their place of origin. In contrast, invasive species are a subset of those non-native species that once introduced, are able to colonize and spread beyond cultivation and human care to impact natural habitats, biological diversity and/or the economy (Schwartz et al. 1996, Wilcove 1998, Pimental et al. 2005, NISC 2006). Non-native invasive species are widely recognized as posing threats to biological diversity second only to direct habitat loss and fragmentation, and have been implicated in the decline of endangered species worldwide (Baillie et al. 2004). Non-native invasive plants in particular are known to outcompete or displace native plants, provide unsuitable forage or nesting sites for native wildlife species, alter gene pools through hybridization, or alter vital ecosystem processes such as fire, hydrology and nutrient cycling (Macdonald et al. 1989, D'Antonio & Vitousek 1992, Chornesky & Randall 2003).

In the United States, thousands of non-native plant species have been intentionally or accidentally introduced for a multitude of reasons, such as for food, ornamental use, erosion control and other reclamation purposes, and many species have also arrived as hitchhikers in agricultural products, ship ballast, or transported on road machinery (Kolar & Lodge 2000, Mack 2003, Ruiz & Carlton 2003). Of these thousands of non-native plants however, it is estimated that less than 4% have the tendency to escape cultivation and become invasive in natural areas (Rapaport 1991), severely impacting native biological diversity and habitat functions.

In California, approximately 18% of the plant species found in the wild are non-native in origin, with the majority of exotic species establishing in the past 150 years (Randall et al. 1998). The California Invasive Plant Council (Cal-IPC) maintains a list of Exotic Pest Plants of Greatest Ecological Concern in California that includes only invasive pest plants of natural areas (Cal-IPC 2006, 2007). This current inventory contains a total of 198 species (ranked as 39 High, 93 Moderate, and 67 Limited), indicating that only a relatively small proportion of those non-native species cause significant ecological damage.

The National Park Service (NPS) acknowledges the spread of invasive species as one of the major factors contributing to ecosystem change and instability. Across the NPS, 6,500 non-native invasive species have been documented on park lands, 70% of documented invasive species on park lands are invasive plant species, and around 5% of park lands are dominated by invasive plants (NPS 2009).

Sequoia-Kings Canyon National Parks (SEKI) has recognized the threat of non-native invasive plants to its resources and values for some time (NPS 1999, NPS 2006a) and in 2001 started an active management program to map, monitor and control their invasive plants (Demetry 2010). Additionally, since 2002, a parkwide weed database works to track the current status of mapped invasive plant populations and management progress. This database was initially populated by data from a 1996-1998 weed survey, and now also contains recently mapped weeds, but does not include other past plant datasets.

The overall goals of this Natural Resources Condition Assessment (NRCA) chapter on non-native plants at SEKI are therefore to compile, analyze and summarize existing non-native plant data from multiple sources collected over the past few decades, to develop a synoptic spatial picture of sampled areas, sampling gaps, and existing non-native plant threats. We further seek to determine and describe the current condition of non-native plants for particular areas in the park at different scales, and to develop threat indices for each vegetation type in the park, at the Hydrologic Unit Code (HUC) 10 landscape unit scale, and for the park as a whole. We hope that this newly compiled and disseminated information will be used to inform the prevention and management of non-native plants to ensure the long-term health and survival of fish, wildlife, plants, and their habitats at SEKI (Wittenberg & Cock 2001, Tu 2009).

Critical Questions

To best address the current condition of non-native plants for particular areas in the park at different scales and for the park as a whole, we focused on two primary critical questions:

- 1) What is the condition of the park, relative to non-native plants?
- 2) What is the level of risk from invasive non-native plants to the park?

The purpose of the first critical question is to quantify and compare the non-native plant situation at SEKI with other sites and parks, using accepted tabular and spatial data analysis techniques, and to develop an overall coarse scale baseline measurement that can be used in later years to compare changes over time and management effectiveness. We also hope that providing these new data summaries will enable the use of the best science for directing future funding, resources and making on-the-ground management decisions. Specific sub-questions that will be addressed within the first critical question include:

- a. Which areas within the park have and have not been inventoried for non-native plants?
- b. Which non-native plants are present in the park, and what are their distributions and abundances?
- c. Which non-native plant species pose the highest threat to park resources?
- d. What factors are most associated with where non-native plants are located, and level of invadedness?
- e. Which sites are most highly-invaded and least-invaded and/or weed-free?

The purpose of the second critical question is to assess the condition of the park relative to invasive plant threats across the park and at useful scales. This will identify which sites or habitats are most threatened by invasive non-native plants. Specific sub-questions that will be addressed within this critical question include:

- a. What criteria and metrics can we use to assess the condition of non-native plants in the park?
- b. What does the non-native plant condition look like spatially across the park, using these integrity indices and vulnerability maps?

Data Sources and Types Used in Analysis

To inform our non-native plants analyses we reviewed all available vegetation data from SEKI and utilized data from seven main sources, as described and detailed below and in Table 1. Across all of the datasets, only non-native plant data were utilized in our analyses. Data were discarded if they lacked UTM locations, and the number of observations per dataset was derived from only true presence or positive data. Data were then taken directly or translated into percent cover values, then converted to spatial dataset and GIS data layers. Further, we attempted to attribute all of our data to California Wildlife Habitat Relationships (CWHR) vegetation types. Due to mapping resolution inconsistencies and/or errors however, we were only able to attribute

about 75% of our non-native plant data into specific CWHR vegetation types. We also assigned all plots based on their UTM locations into HUC 10 landscape unit designations.

The Comprehensive Vegetation and Mapping Plots are comprised of data from the Stephenson Vegetation/Gradient Analysis Plots dataset, the SEKI Vegetation Mapping, Accuracy Assessment, and Rapid Assessment plots dataset, and the Natural Resource Inventory Plots dataset. With the exception of the Accuracy Assessment and Rapid Assessment plots, these datasets are considered as comprehensive plots since these recorded all vegetation (both native and non-native plants) encountered in each plot. Therefore, absence of non-native plants could be assumed if a species was not recorded. Details of sampling plot placement and sampling methods used for these plots are described in detail elsewhere in this NRCA report.

Four non-native plant-specific datasets comprised the rest of our data. The SEKI Weed Management Database is the current and active tool used to house and manage data regarding invasive plants within SEKI. This database was initiated in 2002, and in addition to keeping track of non-native plant locations and monitoring the status of specific populations to inform the park wide SEKI Weed Management Plan (Demetry 2010), it also tracks management activities on those infestations and progress over time. One caveat of this database is that some of the point/species data is duplicated from the USGS Alien Plant Survey data (Gerlach et al. 2003), as the Weed Management Database revisited their point locations to conduct more detailed mapping and monitoring associated with control activities.

The USGS Alien Plant Survey (Gerlach et al. 2003) was undertaken to provide a synoptic picture of non-native invasive plants in both SEKI and Yosemite National Parks (Moore & Gerlach 2001). This survey was designed as a “directed survey” to complement the Natural Resource Inventory (NRI) plots. NRI plots were placed in systematic 1-km grids park wide and recorded all plant species – both natives and non-natives- detected. Prior to this survey report, there had been no attempts at SEKI to specifically identify and map existing non-native plants threats park-wide, and the effort added 96 taxa to the non-native flora. Additionally, this report sought to provide sufficient information on the distribution, abundance and invasiveness of species present, to form the basis for management prioritization. While this report provided a park wide assessment of invasive plants in SEKI, it focused only on those areas most likely to be invaded, such as near roads, trails, livestock corrals, campgrounds, and other disturbed areas.

The USGS Kern Canyon Alien Plant Survey (McGinnis 2004) was carried-out to obtain a full survey of the floor of Kern Canyon specifically for seven target weed species, including cheatgrass (*Bromus tectorum*), bull thistle (*Cirsium vulgare*), ripgut brome (*Bromus diandrus*), yellow starthistle (*Centaurea solstitialis*), woolly mullein (*Verbascum thapsus*), dandelion (*Taraxacum officinale*) and Kentucky bluegrass (*Poa pratensis*). The overall purpose of the survey was to determine if there was a potential for weeds to exploit burned areas and to determine if certain weeds, namely cheatgrass, could be feasibly managed in the canyon.

Finally, the NASA Invasive Plant Habitat Modeling project (Morisette et al. 2006) was completed in an attempt to use MODIS satellite imagery to support invasive plant habitat modeling efforts. The NASA data was very specific in scope, only accounting for cheatgrass and bull thistle in a limited number of plots.

In all, we accumulated non-native plant data representing 4,018 plots from across the park. Only 2,177 or about half of the plots had non-native species present. There were a total of 3,892 non-native species observations (with each individual non-native species within a plot counted as its own observation), each with a visual estimate of vegetative percent cover. Finally, we were able to attribute about 75% of our data, or 3,077 plots to a specific CWHR vegetation type when CWHR type was indicated, or by crosswalking the data from Holland Codes or from vegetation Alliance Codes.

Table 1. Data sources and descriptions of the data utilized in the analyses. Superscripts describe the data that were used, and should be applied across this table: a = The total number of plots that were obtained from each dataset, b = the number of plots with non-native plants present, c = the total number of non-native species observations for each dataset, and d = the number of plots per dataset that we were able to attribute to a specific CWHR vegetation type. The abbreviation NN = non-native plants.

Data Type	Dataset	Sampling Intensity	Subtotals
Comprehensive Vegetation & Mapping Plots	Stephenson Vegetation/Gradient Analysis Plots 1982-1984	228 total plots ^a 6 plots w/ NN present ^b 18 observations ^c 0 plots w/ veg data ^d	1,395 total plots ^a 317 plots w/ NN present ^b 1,086 observations ^c 1,141 plots w/ veg data ^d
	SEKI Vegetation Mapping, Accuracy Assessment & Rapid Assessment Plots 2000-2004	555 total plots 247 plots w/ NN present 635 observations 533 plots w/ veg data	
	Natural Resource Inventory Plots 1985-1996	612 total plots 64 plots w/ NN present 433 observations 608 plots w/ veg data	
Non-Native Plant Plots	SEKI Weed Management Database (2002-current)	1,742 total plots 1,391 plots w/ NN present 1,733 observations 1,548 plots w/ veg data	2,623 total plots 1,860 plots w/ NN present 2,806 observations 1,936 plots w/ vegetation data
	USGS Alien Plant Survey (Gerlach et al. 2003) 1996-1998	572 total plots 389 plots w/ NN present 993 observations 387 plots w/ veg data	
	USGS Kern Canyon Alien Plant Survey 2004-2005 (McGinnis 2004)	109 total plots 72 plots w/ NN present 72 observations 0 plots w/ veg data	
	NASA Invasive Plant Habitat Modeling 2008 (Morissette et al. 2006)	200 total plots 8 plots w/ NN present 8 observations 1 plot w/ veg data	
Total			4,018 total plots 2,177 plots w/ NN present 3,892 total observations 3,077 plots w/ attributable vegetation data

Reference Conditions

According to Randall et al. (1998), non-native invasive plants were not a significant part of the California flora prior to the 1800s, and the most invaded regions within the state are low elevation and coastal areas. This suggests that since SEKI is both inland and located at higher elevations, and is classified as part of the Southern Sierra Nevada Foothills and the Southern High Sierra Nevada Jepson sub-regions, that it would likely have remained relatively uninverted, especially at the higher elevations, by non-native plants until fairly recently (Schwartz et al. 1996).

It is difficult to determine exact dates and rates of non-native plant invasion into SEKI because of a lack of repeated comprehensive plant surveys, biased sampling (and vouchering of plant specimens) focused primarily on native plants, and a deficiency in sampling specific to non-native plants until the mid- to late-1990s. Additionally, there is a noticeable increase in sampling effort (both for comprehensive plant and for non-native plants) in the past twenty years, making it difficult to determine actual plant invasion events. Even with these difficulties, it does appear that there is a true trend of increasing numbers of non-native plant species and abundances within park boundaries over time.

In 1998, based on analyses mostly completed from the Jepson Manual (Hickman 1993), Randall et al. determined that the total numbers of exotic plant species for the Southern Sierra Nevada Foothills and the Southern High Sierra Nevada Jepson sub-regions to be 282 and 238 species, respectively, with an overall trend of exotic species decline with increasing elevation and with increasing distance from the coast.

In 1999, the SEKI Natural and Cultural Resource Management Plan (NPS 1999) stated that more than 120 exotic vascular plant species were within park boundaries. By 2002, the SEKI weed management database, using data from the USGS (Gerlach et al. 2003) report and from actual mapping and ground truthing, included 209 non-native plant taxa. As of 2010, the current database now reports a total of 219 non-native plants. Five of these new records reflect new documentations rather than new introductions, and one of the records is a native species that was unintentionally introduced at a higher elevation. Therefore it is estimated that since the inception of the SEKI weed management database and good records have been kept, that there have been approximately five new introductions or detections of new non-native species over the past eight years in the park (A. Demetry, pers. comm.).

Spatial and Temporal Analyses

In this NRCA invasive plants report, we seek to answer the overall question of, “What is the current condition of the park, relative to non-native plants?” Additionally, we will create specific threat indices that reflect the threat level non-native plants currently pose to different regions within the park, and to the park as a whole. To determine the overall condition of non-native plants within the park, we focused on five sub-questions:

- a. Which areas within the park have and have not been inventoried for non-native plants?

- b. Which non-native plants are present in the park, and what are their distributions?
- c. Which non-native plant species pose the highest threat to park resources?
- d. What factors are most associated with where weeds are located, and level of invadedness?
- e. Which sites are most highly-invaded and least-invaded and/or weed-free?

The following describes the methods and analyses, and discusses the results for each of these sub-questions.

Which areas within the Park have and have not been inventoried for non-native plants?

To determine which areas have and have not been inventoried for non-native plants within the park, we developed an overall map of plot locations where non-native plants have been searched for and recorded (Figure 1a), whether present or absent (Figure 1b). There is an overall trend of increased sampling for non-native invasive plants over time that is not shown in this figure, which may simply be an artifact of increased awareness of invasive plant threats to native biodiversity and ecosystems, especially since the 1990s, and the fact that SEKI began its own invasive plants management program in the early 2000s. Additionally, many of the sampled points are located near likely places of invasion such as near roads, trails, campgrounds, etc., as the USGS project (Gerlach et al. 2003) focused on sampling in these disturbed areas. By looking at Figure 1b, it is apparent that the majority of non-native plant presence occurs at lower elevations and in proximity to roads, and that most of the absence data occurs at higher elevations and away from disturbed sites.

Figures 2a, b and c display a gap analysis completed at the scales of 1.0 square kilometer, CWHR vegetation type, and at HUC 10 landscape unit. We chose these three landscape units to illustrate the effect scale has on determining adequate coverage of sampled units, and also because park staff indicated that different information could be gleaned by evaluating the results in these dimensions. The 1.0 square kilometer scale gives the most detail, showing the exact location of sampled points within each square and allowing for the finest resolution. At this scale, it is obvious when overlaid with the roads and trails layer that some sites and regions within the park are better sampled than others for non-native plants. The purpose of evaluating our data at the CWHR vegetation type scale was to determine if certain vegetation types have been over- or under-sampled for non-native plants, and the HUC 10 landscape unit was used to determine overall park wide trends. As seen in Figure 2a, b and c, there is a trend of an increasing proportion of the park adequately covered by sampled plots at progressively coarser resolutions.

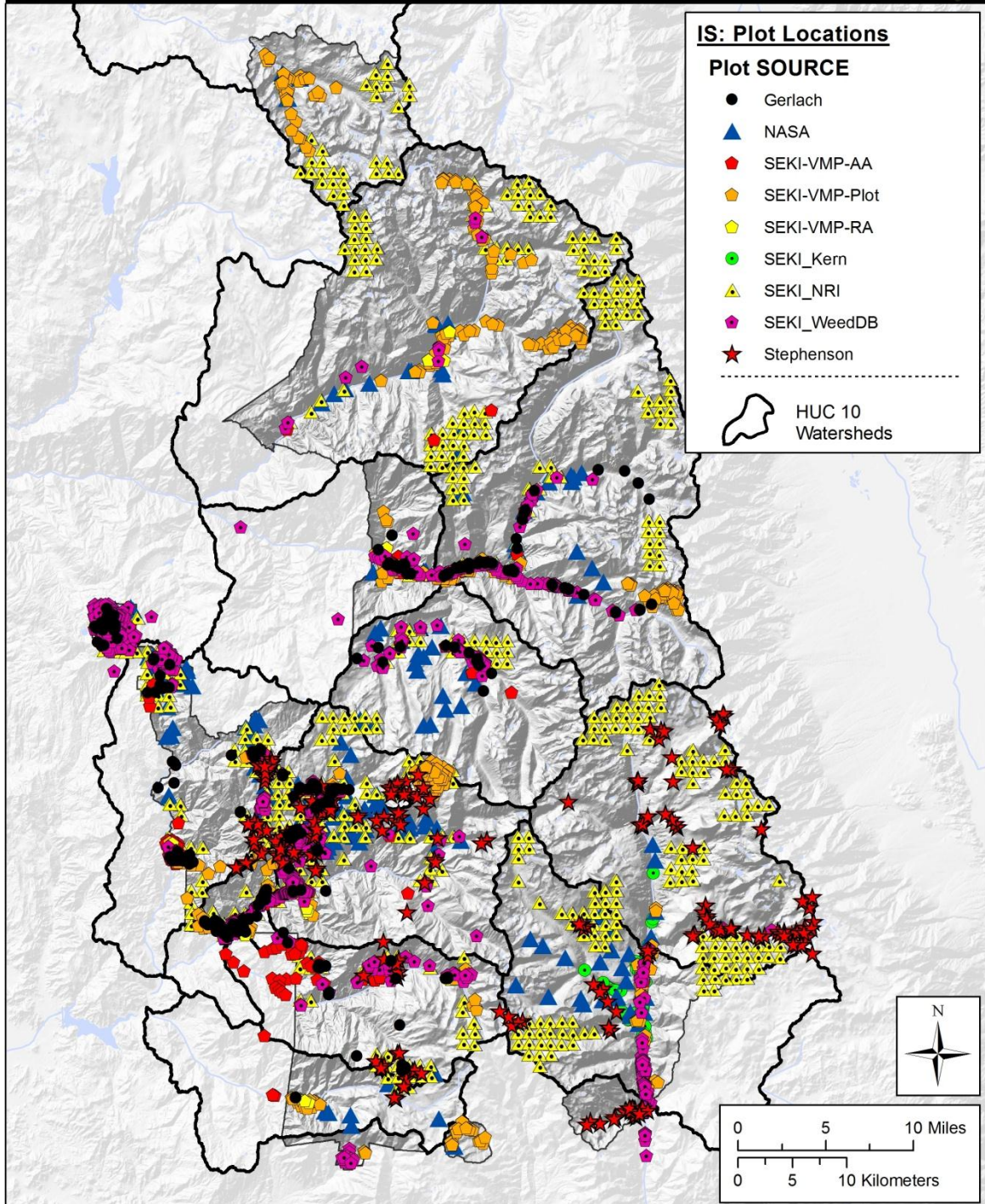


Figure 1a. Map of actual sampled plot locations for non-native plants, sorted by data source.

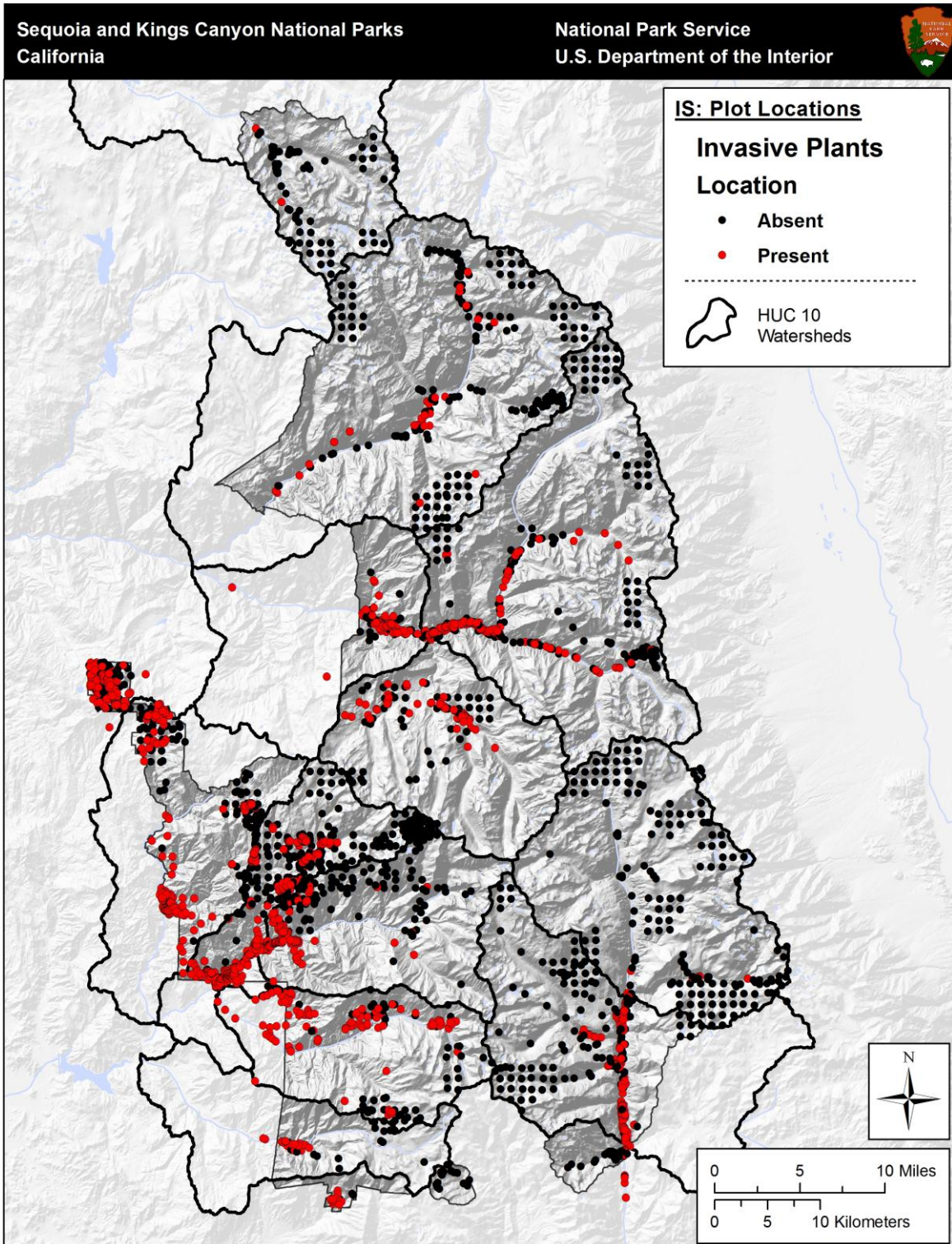


Figure 1b. Map of actual sampled plot locations for non-native plants, displaying those plot locations where invasive plants were recorded as present or absent.

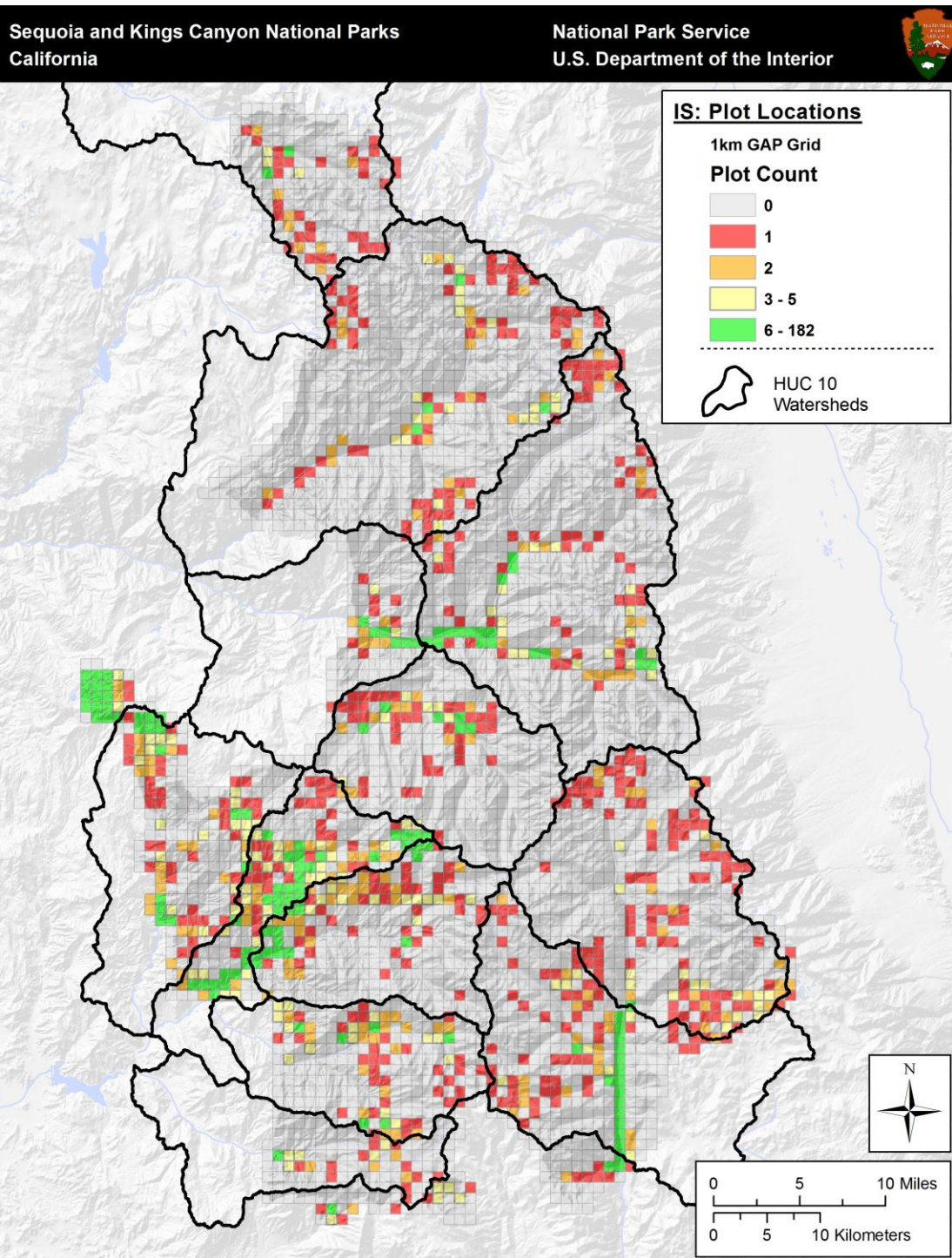


Figure 2a. Gap analysis of sampled plot counts by location for non-native plants at the 1.0 square kilometer scale.

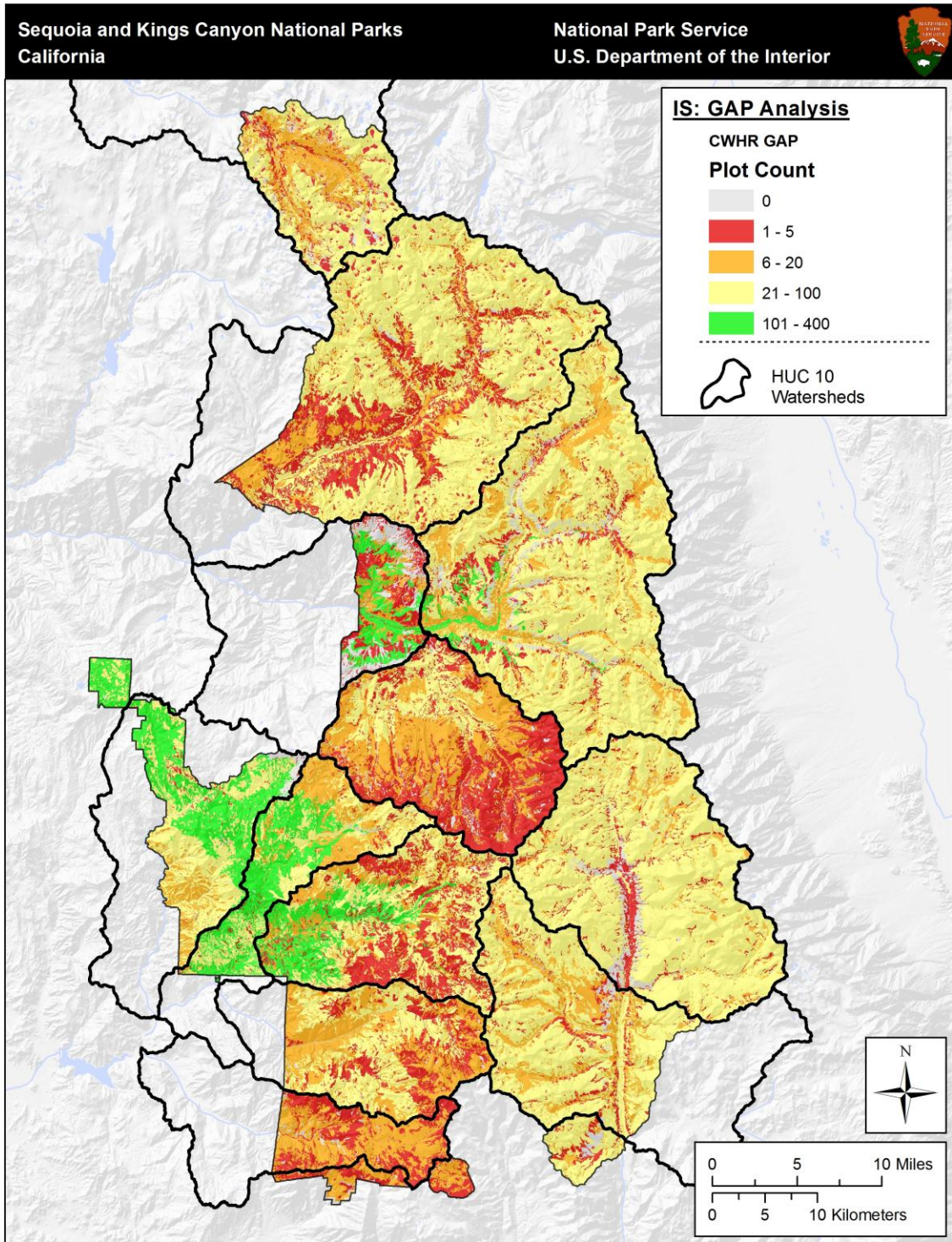


Figure 2b. Gap analysis of sampled plot counts by location for non-native plants at the CWHR vegetation type scale.

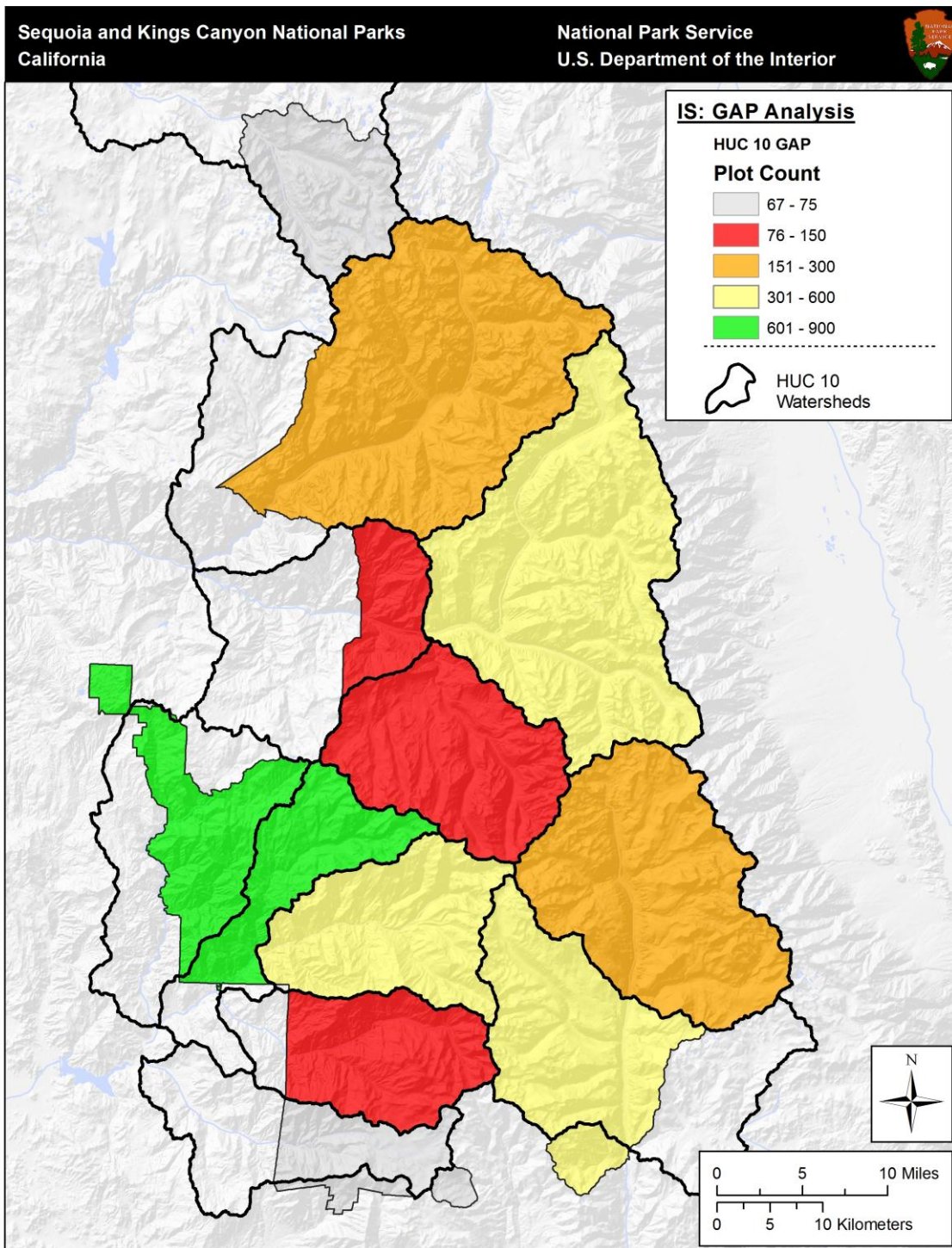


Figure 2c. Gap analysis of sampled plot counts by location for non-native plants at the HUC 10 landscape unit scale.

The map of CWHR vegetation types (Figure 2b) and Figure 3 show that 96% (25 out of 26) of the vegetation types present in the park have been surveyed or inventoried with at least one sample at this scale, and that 73% (19 out of 26) of these vegetation types had been more-or-less adequately sampled with at least 20 samples per type (For this NRCA report, since each data set was collected using different sampling methods, we assumed 20 samples per unit would be sufficient to provide enough data without too much variation). Similarly, there are 26 total HUC 10 units that are present at some extent in the park, and 85% (22 out of 26) of the HUC 10 units have been surveyed or inventoried for non-native plants (Figure 4). However, only 65% (17 out of 26) of these HUC 10 units have been sampled with at least 20 samples per unit. The HUC 10 units with very few samples are likely those that have very little area within the park boundary.

Our results further show that of the CWHR vegetation types, and relative to how much area (in square kilometers) is covered by each type, the best sampled are the Valley Foothill Riparian, Blue Oak Woodland, Ponderosa Pine, Wet Meadow, Mixed Chaparral, Sierran Mixed Conifer, and Montane Hardwood vegetation types. The types that are undersampled for their area are the Sub-Alpine Conifer, Barren, Red Fir, Jeffrey Pine, and Lodgepole Pine vegetation types. Correspondingly at the HUC 10 scale, the best sampled units for their specified area are the Kings River-Mill Flat Creek, Kaweah River-Marble Fork-Kaweah River, Kaweah River-North Fork, Kaweah River-Middle Fork, Kings River-Lower South Fork, and Kern River-Golden Trout Creek units. The most undersampled units are Kings River-Middle Fork, San Joaquin River-Upper South Fork, Kern River-Rock Creek, Kaweah River-South Fork, Kings River-Roaring River, and the Kings River-Upper South Fork units.

Finally, we show the distribution of sampled plots by elevation to determine if certain elevation bands within the park are better sampled than others for non-native plants. Figure 5 illustrates that all elevation bands, in 500 meter increments, were well represented by non-native plant survey or inventory sampled plots with at least 100 plots per elevation band, except at the highest elevations (above 4,000 meters). Lower elevations (below 2,500 meters) are relatively well-sampled, and the higher elevations are likely undersampled for their respective areas. However, since most non-native plants tend to occur in disturbed areas at lower elevations in the park, we believe that we have sufficient sample data across elevations for our analyses.

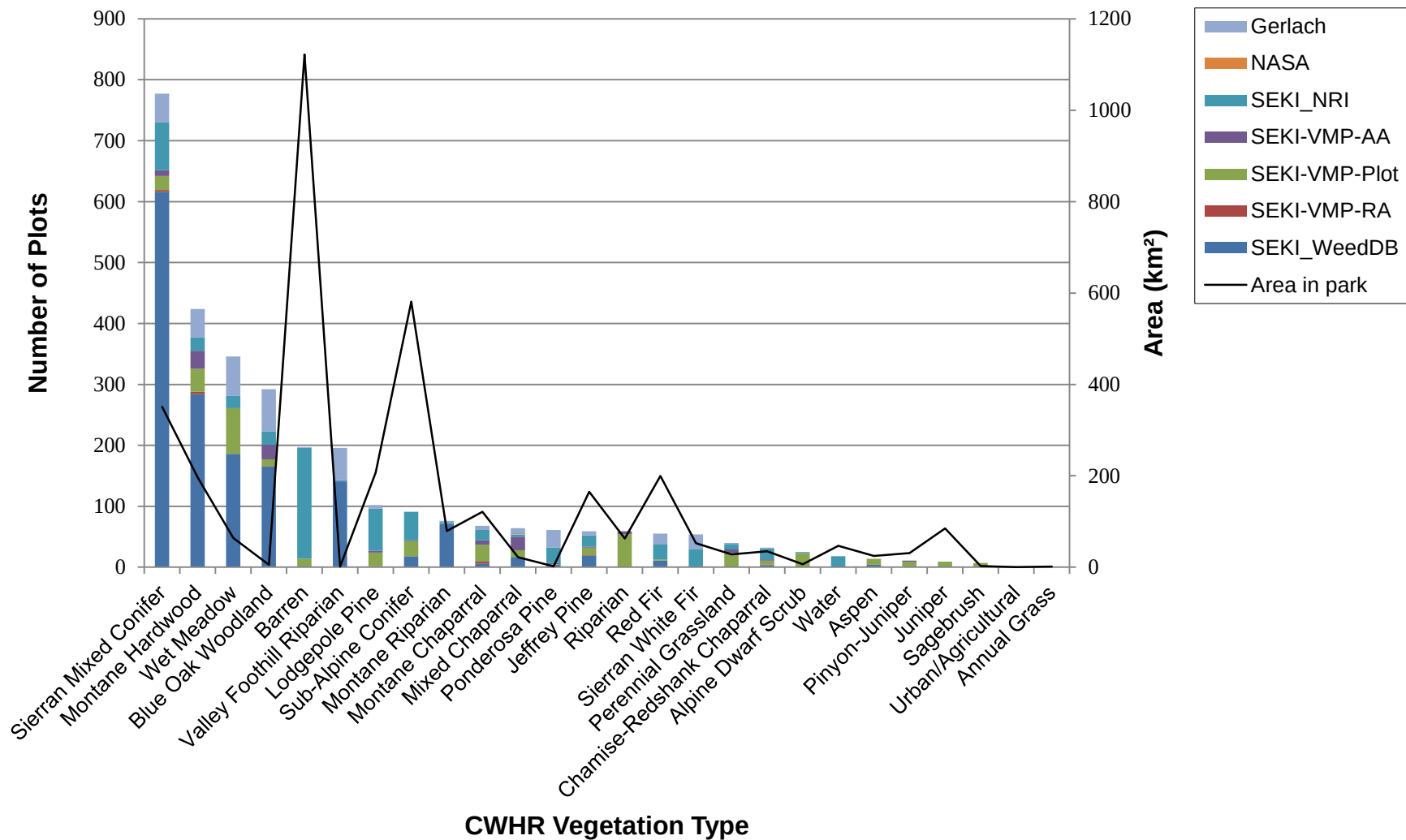


Figure 3. Total number of plots by CWHR vegetation type, which shows the distribution of sampled plots by data set. The secondary y-axis displays the total area (in square kilometers) that make up each vegetation type in the park.

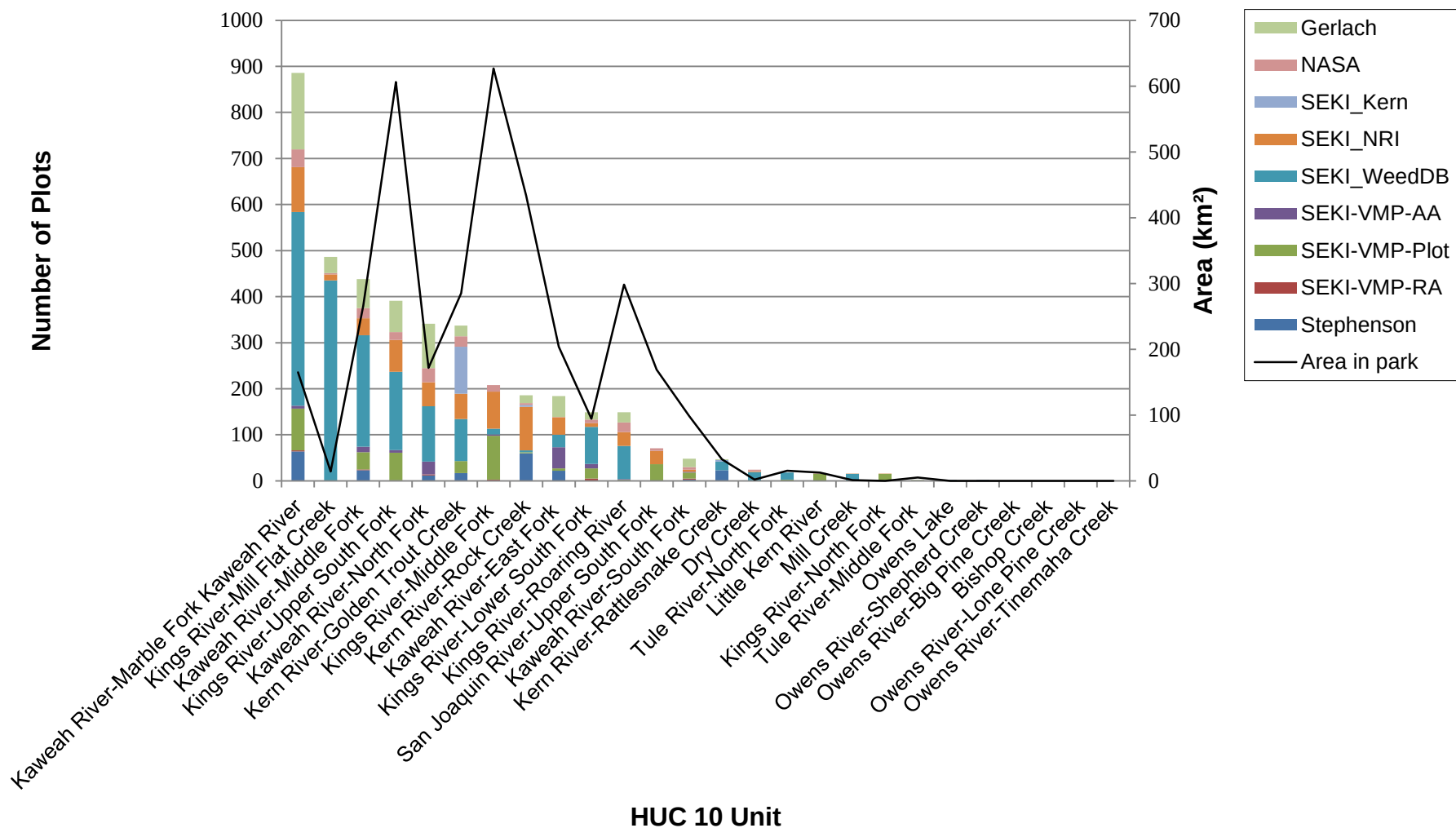


Figure 4. Total number of plots by HUC 10 landscape unit, which shows the distribution of sampled plots by data set. The secondary y-axis displays the total area (in square kilometers) that make up each HUC 10 unit in the park.

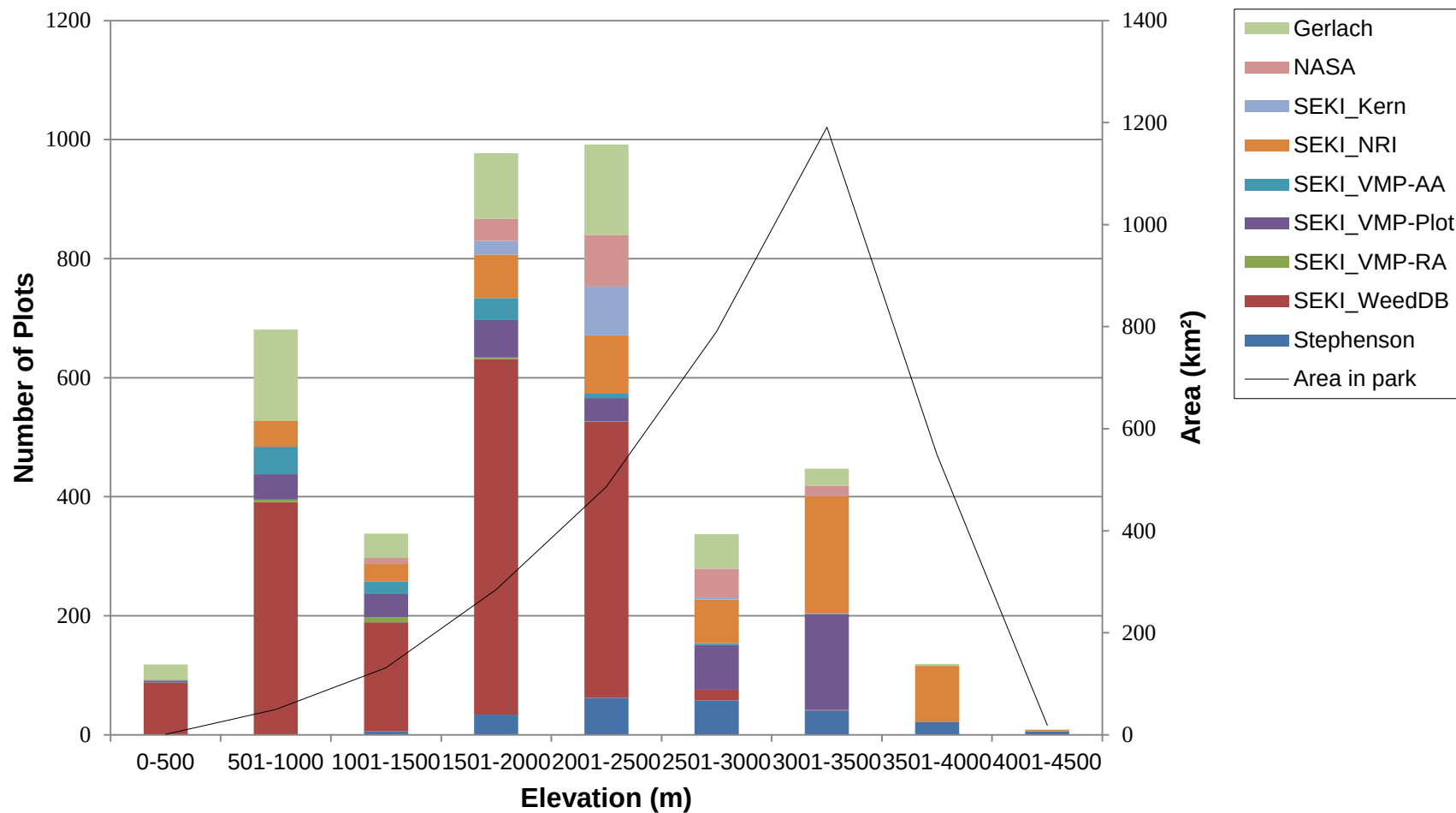


Figure 5. Total number of plots by elevation band, shown in 500 meter increments, and also illustrates the distribution of sampled plots by data set. The secondary y-axis displays the total area (in square kilometers) that comprise each elevation band in the park.

Which non-native plants are present in the Park, and what are their distributions?

A complete list of all 219 non-native plant taxa in SEKI are presented in Appendix 1. For comparison, Yosemite National Park, which has actively managed non-native invasive weeds since the 1930s, reports a total of 177 non-native plant species (NPS 2008, 2010). Further, Yosemite reports that about 10 new non-native species are found every year (M. Hutten, pers. comm. to A. Demetry). At lower elevations and near the coast, the Santa Monica Mountains National Recreation Area reports 334 non-native species from their vascular plant species list (NPS 2006b).

Appendix 2 then lists the top 78 species that the USGS (Gerlach et al. 2003) assessed as invasive and placed into categories for management prioritization. Gerlach et al. (2003) separated these 78 species into three management categories:

Management Category 1: Exotics that are currently restricted to a relatively small number of sites in each park and have been shown either to greatly affect native vegetation or to have a high probability of causing serious impacts. They require immediate management action to isolate and eliminate their populations. (54 species)

Management Category 2: Exotics that are generally predicated to have a lesser effect on native vegetation and are restricted to a relatively small number of sites. These predictions are based on very little data. In some park locations, Category 2 species can be eliminated along with Category 1 species without expending significant additional resources. (20 species), and

Management Category 3: Exotics that have been shown to have a great effect on native vegetation, are broadly distributed in the parks, and are apparently increasing their ranges within the parks. Category 3 dicot species cannot be eliminated without expending a significant amount of park resources. Category 3 grass species will be impossible to eliminate, and management efforts should focus on sites of great importance and on reducing seed dispersal (4 species).

Finally, the SEKI Weed Management Plan lists 19 species that the park is actively managing (Appendix 3). For the purposes of this NRCA report, we further created a shorter list of nine “transformer” species (as defined in Richardson et al. 2000) that have wide-ranging impacts on park resources and diversity (Appendix 4). These transformer species are those that not only displace native plant species and habitats, but are also able to modify or alter ecosystem functions. Table 2 describes the commonly associated vegetation types where these transformer species are typically found within SEKI, and also depicts some of the processes that may be altered. We were interested in knowing the locations and distributions of these transformer species, as well as determining if there are discernable differences in species distributions between transformer species and other larger groupings (all non-native plants, Gerlach’s top 78, management top 19) of non-native plants.

The distribution and number of occurrences of the 78 invasive non-native plant species in the park, with the top 19 and transformer species highlighted, are shown in Figure 6. This figure does not include those taxa with three or fewer occurrences in the park. Figure 6 reveals that the

twelve most common non-native plants in the park are Italian thistle (*Carduus pycnocephalus*), bull thistle (*Cirsium vulgare*), cheatgrass (*Bromus tectorum*), mullein (*Verbascum thapsus*), yellow salsify (*Tragopogon dubius*), velvet grass (*Holcus lanatus*), foxglove (*Digitalis purpurea*), Kentucky bluegrass (*Poa pratensis*), reed canarygrass (*Phalaris arundinacea*), lambsquarters (*Chenopodium album*), Armenian blackberry (*Rubus armeniacus*), and curvseed butterwort (*Ranunculus testiculatus*). Even though these twelve most common species comprise almost 90% of all recorded non-native plant occurrences in the park, this may be an artifact of the park's choice to manage and control these species, because one of the main data sources, the Weed Management Database, targets species chosen for management for survey, mapping, and documentation. Therefore the high number of occurrences of these common species may not accurately reflect the actual proportion of these plants across the park landscape.

Figure 7 displays the distribution of these 78 species across an elevation gradient, as well as their elevation range from plot samples within the park, again excluding those taxa with three or fewer occurrences. It seems evident that those taxa with larger numbers of occurrences are also those that experience a wide elevation range within the park. For instance, Italian thistle, cheatgrass, bull thistle, and Kentucky bluegrass all occur over a range of 1,000 meters in elevation. Lastly, the locations of the nine transformer species spatially across the park are depicted in Figure 8, and show that cheatgrass is the most widely distributed of the transformer species across the park and that most mapped locations are along roads and disturbed areas.

Table 2. List of Transformer Species and Impacts

Scientific Name	Common Name	Associated Vegetation Type(s) within SEKI	Processes Altered/Impacts	References
<i>Arundo donax</i> L.	giant reed	Riparian, freshwater aquatic systems, meadows & seeps, marshes & swamps	High water use, light suppression of competing species, water temp increase, displaces native vegetation	Hoshovsky 1986, DiTomaso 1998a, Iverson 1998, Dudley 2000
<i>Bromus tectorum</i> L.	cheat grass	Valley & foothill grasslands, woodlands, lower montane coniferous forests	Alters frequency, extent and timing of wildfires, outcompetes native veg by outcompeting for soil moisture	Whisenant 1989, Melgoza et al. 1990, Moseley et al. 1999, Young 2000
<i>Centaurea solstitialis</i> L.	yellow star thistle	Valley & foothill grasslands, cismontane woodlands	Depletes soil moisture, displaces native plants, fragments habitats	Borman et al. 1992, Roche et al. 1994, Gerlach et al. 1998, Sheley et al. 1999, DiTomaso et al. 2006
<i>Genista monspessulana</i> (L.) L. Johnson	French broom	Chaparral, valley & foothill grassland, riparian woodland, riparian scrub, cismontane woodland, broadleaved upland forest	Alters fire regime, increasing fire frequency and intensity, alters nutrient and water cycling	Hoshovsky 1986, Carreira & Niell 1992, Bossard 2000
<i>Phalaris arundinacea</i> L.	reed canary grass	Riparian, meadow & seeps, wetlands	Outcompetes native vegetation, elevates wetlands, alters sedimentation	Apfelbaum & Sams 1987, Maurer et al. 2003, Tu 2006
<i>Rubus armeniacus</i> Focke (<i>R. discolor</i> Weihe & Nees) & <i>Rubus laciniatus</i> Willd.	Armenian/ Himalayan blackberry & cut-leaved blackberry	Meadows & seeps, riparian forest, riparian woodlands and scrub, cismontane woodland, broadleaved upland forest, lower montane coniferous forest	Shades and displaces subcanopy vegetation, flammable, reduces soil moisture	Hoshovsky 1989, 2000
<i>Spartium junceum</i> L.	Spanish broom	Valley & foothill grassland, riparian woodland, cismontane woodland, broadleaved upland forest, lower montane coniferous forest	Changes soil chemistry and fire intensity, reduces biomass & diversity of native species	Nilsen & Semones 1997, Nilsen 2000
<i>Tamarix</i> sp. L.	tamarisk	Riparian forest & woodlands, meadows & seeps, riparian scrub	High water use, deposits salts on soil surface, alters hydrology, fire	Busch & Smith 1992, DiTomaso 1998b, Lovich 2000

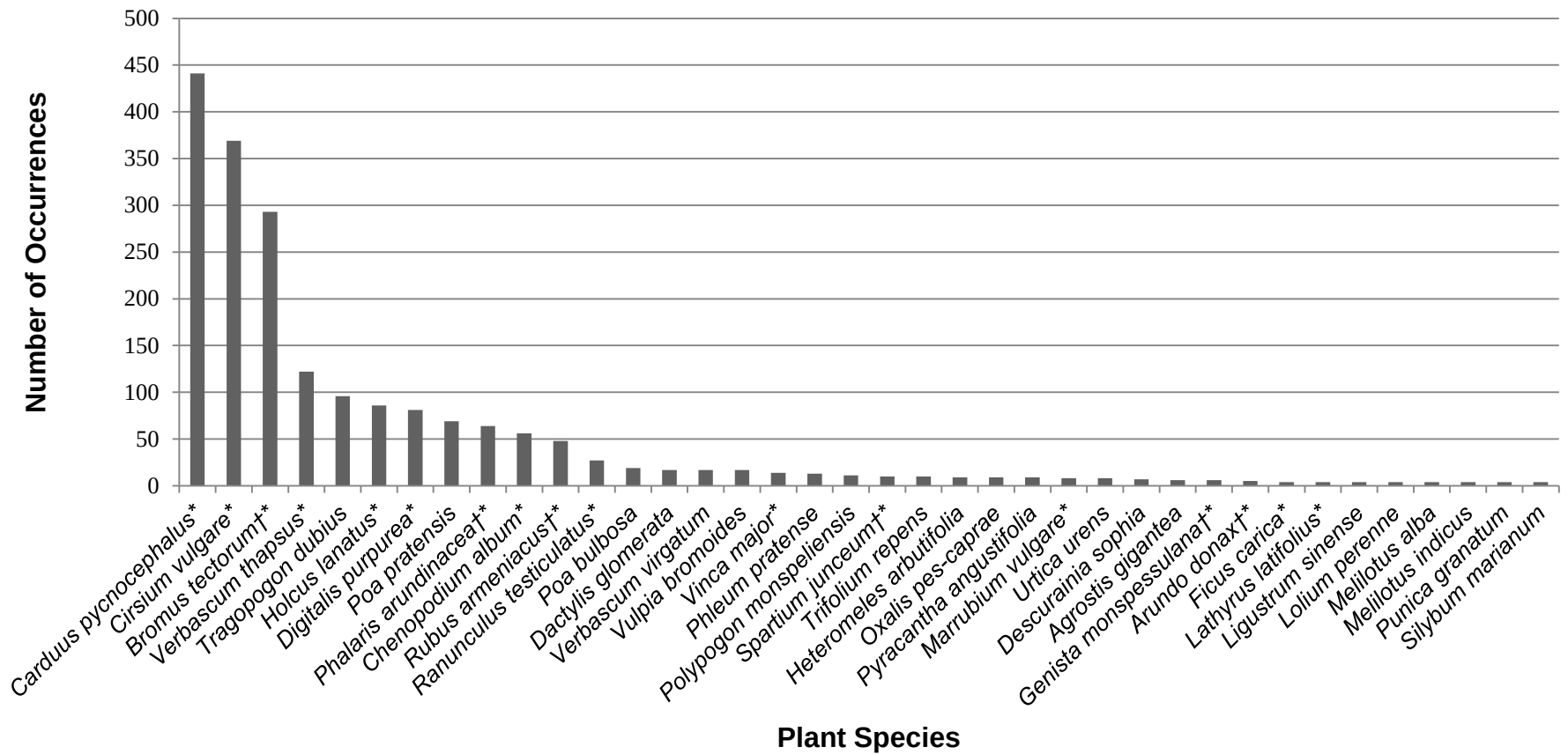


Figure 6. Number of occurrences of each of the Top 78 non-native invasive plant species recorded from plot data from across the park. Those species with three or fewer occurrences are not represented. Superscripts indicate those species that are also included as part of the Top 19 (SEKI Weed Management Plan) or as a Transformer species, with * = Top 19 and †= Transformer.

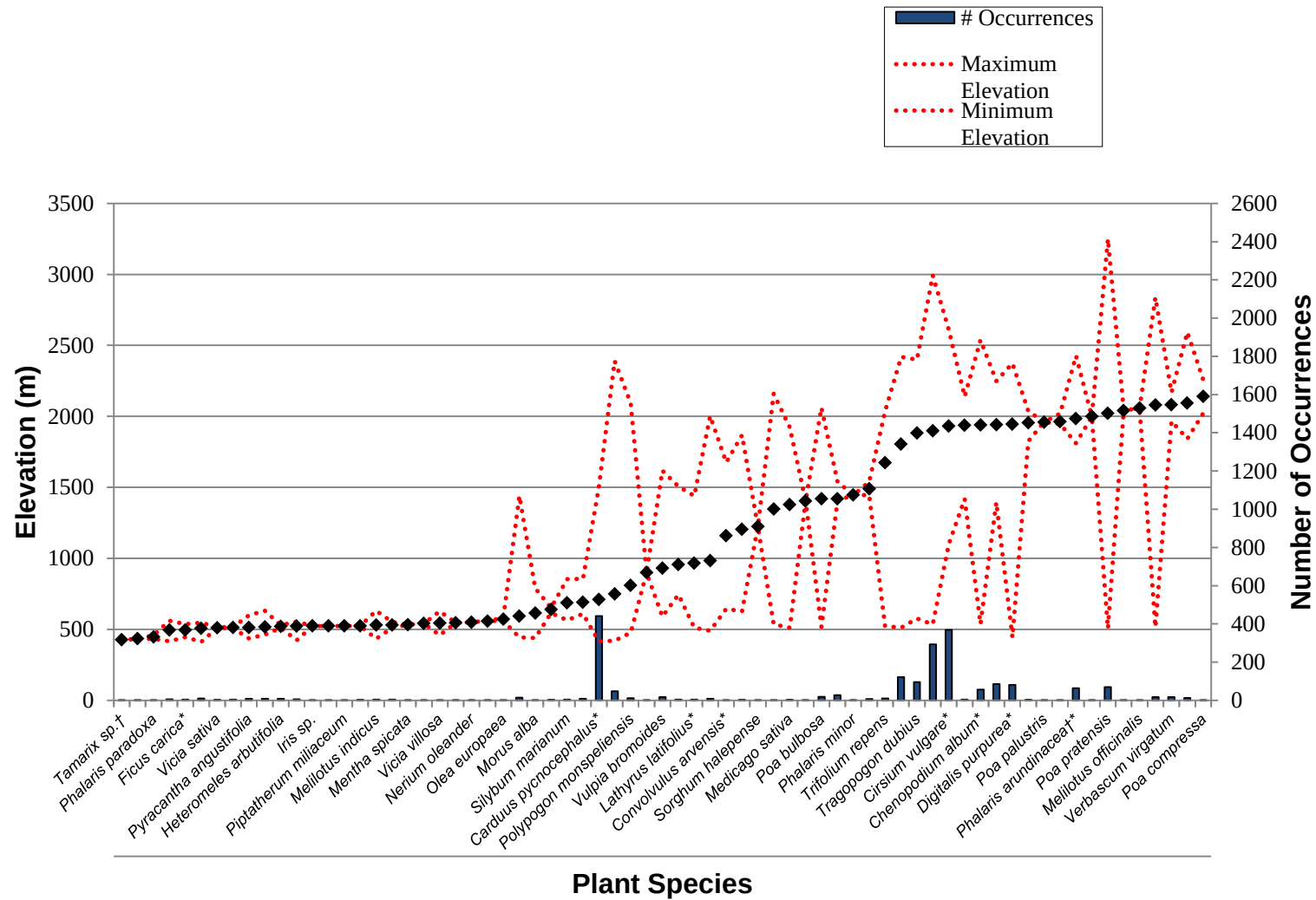


Figure 7. Average elevation and elevation ranges (dotted lines) of the Top 78 non-native invasive plants, recorded from plot data from across the park. Those species with three or fewer occurrences are not represented. Superscripts indicate those species that are also included as part of the Top 19 (SEKI Weed Management Plan) or as a Transformer species, with * = Top 19 and † = Transformer. The secondary y-axis displays the same information as Figure 6.

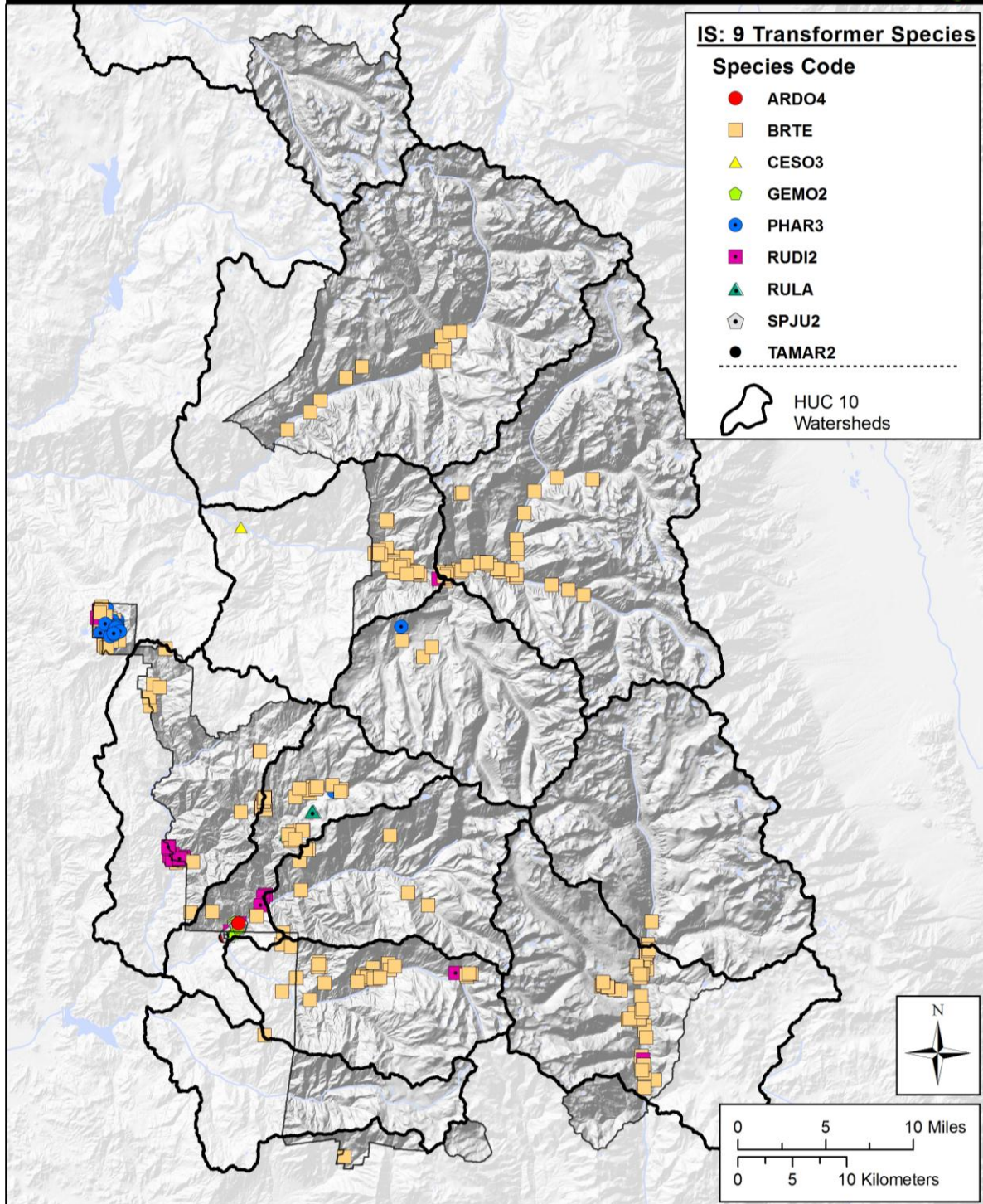


Figure 8. Map displaying the distributions of the nine transformer species. Transformer species are as follows: ARDO4 = *Arundo donax*, BRTE = *Bromus tectorum*, CESO3 = *Centaurea solstitialis*, GEMO2 = *Genista monspessulana*, PHAR3 = *Phalaris arundinacea*, RUDI2 = *Rubus armeniacus*, RULA = *Rubus laciniatus*, SPJU2 = *Spartium junceum*, TAMAR2 = *Tamarisk ramossissima*.

Which non-native species pose the highest threat to park resources?

As mentioned in the previous section, Figure 6 displays the total number of occurrences per plant species, of the top 78 non-native invasive species. Of these occurrences, the most common non-native species encountered in sampling plots is Italian thistle, followed by bull thistle and cheatgrass. Also noteworthy, is that 10 of the top 12 most commonly encountered species are those that are currently being actively managed in SEKI, as part of the “top 19” species mentioned in the SEKI Weed Management Plan. Lastly, those plants with three or fewer occurrences across the entire park are not represented in Figure 6, but are listed below in Table 3. Some of these species in Table 3, especially those with only one known occurrence, might have been intentionally planted (A. Demetry, pers. comm.), especially those located near old homesteads and are known ornamentals, for instance, English walnut (*Juglans regia*), oleander (*Nerium oleander*), white mulberry (*Morus alba*), and olive (*Olea europaea*). However, since the plants in Table 3 have limited occurrences and distributions across the entire park, and/or may be relatively newly established species, they are good candidates for early detection and rapid response efforts, as it is possible to eliminate these species from park boundaries.

To best determine which non-native plant taxa pose the highest risk to the park spatially, we would need to overlay our data with priority park resources to determine the highest priorities for management (Timmins & Owen 2001). This task is beyond the scope of this analysis, but is recommended for inclusion when the park creates a new Invasive Plant Management Plan. In the interim, the first author believes that the current SEKI Invasive Plant Management Annual Work Plan (Demetry 2010) does a relatively thorough treatment of evaluating and ranking management priorities by invasive plant taxa and locations for the commonly occurring species and known threats. For those taxa that only occur rarely in the park (Table 3), we recommend rapidly responding to eradicate those few populations, if possible, especially those taxa that are known invaders elsewhere or are easily dispersed. For instance, yellow starthistle (*Centaurea solstitialis*) and salt cedar (*Tamarix* sp.) are known invaders elsewhere, and are already being actively managed by the park. Additionally, English ivy (*Hedera helix*), pennyroyal (*Mentha pulegium*), and meadow fescue (*Festuca pratensis*) should be considered for active management.

Finally, while Figure 7 illustrates the mean elevation and ranges of the top 78 non-native plant species in the park, this figure only shows the distribution of species across an elevation gradient. What is more interesting, and may have further management implications, is Table 4, which highlights those species that have been recorded in the park at elevations beyond those cited from the literature. Species ranges from the literature are taken from the Jepson Manual (Hickman 1993), Weeds of California and Other Western States (DiTomaso & Healy 2007), and the new Jepson Online Interchange (2011). We speculate that this sizeable number (28 species) of range extensions might be attributed for several reasons. A lack of making and obtaining voucher specimens, especially those focused on non-native species, and then not reporting this data or sending duplicate specimens to larger herbaria, may partially explain the reason for all of the range extensions. Another potential cause for at least some species, are that some plants (especially those that only occur in one or two instances) may have been intentionally planted at higher elevations for ornamental or other purposes. It is documented at SEKI that the vast majority of intentional plantings are at Ash Mountain at about 500 meters elevation, or are from historic settlements in the foothills (A. Demetry, pers. comm.). Taxa that may have been

intentionally planted as ornamentals include apple (*Malus sylvestris*), pomegranate (*Punica granatum*), olive, and English walnut.

A final possibility of elevation range expansion is that some taxa may be experiencing range increases due to climate change adaptations, or that those species have finally developed enough of a propagule source to spread upwards in elevation. Some of the taxa at the top of our list in Table 4, especially those with sizable number of occurrences seem to indicate that this might be the case, as it is unlikely that those taxa with more than 40 occurrences would have been planted intentionally, and are likely in self-sustaining populations. For instance, it seems likely that Armenian blackberry, lambsquarters, reed canarygrass and foxglove are at the upper limits of their elevation range.

Regardless of the reason for these elevation range expansions, the species listed in Table 4, especially those that exhibit range expansions beyond several hundred meters, should be considered as species that are actively expanding their suitable range upwards in elevation, and may become (if not already) highly impactful invaders in new and novel habitats and communities.

Table 3. List of non-native plant species that currently occur in three or fewer occurrences in the park. Superscripts indicate those species that are also included as part of the Top 19 (SEKI Weed Management Plan) or as a Transformer species, with * = Top 19 and †= Transformer.

Species Name	Number of Occurrences
<i>Ampelopsis arborea</i>	1
<i>Centaurea solstitialis</i> †*	3
<i>Convolvulus arvensis</i> *	2
<i>Echinochloa crus-galli</i>	2
<i>Eucalyptus citriodora</i>	1
<i>Festuca pratensis</i>	1
<i>Hedera helix</i>	3
<i>Iris sp.</i>	1
<i>Juglans regia</i>	1
<i>Malus sylvestris</i>	1
<i>Medicago sativa</i>	3
<i>Melilotus officinalis</i>	1
<i>Mentha pulegium</i>	1
<i>Mentha spicata</i>	1
<i>Morus alba</i>	1
<i>Nerium oleander</i>	2
<i>Olea europaea</i>	2
<i>Phalaris minor</i>	1
<i>Phalaris paradoxa</i>	2
<i>Piptatherum miliaceum</i>	1
<i>Poa compressa</i>	2
<i>Poa palustris</i>	1
<i>Polypogon interruptus</i>	1
<i>Ranunculus parviflorus</i>	3
<i>Rubus laciniatus</i> †	3
<i>Sorghum halepense</i>	1
<i>Tamarix sp.</i> †	1
<i>Tanacetum parthenium</i>	1
<i>Vicia benghalensis</i>	1
<i>Vicia sativa</i>	3
<i>Vicia villosa</i>	2

Table 4. List of non-native invasive plant species that have been recorded at elevations exceeding those previously reported in the literature, sorted by total change in elevation (representing a range expansion upwards in elevation). Superscripts indicate those species that are also included as part of the Top 19 (SEKI Weed Management Plan) or as a Transformer species, with * = Top 19 and †= Transformer.

Scientific Name	Number of Occurrences	Elevation Range from the Literature (m)	Maximum Elevation recorded at SEKI (m)	Change in Elevation (m)
<i>Phalaris minor</i>	1	0-300	1446	1146
<i>Rubus armeniacus</i> †*	48	0-1600	2389	789
<i>Chenopodium album</i> *	56	0-1800	2538	738
<i>Phalaris arundinacea</i> †*	64	0-1700	2427	727
<i>Digitalis purpurea</i> *	81	0-1700	2373	673
<i>Verbascum virgatum</i>	17	5-1555	2168	613
<i>Trifolium repens</i>	10	0-1500	2034	534
<i>Lolium perenne</i>	4	0-1000	1506	506
<i>Poa compressa</i>	2	0-1800	2259	459
<i>Malus sylvestris</i>	1	0-1000	1404	404
<i>Pyracantha angustifolia</i>	9	0-200	600	400
<i>Olea europaea</i>	2	0-200	582	382
<i>Juglans regia</i>	1	0-200	558	358
<i>Dactylis glomerata</i>	17	0-2500	2837	337
<i>Cirsium vulgare</i> *	369	0-2350	2609	259
<i>Marrubium vulgare</i> *	8	0-600	855	255
<i>Melilotus alba</i>	4	0-1900	2139	239
<i>Eucalyptus citriodora</i>	1	0-200	434	234
<i>Piptatherum miliaceum</i>	1	0-300	524	224
<i>Phalaris paradoxa</i>	2	0-300	459	159
<i>Echinochloa crus-galli</i>	2	0-2000	2159	159
<i>Rubus laciniatus</i> †	3	60-1900	2037	137
<i>Vulpia bromoides</i>	17	0-1500	1618	118
<i>Sorghum halepense</i>	1	0-1160	1224	64
<i>Poa bulbosa</i>	19	0-2000	2061	61
<i>Punica granatum</i>	4	0-500	552	52
<i>Festuca pratensis</i>	1	0-2000	2041	41
<i>Agrostis gigantea</i>	2	0-2000	2020	20

What factors are most associated with where weeds are located, and level of invadedness?

To adequately address which factors are most associated with where non-native plants are located within SEKI, we would need to complete further analyses using classic vegetation ecology methods such as a canonical correspondence, detrended correspondence, or nonmetric multidimensional scaling analyses. Since our time and data were limited in this NRCA project, and we did not have certain supplemental information available such as soil type, soil nutrients, slope, aspect, distance to disturbed areas, etc. for the sampled plots, we were not able to complete a detailed analysis of these related factors.

It is well-established in the literature however, that the presence and abundance of non-native invasive plants and the vulnerability of ecosystems to non-native plant invasion are correlated and may be partially explained by a variety of factors. Rejmánek (1989) and Rejmánek et al. (2005) review the literature and cite that the most important factors and processes that are assumed responsible for invasions of exotic species into plant communities are the availability of resources, natural and human-caused disturbances, input of propagules, and the actual identity of the exotic species. Others have also alluded to similar factors that contribute to invadedness. For instance, disturbances such as roads and trails (Gelbard & Belnap 2003), streams and/or flooding (Parendes & Jones 2000), altered fire regimes (Brooks 2006, Zouhar et al. 2008) and a history of grazing (Keeley et al. 2003) are typically highly correlated with invasive plant richness and abundance.

In SEKI and the Sierra Nevadas, Gerlach et al. (2003) clearly showed a high correlation of elevation and the presence of non-native plants in disturbed areas, such as campgrounds/camps, developments, pack stations, trails, dirt roads, pastures and riparian areas (Figure 9). Keeley et al. (2003) similarly concluded that exotic species richness and cover declined with increasing elevation, and added that a history of livestock grazing as well as fire severity and time since fire as important determinants of invasive plant presence. D'Antonio et al. (2004) adds that while the invasion of potentially problematic plant species in the Sierra Nevada are still at a relatively early stage, that the identification of pathways and vectors of invasion, especially those that are natural or human-caused disturbances, will likely play a role in the future spread of exotics into intact or not yet invaded plant communities. Schwartz et al. (1996) summarized that habitat disturbance, the introduction of exotic plant materials through horticulture, the quantity of non-natural habitats, the importation of landfill, and movement of animals and people as vectors, all contribute to invasion success. Schwartz et al. (1996) adds however, that estimated development pressure is the single most important factor in predicting invasiveness.

Park staff at SEKI bear out these conclusions that the strongest factors appearing to determine invasions within the parks are elevation, current or past disturbances such as roads, trails, recent fire and fire-fighting activities, helicopter landing sites, camps, and riparian sites. And, though a quantitative analysis was not completed, SEKI staff recognize a correlation of current infested areas with the intersection of these disturbances and high resource availability areas such as: meadows/streams/seeps/moist areas, sites with recent fires, locations with past and current stock activity (pastures and corrals), and gray water spray fields. Accordingly, these areas are given high priority with respect to both eradication and early detection efforts.

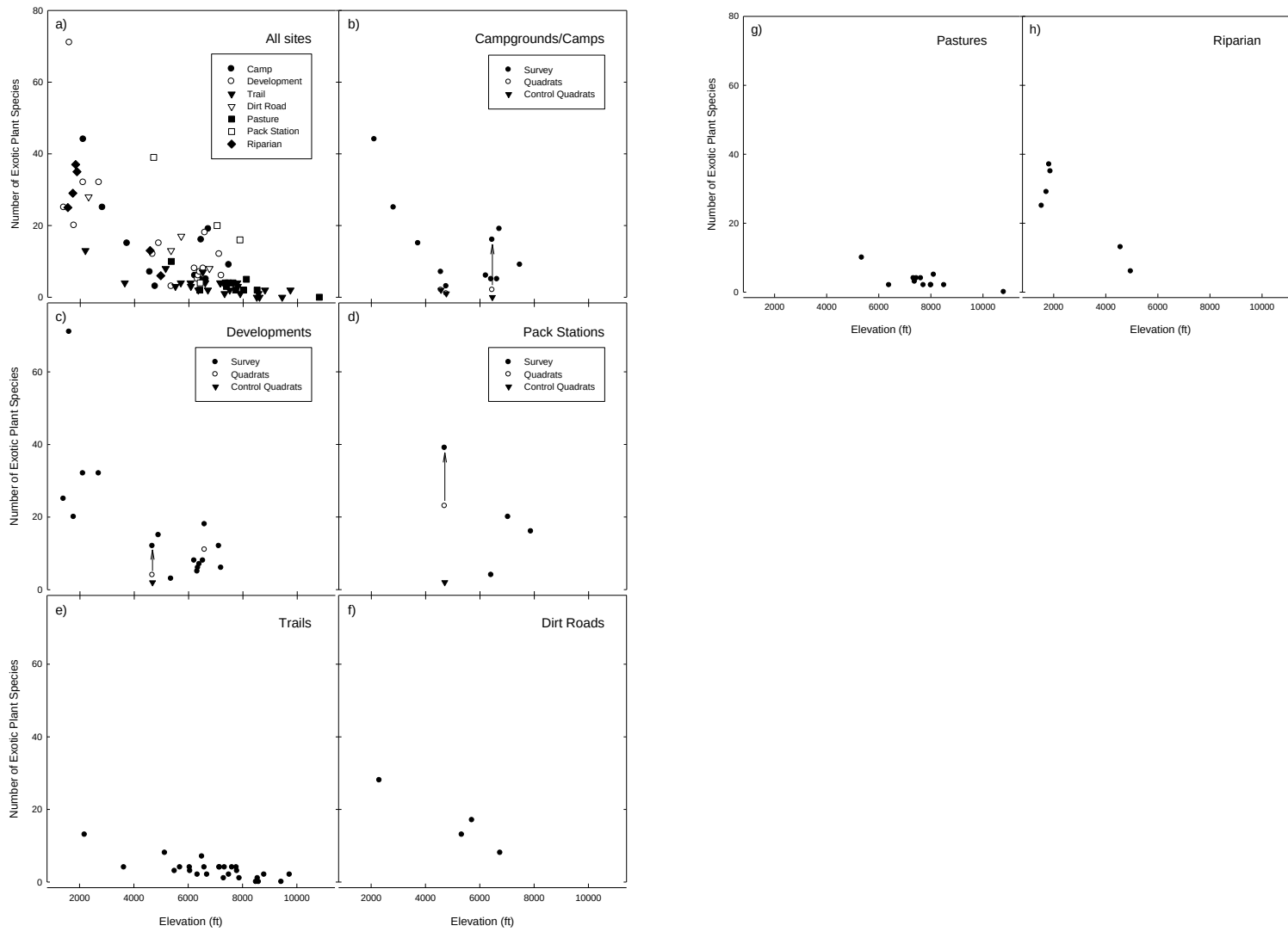


Figure 9. Non-native plant species richness by elevation and disturbance type (reproduced from Gerlach et al. 2003).

Which sites are the most highly-invaded, least-invaded and/or weed-free?

To determine which sites in the park are the most highly- and least-invaded by non-native invasive plants, we evaluated several measures of non-native plant abundance at both the CWHR vegetation type and HUC 10 unit scales. Sites that are relatively uninvaded or are weed-free can be used as “sentinel sites,” or as places that are a high priority to monitor on a regular basis for new incursions of invasive plants (early detection and rapid response to new invasive plant sites). Measures of abundance that were used on a per area basis included: the total number of non-native plant species, the average number of non-native plant taxa, the percent of vegetative cover that is infested with non-native plants (calculated as an average sum across that area), and the total number of infested hectares.

Figures 10a and 10b illustrate the degree of species richness and maximum vegetative cover, respectively, of non-native plants at the 1.0 square kilometer scale across the park. This spatial extent reveals that levels of non-native species richness and cover appear to be highly correlated (as expected), and that although there is likely bias in sampling, that non-native species are most commonly present in abundance near roads and other disturbed sites. Details of these resultant maps are further described in Tables 5 and 6 for CWHR vegetation types and HUC 10 units, respectively. We then used these two measures of abundance to derive our final stress condition maps (Figures 12 and 13), as described in the Stress portion of this report.

For the CWHR vegetation types, the Urban/Agricultural, Juniper, Sagebrush, and Annual Grass vegetation types are all severely undersampled (with 1, 9, 7 and 0 sampled plots, respectively), so do not provide much useful information. Based on those vegetation types with at least 20 samples, we determined that the top five most highly-invaded (based on percent non-native vegetative cover), in order, are the Blue Oak Woodland, Ponderosa Pine, Montane Hardwood, Chamise-Redshank Chaparral, and Valley Foothill Riparian vegetation types. This is similar to the findings reported by Schwartz et al. (1996) who also indicated that valley grassland, foothill oak woodlands, riparian zones, and disturbed areas are the most highly invaded habitats in the Sierra Nevada ecosystem. If we examine the average number of non-native plant taxa per vegetation type, the top five in order are Chamise-Redshank Chaparral, Blue Oak Woodland, Mixed Chaparral, Ponderosa Pine, and Valley Foothill Riparian.

The least-invaded CWHR vegetation types (excluding those types with fewer than 20 samples), from our data based on percent non-native vegetative cover are, in order, Alpine Dwarf Scrub, Pinyon-Juniper, Barren, Riparian, Montane Riparian. Likewise, the vegetation types with the least number of non-native plant taxa are Barren, Lodgepole Pine, Sub-Alpine Conifer, Perennial Grassland, and Montane Chaparral.

In the HUC 10 units, there were 11 out of 26 units that have fewer than 20 sample plots per unit, so we have excluded those units from our discussion. Of the HUC 10 units that were adequately sampled, the most highly invaded units based on non-native percent vegetative cover are the Kaweah River-Marble Fork-Kaweah River, Kaweah River-Middle Fork, Kaweah River-North Fork, Kings River Lower South Fork, and the Kaweah River-East Fork units. Based on the average number of non-native plant taxa, our results are similar in that the Kaweah River-North Fork, Kaweah River-Marble Fork Kaweah River, Kings River Lower South Fork, Kaweah

River-East Fork, and Kings River-Mill Flat Creek units have the most non-native plant taxa per HUC 10.

The least-invaded HUC 10 units based on percent infested are the Dry Creek, San Joaquin River-Upper South Fork, Kern River-Rock Creek, Kings River-Middle Fork, and the Kern River-Rattlesnake Creek units. Based on the average number of non-native plant taxa, that least-invaded units are San Joaquin River-Upper South Fork, Kern River-Rock Creek, Kings River-Middle Fork, Kern River-Rattlesnake Creek, and Kern River-Golden Trout Creek. Based on our findings therefore, we can begin to make some sentinel site designations for regularly monitoring for new invaders, based on those CWHR vegetation types and/or HUC 10 units that are relatively uninvaded.

What is the overall condition of the park, relative to non-native invasive plants?

Finally, Tables 5 and 6 display the estimated total number of hectares infested by non-native plants at SEKI, per CWHR vegetation and HUC 10 landscape unit respectively, and as a whole. These estimates were calculated from all of our available combined data, and are based on the estimated total percent vegetative cover by non-native plants. To arrive at the estimated total number of infested hectares across the park, we calculated the “Percent Infested” of each CWHR type or HUC 10 unit by summing the percent vegetative cover of all non-native plant species within a plot to obtain total percent cover of non-natives per plot, then averaged total percent cover, including zeros, for all plots per CWHR type or HUC 10 unit. We then summed the resultant estimated number of infested hectares per CWHR type or HUC 10 unit to determine the overall total number of infested acres. We realize that using “Percent Infested” is a very coarse measure, and also very likely provides a strong overestimate of invasion, since we used all of our available plant data in this analysis, and several data sets were heavily biased toward plots where non-natives are present (i.e., In both the USGS survey (Gerlach et al. 2003) and the SEKI Weed Management Database, plots were intentionally located in sites where non-native plants are present).

By using CWHR vegetation types, our data suggest that a maximum of 23,904 hectares, or 6.83% of the park may be covered by non-native plants. Using HUC 10 units, we estimate 30,346 hectares, or 8.66% of the park, may be covered by non-native plants.

Therefore, we believe that while these overall numbers are fairly accurate in magnitude (our educated guess is that the total percent infested is closer to 2 to 5 percent overall), our data provides an overestimate of invasion because of the bias toward presence explained above. In order to estimate the true proportion of the park invaded by non-native plants, random or systematic samples across the entire would be needed. As a comparison, if we only evaluate the NRI plots (which were located systematically across the park), only 3.13% of the park had non-native plant cover (data not shown here). Hence, we report the results of this analysis using all available plant data here, but acknowledge the shortcomings of the approach and urge heavy caution in the application of these results.

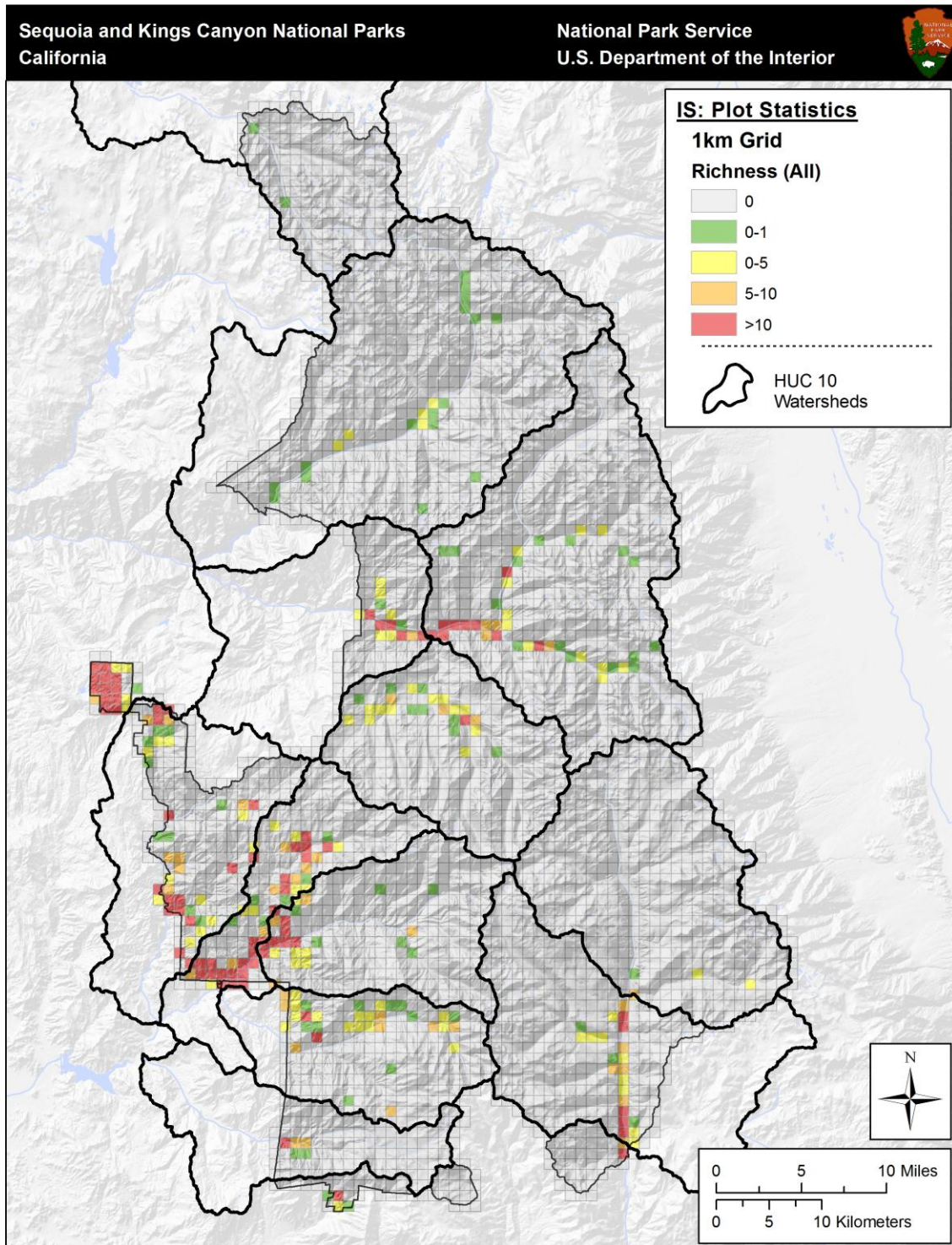


Figure 10a. Non-native plant species richness at the 1 square kilometer grid scale.

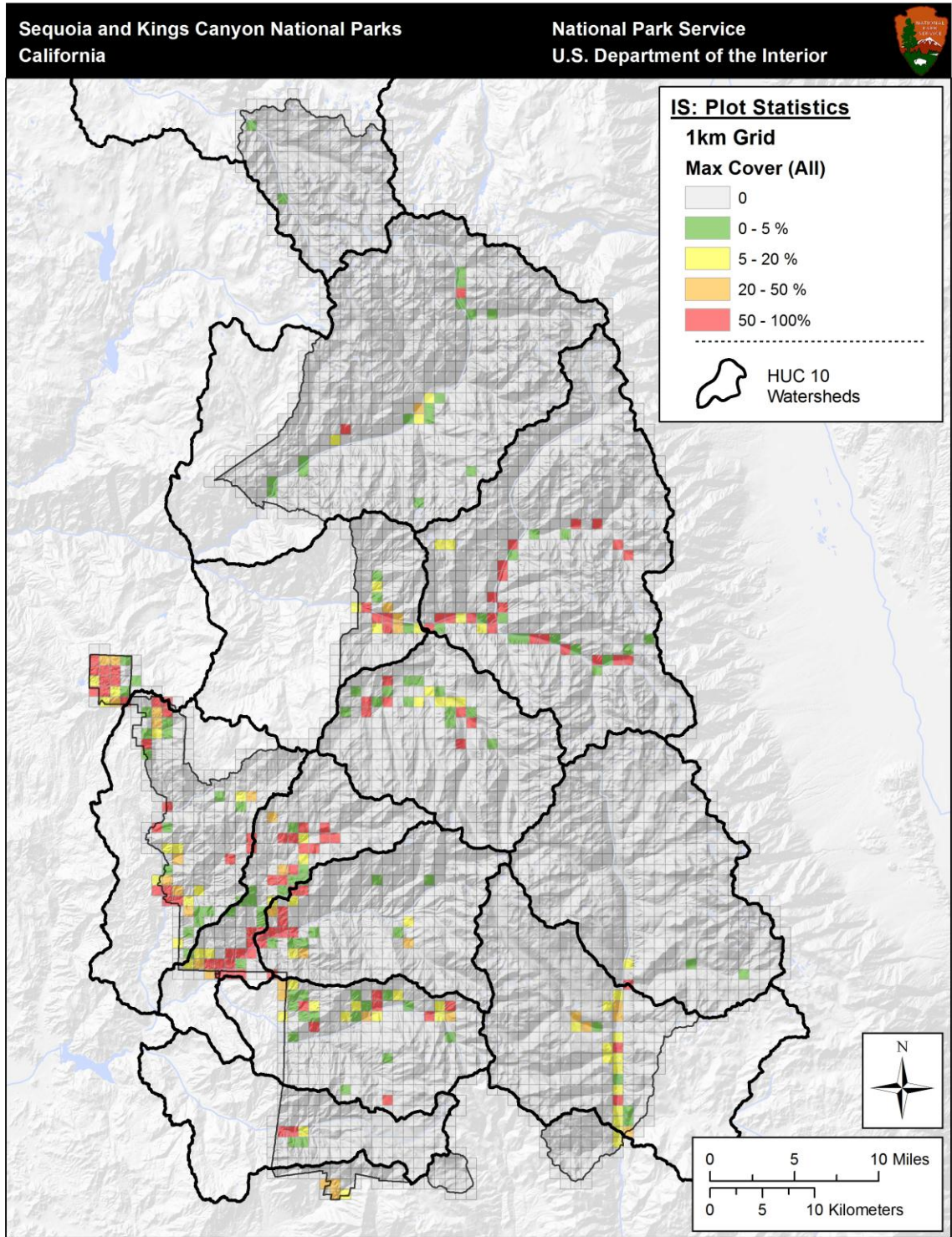


Figure 10b. Maximum percent vegetative cover of non-native plant species at the 1.0 square kilometer grid scale.

Table 5. Descriptive data for each CWHR vegetation type in the park. Superscripts indicate: a = no attributed data to this vegetation type; b = result is from combining the Chamise and Chamise-Redshank Chaparral vegetation types, c = result from combining Sequoia Big Trees Forest and Sierran Mixed Conifer vegetation types, and d = percent infested vegetative cover cannot be greater than 100%. *Values reported here are likely overestimates; see text for explanation.

CWHR Vegetation Type	Number of pLots (N=)	Total Number of NN Taxa per CWHR	Average Number of NN Taxa $\pm$ S.D per CWHR	Percent Infested * $\pm$ S.D	Number of Hectares per CWHR Type	Estimated Number of Infested* Hectares
Alpine Dwarf Scrub	25	0	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	673.55	0
Annual Grass	0				167.03	0.00a
Aspen	14	5	0.50 $\pm$ 0.65	3.36 $\pm$ 6.94	2492.29	83.85
Barren	197	1	0.02 $\pm$ 0.12	0.34 $\pm$ 4.49	112182	375.84
Blue Oak Woodland	292	125	2.80 $\pm$ 4.28	47.55 $\pm$ 113.10	553.84	263.34
Chamise-Redshank Chaparral	22	28	4.91 $\pm$ 4.34	27.82 $\pm$ 29.54	3505.99	975.25b
Chamise	10	19	4.90 $\pm$ 3.21	14.82 $\pm$ 17.39		
Jeffrey Pine	58	19	0.74 $\pm$ 1.07	8.45 $\pm$ 26.46	16488.89	1393.31
Juniper	9	2	0.22 $\pm$ 0.44	0.02 $\pm$ 0.04	8491.82	1.89
Lodgepole Pine	102	9	0.17 $\pm$ 0.49	2.90 $\pm$ 18.62	20688.42	600.17
Mixed Chaparral	64	36	2.06 $\pm$ 2.05	17.74 $\pm$ 19.74	2197.34	389.83
Montane Chaparral	68	19	0.59 $\pm$ 1.12	10.32 $\pm$ 24.45	12131.24	1251.48
Montane Hardwood	424	103	1.35 $\pm$ 1.70	27.10 $\pm$ 70.34	19621.48	5318.19
Montane Riparian	76	12	1.17 $\pm$ 0.94	2.42 $\pm$ 7.78	828.75	20.02
Riparian	59	23	1.07 $\pm$ 1.74	1.35 $\pm$ 4.12	7902.23	106.35
Perennial Grassland	40	8	0.45 $\pm$ 1.08	8.87 $\pm$ 21.58	2806.11	248.83
Pinyon-Juniper	11	2	0.64 $\pm$ 0.50	0.24 $\pm$ 0.59	3097.05	7.32
Ponderosa Pine	61	53	1.69 $\pm$ 3.37	30.37 $\pm$ 78.22	180.83	54.91
Red Fir	55	25	0.85 $\pm$ 1.35	10.73 $\pm$ 37.39	19972.81	2142.54
Sub-Alpine Conifer	91	6	0.24 $\pm$ 0.48	9.62 $\pm$ 23.48	58100.06	5590.38
Sagebrush	7	0	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	6253.17	0
Sequoia Big Trees Forest	142	22	0.76 $\pm$ 0.91	7.01 $\pm$ 20.40		

Table 5. Descriptive data for each CWHR vegetation type in the park. Superscripts indicate: a = no attributed data to this vegetation type; b = result is from combining the Chamise and Chamise-Redshank Chaparral vegetation types, c = result from combining Sequoia Big Trees Forest and Sierran Mixed Conifer vegetation types, and d = percent infested vegetative cover cannot be greater than 100%. *Values reported here are likely overestimates; see text for explanation (continued).

CWHR Vegetation Type	Number of pLots (N=)	Total Number of NN Taxa per CWHR	Average Number of NN Taxa $\pm$ S.D per CWHR	Percent Infested * $\pm$ S.D	Number of Hectares per CWHR Type	Estimated Number of Infested* Hectares
Sierran Mixed Conifer	635	65	1.04 $\pm$ 1.23	9.42 $\pm$ 31.20	35100.11	3307.65c
Urban/Agricultural	1	5	5	172.5	28.92	28.92d
Valley Foothill Riparian	196	86	1.45 $\pm$ 2.01	19.85 $\pm$ 37.65	121.94	24.21
Sierran White Fir	54	36	0.87 $\pm$ 1.73	11.27 $\pm$ 25.66	5234.48	589.85
Wet Meadow	346	39	0.91 $\pm$ 1.16	17.40 $\pm$ 40.37	6371.35	1108.44
Water	18	0	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	4695.1	0
Total #Hectares in SEKI*						349886.82
Total #Infested Hectares SEKI*						23903.52
Percent infested with non-natives*						6.83%

Table 6. Descriptive data for each HUC 10 unit in the park. *Values reported here are likely overestimates; see text for explanation.

HUC 10 Unit	Number of pLots (N=)	Total Number of NN Taxa per HUC 10	Average Number of NN Taxa $\pm$ S.D per HUC 10	Percent Infested * $\pm$ S.D	Number of Hectares per HUC 10	Estimated Number of Infested* Hectares
Bishop Creek	0				3.78	0
Dry Creek	24	5	0.96 $\pm$ 1.00	0.00 $\pm$ 14.57	192.36	0
Kaweah River-East Fork	184	50	1.07 $\pm$ 1.75	16.53 $\pm$ 50.02	20402.83	3372.79
Kaweah River-Marble Fork						
-Kaweah River	886	165	1.42 $\pm$ 2.70	23.65 $\pm$ 55.35	16503.2	3903.41
Kaweah River-Middle Fork	438	72	1.03 $\pm$ 1.90	20.43 $\pm$ 90.87	26628.2	5439.31
Kaweah River-North Fork	356	95	1.68 $\pm$ 3.09	20.26 $\pm$ 61.90	17186.44	3481.58
Kaweah River-South Fork	48	18	0.83 $\pm$ 1.59	14.84 $\pm$ 51.40	9829.53	1458.87
Kern River-Golden Trout Creek	337	9	0.49 $\pm$ 0.51	5.16 $\pm$ 13.26	28506.12	1471.24

Table 6. Descriptive data for each HUC 10 unit in the park. *Values reported here are likely overestimates; see text for explanation (continued).

HUC 10 Unit	Number of pLots (N=)	Total Number of NN Taxa per HUC 10	Average Number of NN Taxa ±S.D per HUC 10	Percent Infested * ±S.D	Number of Hectares per HUC 10	Estimated Number of Infested* Hectares
Kern River-Rattlesnake Creek	47	2	0.34±0.48	1.74±3.52	3289.85	57.4
Kern River-Rock Creek	186	6	0.04±0.27	0.37±3.30	43346.32	158.47
Kings River Lower South Fork	149	57	1.31±2.25	20.08±52.02	9419.47	1891.54
Kings River-Middle Fork	208	6	0.15±0.37	1.66±8.53	62689.87	1040.11
Kings River-Mill Flat Creek	486	43	1.04±1.08	8.90±25.24	1417.53	126.15
Kings River-North Fork	1	0	0.00±0.00	0.00±0.00	2.34	0
Kings River-Roaring River	149	14	0.56±0.68	10.11±36.25	29831.79	3016.21
Kings River-Upper South Fork	391	33	0.73±0.95	7.64±25.20	60639.92	4631.04
Little Kern River	17	0	0.00±0.00	0.00±0.00	1277.71	0
Mill Creek	16	6	1.13±0.89	2.13±4.94	116.37	2.47
Owens Lake	2	0	0.00±0.00	0.00±0.00	4.36	0
Owens River-Big Pine Creek	0				1.41	0
Owens River-Lone Pine Creek	0				5.55	0
Owens River-Shepherd Creek	2	0	0.00±0.00	0.00±0.00	8.57	0
Owens River-Tinemaha Creek	0				1.79	0
San Joaquin River-Upper South Fork	71	2	0.03±0.17	0.00±0.02	16888.87	0.48
Tule River-Middle Fork	2	0	0.00±0.00	0.00±0.00	510.24	0
Tule River-North Fork	18	3	1.06±0.64	19.22±11.23	1538.53	295.74
Total #Hectares in SEKI*						350252.96
Total #Infested Hectares SEKI*						30346.81
Percent infested with non-natives*						8.66%

Analysis Uncertainty

On the topic of analysis uncertainty, the level of confidence in our results are as good as the data that were collected and utilized in our analyses. We acknowledge that there are several shortcomings in the data, but also realize that there are likely enough data points in certain areas at multiple scales to produce a robust dataset from which to analyze our data.

First of all, the datasets and data that were used in our analyses were collected for a variety of purposes and objectives, using different sampling methods. For instance, the USGS survey data (Gerlach et al. 2003) were collected at locations focused mostly on developed and disturbed areas (campgrounds, trails, etc.), and the NASA data (Morissette et al. 2006) sampled specifically for two exotic plant species. The SEKI Weed Management Database is also not a comprehensive survey, but specifically targeted for mapping and monitoring those non-native plant species and populations for management and control, especially at lower elevation and disturbed areas. While it may be most efficient to direct surveys to these areas where the most non-native species and infestations would be found for management purposes, it does bias our data.

Consequently, there is a lack of a thorough systematic (or random) vegetation sampling scheme across the park, resulting in not having a full survey and inventory of non-native plants. The NRI plots were designed as systematic vegetation sampling across the park, but only comprise about 15% of our total data samples, and are now somewhat dated (from 1985-1996). Systematic sampling also does not necessarily do the best job at finding non-native species that are rare in upon the landscape. We combined all available plant data in our analyses for this report, but it likely produced an overestimate of non-native plant invasion.

Additionally, there is a historic bias in sampling and vouchering more for native (or unique) plants and communities, rather than for non-native plants. Over the past 10 to 15 years however, there has been increasing levels of awareness and knowledge about invasive plants, and the collection of exotic-specific plant data has increased at the park.

Based on the number of sampled plots by unit type, and the breadth and range of most of the non-native plant data (Figures 1 to 10), we believe that our data – while incomplete and varying in sample intensity – do represent an accurate picture of the non-native invasive plant situation in SEKI.

Interactions with Other Focal Resources

Non-native invasive plants can have many direct or indirect interactions with a variety of other focal resources. In this section, we will touch upon some of the possible interactions that invasive plants might have with some of these other resources (interactions with other stressors are covered in the next section). Below are listed the focal resources covered in this NRCA project, under the headings that we deemed most appropriate for the scale at which we are discussing possible interactions. Since the invasive plants group did not have the resources to adequately address these interactions with other focal resources, we will only be discussing

possible interactions in general terms, and proposing some possible avenues of future research and analysis.

Community/Population-level interactions

At the community or population-level, non-native invasive plants have been documented to alter stand structure, compromise the recruitment of native species, and to compete with native species for resources (Macdonald et al. 1989, reviewed in Gordon 1998). Focal resources that may be directly or indirectly impacted by non-native invasive plants include: birds, sensitive plants, intact forests, meadows, sequoias, and foothills vegetation.

Ecosystem-level interactions

While not all non-native plants have obvious impacts on native populations, communities or ecosystems, there are some notable species (referred to as “transformer” species by Richardson et al. 2000 and in this context) that are well-known to have effects on ecosystem-level processes. These ecosystem-level effects may include altered geomorphological processes, hydrological cycling, biogeochemical cycling, and/or changed disturbance regimes (Macdonald et al. 1989). Focal resources in this NRCA project that might be affected by non-native invasive plants at this scale include: biodiversity and water quality.

Potential research or further analyses that might further elucidate the degree of non-native invasive plant impact on these resources include:

- Determine the sites or populations that are of highest value (highest degree of diversity, sensitive species, or unique or rare communities). Overlay those positions with known locations of priority non-native plants and complete a proximity analysis to determine which non-native species or populations are of highest priority to manage and control.
- Spatially evaluate the locations of transformer species with their known abundances (from the SEKI Weed Management Database), and prioritize control and management based on spatial distribution of those non-native invasive plants.
- Determine if there are ecosystem functions and processes (sites of past fires, floods, etc.) that might be impacted by non-native invasive plants by overlaying those locations with known locations of non-native plants.

Stressors

As with the “Interactions with Other Focal Resources” section above, the non-native plants group did not have the resources to delve deeply into the topic of possible stress-related interactions. We briefly discuss some potential interactions between non-native invasive plants with other stressors, and again pose a few possible future analyses that might be used to investigate the degree and possible impacts of these interactions.

Stresses investigated in this NRCA report that directly or indirectly cause, impact, or are correlated with non-native invasive plants include: land use and fragmentation, air quality, fire regimes, climate change, and disease paradigms. It is widely accepted in the literature that increasing land use, fragmentation, and human-caused disturbances, such as by agriculture, grazing, pasturing, and the presence of roads and trails, are highly correlated with and are often the source of non-native plant invasion (Hobbs 2000, Mooney & Hobbs 2000). Similarly, altered fire regimes, specifically fire intensity, severity, and time since fire (fire return interval) increase the number and presence of non-native plants (Keeley et al. 2003). Some invasive plants such as cheatgrass and other annual grasses can create dense loads of fine fuels in certain vegetation and habitat types that increase fire intensity and severity, and/or provide continuous flammable material that lead to decreased fire return intervals and consequently produce a feedback loop influencing fire behavior (D’Antonio & Vitousek 1992, Brooks et al. 2004).

As for air quality, if we first consider nitrogen deposition, nitrogen enrichment tends to favor invasion by exotic annual grasses (Fenn et al. 2010). Brooks (2003) adds that invasive alien plants are highly responsive to nitrogen and have caused declines in native species and increased fire frequency in deserts and coastal sage scrub habitats. Nitrogen-fixing weeds such as invasive brooms may especially benefit from increased nitrogen deposition (Poorter & Navas 2003). In regards to carbon, rising levels of carbon dioxide often promote the growth of many fast growing C3 plants, many of which are invasive weeds (Dukes 2000). Ziska et al. (2005) further showed that increasing carbon dioxide results in higher rates of productivity in cheatgrass.

Correspondingly, climate change is also expected to worsen invasive species problems (Dukes & Mooney 1999). Many climate change scenarios predict alterations or disruptions in fire regime, hydrological changes, precipitation and temperature, or an increase in extreme events such as cyclones and hurricanes (Low 2008). With these changes, many invasive plants are projected to benefit from these shifting conditions and colonize and spread to new sites (Mack et al. 2000). In California, the California Invasive Plant Council (Cal-IPC 2011) has produced prediction and risk maps based on slight increases in temperature for many invasive plants on their plant inventory list. Figure 11 A-D show the current abundance and predicted suitable habitats under existing climate conditions, as well as the predicted suitable habitats with a 3°C increase in average annual temperature for Italian thistle, the most commonly occurring invasive plant in SEKI, and for Armenian (previously known as Himalayan) blackberry, one of our transformer species that is a common invader of riparian and seasonally moist areas. While these Cal-IPC maps are coarse in scale (displayed at the county scale), it provides useful information regarding the potential spread of these non-native invasive plants, and can work to inform early detection watch lists in the park.

Finally, non-native invasive plants can interact with, be the host organism or a vector of, or may even be identified along with certain infectious insects and diseases. The forests of the southern Sierra Nevada mountains have been studied by several researchers regarding the influence and impact of both native and non-native pests and pathogens on forest trees and communities (reviewed in Ferrell 1996), as well as the interactions of these pests and pathogens with other stressors such as fire (or fire suppression and/or exclusion), forest management, and climate changes (van Mantgem et al. 2004, Parker et al. 2006). While the presence and effect of invasive plants have not been explicitly mentioned as a principal factor in the maintenance of forest health within the context of forest insects, pests, pathogens and diseases in the Sierra Nevadas (to our knowledge), invasive plants have been implicated in their role as a vector of pathogens (e.g. sudden oak death, spread by ornamental horticulture, Kliejunas 2010), by increased competition for resources thereby lowering resistance to certain pathogens (Gordon 1998), or by altering fire behavior by providing larger quantities of fine fuels that alter forest structure (Brooks et al. 2004).

Potential future research or spatial analyses that might be used to investigate the degree, possible impacts, or possible synergistic interaction of invasive plants with these other stressors include:

- Overlay known non-native plant locations with recognized disturbed sites, such as in pastures, places of past grazing activities, campgrounds, and places of possible nutrient input (sewage ponds, stock ponds, etc.) etc. to identify possible sites of plant invasion. (Note: This might actually be something that the land-use group is doing as part of this NRCA project)
- Overlay known non-native plant locations with fire history data, including time since last fire, fire severity, sites with known departure from normal fire regimes, etc., to indicate possible sites where new invasive plants might become established. This can also be used to identify possible sites of invasive plant dispersal and spread during fire management activities, or to determine potential invasive plant prevention activities, prior to a prescribed burn.
- Create simple climate change models (similar to those developed by Cal-IPC 2011) for some of the most potentially-invasive plant taxa listed in Table 3 (those taxa with three or fewer occurrences) to determine if there are suitable habitats for their persistence and spread into the park.
- Overlay known non-native plant locations with known sites of forest insect pests and pathogens. Determine if non-native plants might be working to compete with and lower resistance of the forest community to these pests and pathogens.

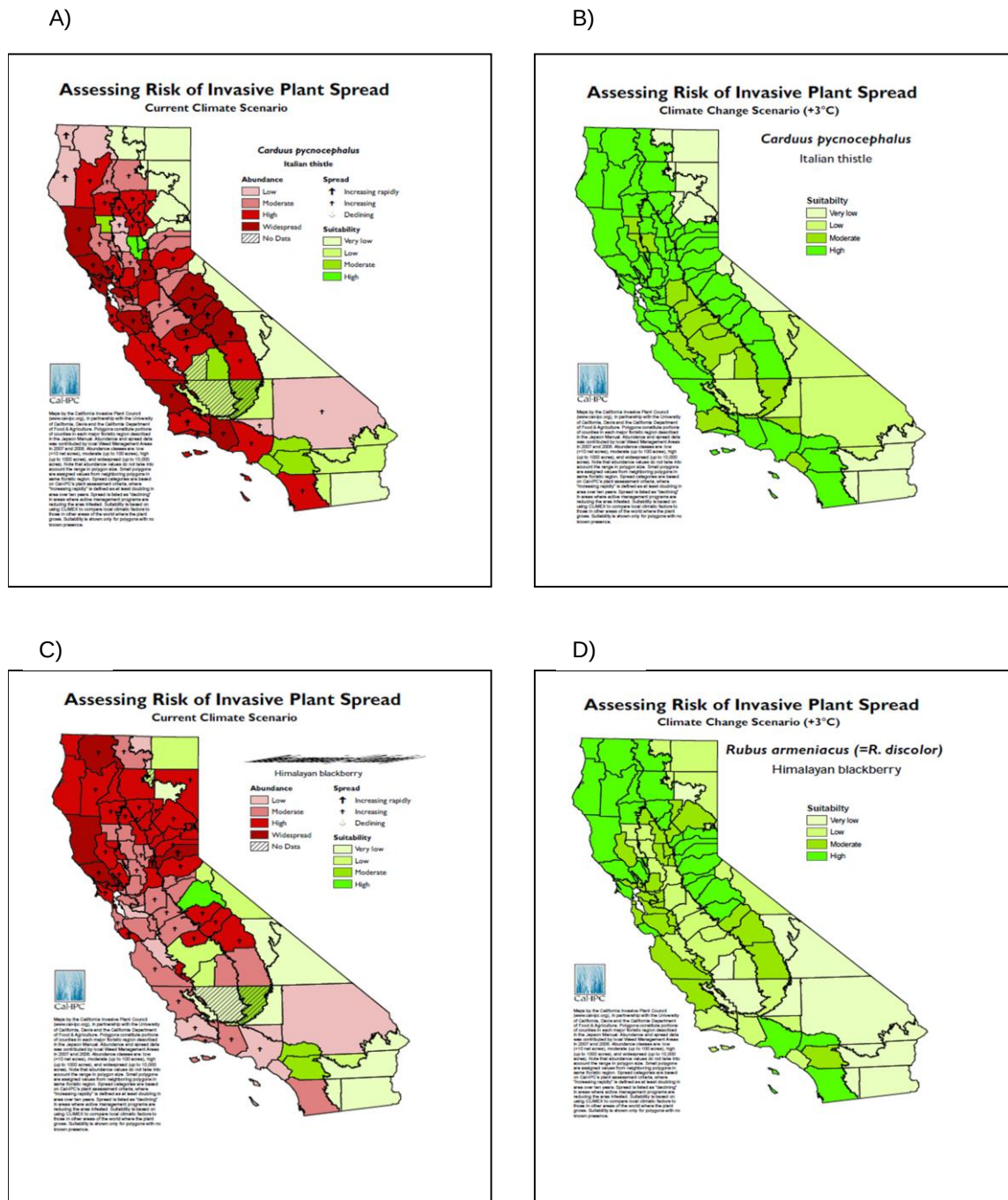


Figure 11. Risk maps of invasive plant spread, shown at the county scale (reproduced from Cal-IPC 2011). Maps show the current abundance and predicted suitable habitat under existing climate conditions (A, C), and their predicted suitable habitats with a 3°C increase in average annual temperature (B, D) for Italian thistle (A, B) and Armenian blackberry (C, D).

Assessment

To determine the overall condition of non-native plants as a threat to SEKI resources, we developed indices of integrity and vulnerability for different units within the park and across the park overall. We wanted to determine which sites (or resources) are most threatened by populations of non-native invasive plants, and to develop spatially-explicit maps that adequately depict the degree of threat.

What criteria and metrics can we use to assess the condition of non-native plants in the park?

In order to develop these maps and to assess the overall condition of non-native plants as a threat to SEKI resources, we used the Conservation Action Planning (CAP) approach developed by The Nature Conservancy (TNC) to evaluate non-native plant threats at both the CWHR vegetation type and HUC 10 landscape unit scales. TNC's CAP approach has been used at hundreds of conservation projects around the world, and seeks to build a transparent process for identifying both targets and threats (TNC 2007). While the entire CAP approach involves multiple steps to evaluate and ultimately develop strategies and measures for conservation areas, we specifically used the portion of the CAP tool that focused on the identification and assessment of critical threats.

We evaluated and ranked all non-native plants threats at the CWHR vegetation type and HUC 10 landscape unit scales. To determine the threat rank for each vegetation type or HUC unit, we used the two criteria of scope and severity to gauge the degree of threat posed by non-native plants. Our definitions for scope and severity are noted in Table 7, and we elected to use the total percent infested by non-native plants (calculated as the average sum of percent vegetative cover, per vegetation type or HUC unit) and average non-native species richness, respectively, to get at these measures. Our cut-off threshold values for determining the three threat rankings of Low, Medium and High for invasive plants are based on the range, averages and medians of our data, and those threat rankings correspond directly to the integrity rankings of Good, Moderate and Poor conditions, respectively, for each unit. We recognize that there is no exact threshold metric that can be used to assess invadedness for all species or in all habitats, although some metrics have been reported in the literature, primarily for individual species (Gooden et al. 2009). Threshold levels for invasive plants are typically used to determine the point of infestation where the management below the threshold allows for native biodiversity to thrive (Panetta & James 1999). Managing non-native invasive plants at levels far below their impact threshold however, or locally eradicating small populations or new invaders when possible, should be the management objective. Consequently, we assigned cut-off threshold values for Low, Medium and High based on what we thought might be most appropriate at SEKI, while attempting to provide a more-or-less bell-shaped distribution of threat ranks.

We believe that by using these two scope and severity measures are indicative of the degree of invadedness of each CWHR vegetation type or HUC 10 unit, as it represents a simplified measure of diversity. Finally, the overall threat rank score for each unit were scored according to Table 8 (Salzer 2007, TNC 2007).

Table 7. Threat ranking criteria for the CWHR vegetation types and HUC 10 units.

Criterion (Description)	Ranking		
	Low	Medium	High
Scope - Most commonly defined spatially as the proportion of the overall area of a project site or target occurrence likely to be affected by a threat under current circumstances.	Very localized in scope, affect the conservation target at a limited portion of the target's locations.	Localized in scope, affect the conservation target at some of the target's populations.	Widespread in scope, affect the conservation target at many of its locations.
Percent Infested, vegetative cover	< 4.3% cover	4.4 to 17.0% cover	>17.1% cover
Severity - The level of damage to the conservation target that can reasonably be expected under current circumstances.	Slightly impair the conservation target over some portion of the target's occurrences.	Moderately degrade the conservation target over some portion of the target's occurrences.	Seriously degrade the conservation target over some portion of the target's occurrences.
Average Number of Non-Native Species per CWHR vegetation type or HUC 10 unit	0-0.2 species	0.3 to 0.5 species	>0.6 species

Table 8. Threat scoring calculation matrix

	Scope			
		High	Medium	Low
Severity	High	High	Medium	Low
	Medium	Medium	Medium	Low
	Low	Low	Low	Low

What does the non-native plant condition look like spatially across the park?

Tables 9 and 10 summarize the threat rankings (as Low, Medium, or High categories) for non-native plant threats using the criteria that we specified above at the individual CWHR vegetation types and HUC 10 units, respectively. For these analyses, we opted to include the presence of all non-native plants as they occurred in our sample plots rather than only a subset of them (USGS top 78, SEKI 19 taxa for management, or the 9 transformer species), as we believe that to properly represent the overall threat of non-native invasive plants to the park, we should include all non-native plants. Correspondingly, Figures 12 and 13 display these threat rankings spatially, for the CWHR vegetation types and HUC 10 landscape units.

For the CWHR vegetation types (Figure 12), by using our two criteria of scope and severity, the vegetation types that are given “high” rankings and are the most threatened by invasive plants are the Blue Oak Woodland, Mixed Chaparral, Montane Hardwood, Valley Foothill Riparian, and Wet Meadow vegetation types. This confirms our earlier results, but is not a complete overlap from Table 5, that also identified the most invaded vegetation types. The types that come across all our analyses as the most invaded are therefore the Blue Oak Woodland, Montane Hardwood, and Valley Foothill Riparian vegetation types. This is in exact agreement with those vegetation types reported as the most invaded in the Sierra Nevada ecosystem by Schwartz et al. (1996), and is also corroborated by SEKI staff.

At the HUC 10 scale (Figure 13), the units that are ranked as the most threatened by non-native invasive plants are the Kaweah River-Marble Fork-Kaweah River, Kaweah River-Middle Fork, Kaweah River-North Fork, Kings River-Lower South Fork, and the Tule River-North Fork units. By comparing these results with those reported earlier in Table 6, the HUC 10 units that are the most invaded across our different analyses include the Kaweah River-Marble Fork-Kaweah River, Kaweah River-Middle Fork, Kaweah River-North Fork, and the Kings River-Lower South Fork units.

What is the overall level of threat risk from non-native plants to the park?

As for assigning an overall threat rank across the entire park utilizing threat ranks at the HUC 10 landscape scale, if we again use the TNC CAP methodology for rolling-up threats across multiple conservation targets, SEKI receives a “high” threat risk for invasive plants across the entire park.

We believe that this is a correct assessment of the threat from non-native plants to resources in the park, as non-native invasive species have the ability to directly and indirectly negatively impact native species and communities in the park. Invasive species can also develop larger impacts and take over more habitat over time, so the “high” threat label is likely correct for this NRCA.

We however, also caution that this “high” threat is an oversimplification of the risk of invasive plants across the entire park. There are obviously sites and habitats that are more at risk from non-native invasive plants than others (e.g., lower elevation sites, places that experience regular disturbance, etc.), and additionally this CAP approach typically evaluates multiple different threats (instead of just focused on invasive plants) per project site, rolling-up and compiling the scoring from 8 to 12 conservation targets (instead of the 26 HUC 10 units). Additionally, stating

that the threat risk of invasive plants is “high” would indicate that conversely the current condition of the entire park is only “poor” to “moderate.” Therefore, since the roll-up scoring is additive, the “high” overall risk score may be an overestimate of the non-native plant threat at the park as a whole.

In conclusion, while we believe that the threat of non-native plants to the biological and ecological resources and values of the park are real, appointing one threat rank for the entire park is likely an oversimplification. However, based on our data on the existing threats from current invasive plant populations, new invasive plant taxa, and potential new infestations into high quality areas, non-native plants are a “high” threat to park resources.

Table 9. Scope, severity, and overall stress rankings for all non-native invasive plants for each CWHR vegetation type.

CWHR Vegetation Type	% Infested Vegetation Cover	Scope Rank	Average # Non-Native Species	Severity Rank	Overall Stress Rank
Alpine Dwarf Scrub	0	Low	0	Low	Low
Annual Grass					No Data
Aspen	3.4	Low	0	Low	Low
Barren	0.3	Low	0	Low	Low
Big Trees Forest	7	Medium	0.5	Medium	Medium
Blue Oak Woodland	47.5	High	3.9	High	High
Chamise	14.8	Medium	0.2	Low	Low
Chamise-Redshank Chaparral	27.8	High	0.5	Medium	Medium
Jeffrey Pine	8.5	Medium	0.2	Low	Low
Juniper	0	Low	0	Low	Low
Lodgepole Pine	2.9	Low	0.1	Low	Low
Mixed Chaparral	17.7	High	0.6	High	High
Montane Chaparral	10.3	Medium	0.2	Low	Low
Montane Hardwood	27.1	High	2.8	High	High
Montane Riparian	2.4	Low	0.4	Medium	Low
Perennial Grassland	8.9	Medium	0.1	Low	Low
Pinyon-Juniper	0.2	Low	0	Low	Low
Ponderosa Pine	30.4	High	0.5	Medium	Medium
Red Fir	10.7	Medium	0.2	Low	Low
Riparian	1.3	Low	0.3	Medium	Low
Sagebrush	0	Low	0	Low	Low

Table 9. Scope, severity, and overall stress rankings for all non-native invasive plants for each CWHR vegetation type (continued).

CWHR Vegetation Type	% Infested Vegetation Cover	Scope Rank	Average # Non- Native Species	Severity Rank	Overall Stress Rank
Sierran Mixed Conifer	9.4	Medium	3.2	High	Medium
Sierran White Fir	11.3	Medium	0.2	Low	Low
Sub-Alpine Conifer	9.6	Medium	0.1	Low	Low
Urban/Agricultural	172.5	High	0	Low	Low
Valley Foothill Riparian	19.9	High	1.4	High	High
Water	0	Low	0	Low	Low
Wet Meadow	17.4	High	1.5	High	High
				Overall Threat	High

Table 10. Scope, severity, and overall stress rankings for all non-native invasive plants for each HUC 10 unit in the park.

CWHR Vegetation Type	% Infested Vegetation Cover	Scope Rank	Average # Non- Native Species	Severity Rank	Overall Stress Rank
Bishop Creek					No Data
Dry Creek	5.44	Medium	0.96	High	Medium
Kaweah River-East Fork	16.53	Medium	1.07	High	Medium
Kaweah River-Marble Fork- Kaweah River	23.65	High	1.42	High	High
Kaweah River-Middle Fork	20.43	High	1.03	High	High
Kaweah River-North Fork	20.26	High	1.68	High	High
Kaweah River-South Fork	14.84	Medium	0.83	High	Medium
Kern River-Golden Trout Creek	5.16	Medium	0.49	Medium	Medium
Kern River-Rattlesnake Creek	1.74	Low	0.34	Medium	Low

Table 10. Scope, severity, and overall stress rankings for all non-native invasive plants for each HUC 10 unit in the park (continued).

CWHR Vegetation Type	% Infested Vegetation Cover	Scope Rank	Average # Non- Native Species	Severity Rank	Overall Stress Rank
Kern River-Rock Creek	0.37	Low	0.04	Low	Low
Kings River-Lower South Fork	20.08	High	1.31	High	High
Kings River-Middle Fork	1.66	Low	0.15	Low	Low
Kings River-Mill Flat Creek	8.9	Medium	1.04	High	Medium
Kings River-North Fork	0	Low	0	Low	Low
Kings River-Upper South Fork	7.64	Medium	0.73	High	Medium
Kings River-Roaring River	10.11	Medium	0.56	Medium	Medium
Little Kern River	0	Low	0	Low	Low
Mill Creek	2.13	Low	1.13	High	Low
Owens Lake	0	Low	0	Low	Low
Owens River-Big Pine Creek					No Data
Owens River-Lone Pine Creek					No Data
Owens River-Shepherd Creek	0	Low	0	Low	Low
Owens River-Tinemaha Creek					No Data
San Joaquin River-Upper South Fork	0	Low	0.03	Low	Low
Tule River-Middle Fork	0	Low	0	Low	Low
Tule River-North Fork	19.22	High	1.06	High	High
Overall Threat					High

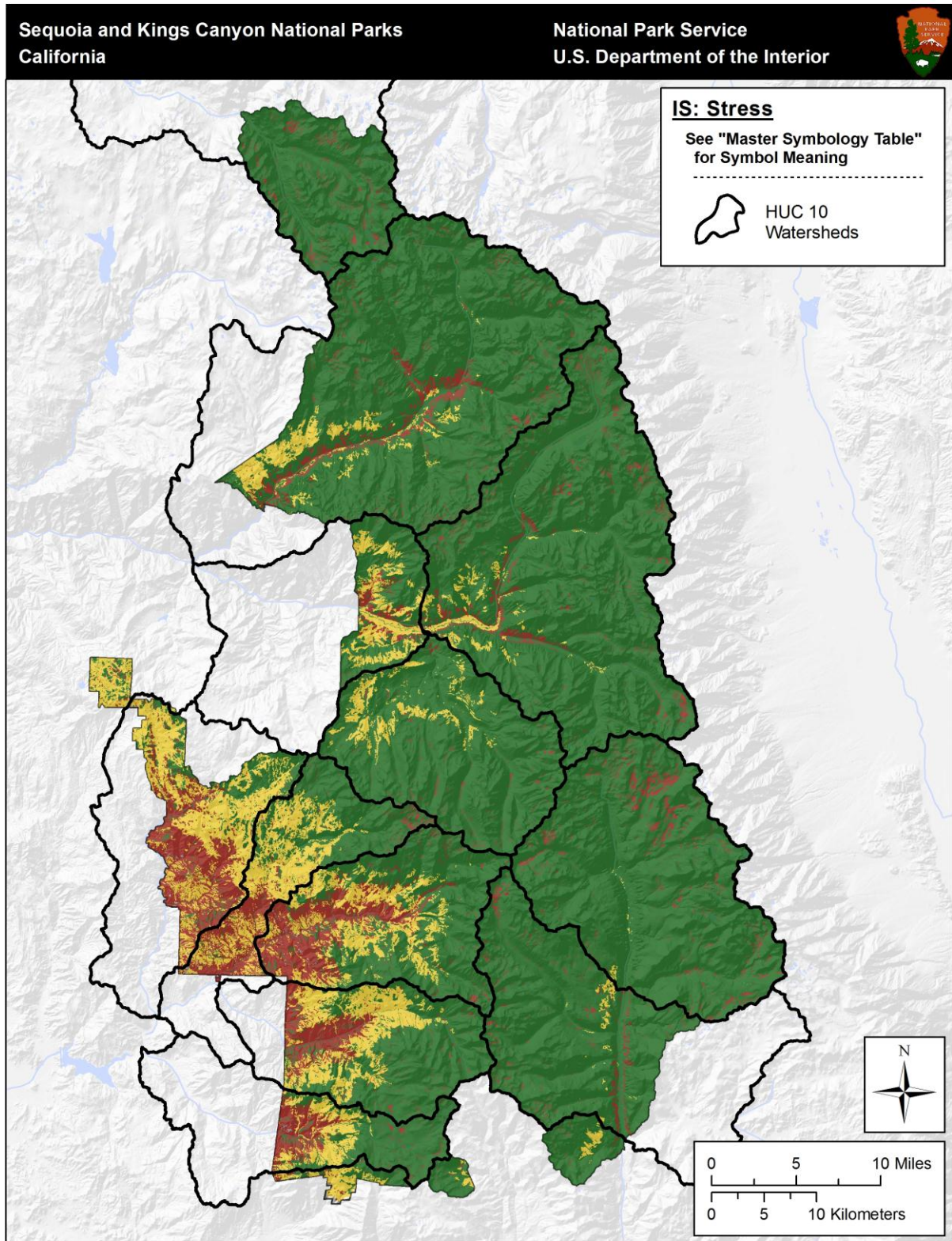


Figure 12. Overall threat rankings, indicating stress levels to SEKI posed by non-native plants, organized by CWHR vegetation type

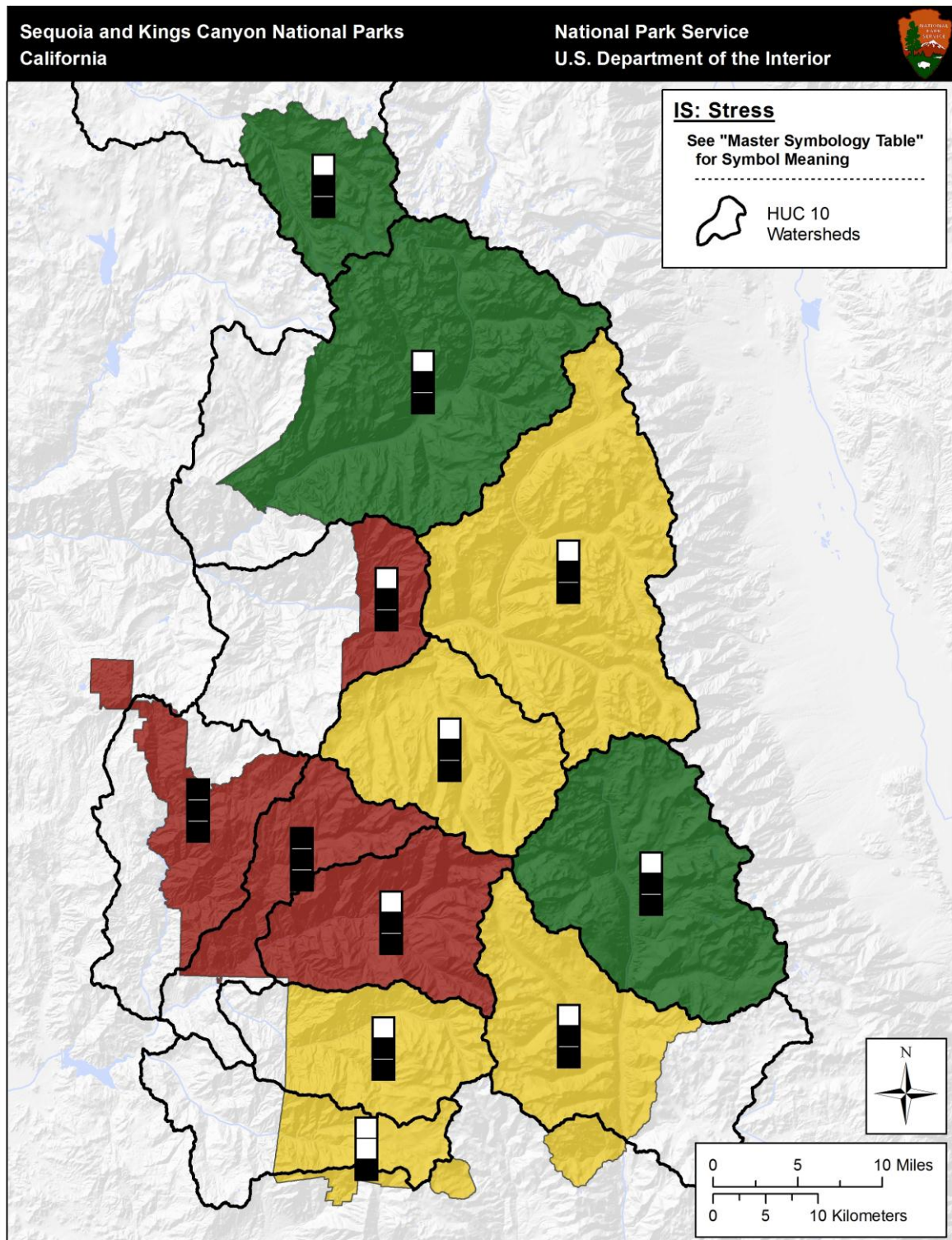


Figure 13. Overall threat rankings, indicating stress levels to SEKI posed by non-native plants, organized by HUC 10 units.

Level of Confidence in Assessment

We have a relatively high level of confidence in the overall results of our assessment of non-native plant threats in SEKI. Although there were some issues with the quantity and quality of available data (as addressed in the earlier Analysis Uncertainty section), especially for certain units within the park (for instance, the Urban /Agricultural CWHR vegetation type only had one sample plot), we believe that we have used a relatively simple but robust technique for ranking threats at different scales in and across the park as a whole. We used a proven methodology for ranking threats using TNC's CAP approach, and the results of our assessment made sense to, and was agreed upon by SEKI staff. Therefore, in most cases where there were adequate data (generally, at least 20+ samples per CWHR vegetation type or HUC 10 landscape unit), the results supported the findings and observations in the field by SEKI staff.

Gaps in Understanding

To really obtain a complete picture of non-native invasive plants in the park, there is a need for a systematic park wide survey and inventory of non-native plants. There have been previous parkwide survey efforts that include non-native plants in their sampling (e.g., NRI plots, Meadows sampling), but there is also a need to include areas searched, as well as true absence data.

While the current SEKI Weed Management Database and this NRCA report paints a picture of the current situation, and the database particularly does a good job of keeping track of management priorities, there are still gaps in the data and sampling. A park wide survey and inventory is therefore needed, to not only determine where weeds currently are, but to also determine concretely where they are not, so that the best prevention practices and early detection for new invaders can be implemented at high priority sites.

Additionally, we were not able to find much existing data on non-native aquatic plants, or on other taxa of non-native invaders such as mammals, insects, pathogens, fish, amphibians, etc. in the park. Information on these other taxa is vital to the focal resources and biodiversity of the park, as some of these other taxa invaders can truly alter ecosystem structure and functions (e.g., feral swine, bullfrogs, etc.), and may pose a higher degree of threat than non-native plants. This NRCA project has a section that is dedicated to non-native animals, which will fill part of this gap in understanding.

Recommendations for Future Study/Research

Possible directions of future study or research regarding non-native invasive plants include:

- Completing a systematic park wide survey and inventory of non-native species, including both terrestrial and aquatic plants, and other taxa of invaders such as mammals, fish, amphibians, pathogens, etc.

- Develop predictive models to determine possible range expansions of non-native species given certain climate change scenarios.
- Evaluate the invasive potential of new non-native invaders, especially those that currently only occur within the boundaries of the park in three or less occurrences.
- Determine the best places to implement “sentinel sites,” those high priority places that are currently mostly uninvaded, to test and put into practice prevention and early detection protocols. Perhaps at scales smaller than the CWHR vegetation type or HUC 10 unit.
- Work to quantify the actual impacts of non-native invaders to park values and resources.

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Appendix 1. List of Non-native Plant Species in SEKI

The complete list of all 219 non-native plant species that have been documented within SEKI boundaries, presented alphabetically by scientific name. This list also includes management categories as defined within the text, for those species belonging in the top 78 (Gerlach 2001; management categories 1 to 3), top 19 (SEKI Weed Management Plan), and top 9 transformer species designations, as well as their threat rankings assigned through the California Invasive Plant Council (Cal-IPC 2006; categories Limited, Moderate and High) and as state-listed noxious weeds by the California Department of Food and Agriculture (CDFA).

Scientific Name	CommonName	Trans. Spp.	Top 19 (SEKI)	Top 78 (Gerlach)	Cal-IPC	CDFA
<i>Agave americana</i> L.	century plant					
<i>Agrostis gigantea</i> Roth.	redtop			1		
<i>Aira caryophylla</i> L.	silver European hairgrass					
<i>Amaranthus albus</i> L.	tumbleweed					
<i>Ampelopsis arborea</i> Koehne	peppervine			1		
<i>Amsinckia menziesii</i> (Lehm.) Nelson & J.F. Macbr.	fiddleneck					
<i>Anagallis arvensis</i> L.	scarlet pimpernel					
<i>Anthemis cotula</i> L.	stinkweed					
<i>Anthriscus caucalis</i> M. Bieb.	bur-chervil					
<i>Arenaria serpyllifolia</i> L. ssp. <i>serpyllifolia</i>	thymeleaf sandwort					
<i>Arrhenatherum elatius</i> (L.) J.S. Presl & C. Presl	tall oatgrass					
<i>Arundo donax</i> L.	giant reed	Trans.	Top 19	1	H	B
<i>Avena barbata</i> Link	slender wild oat				M	
<i>Avena fatua</i> L.	wild oat				M	
<i>Barbarea verna</i> (Miller) Asch.	early winter cress					
<i>Bellis perennis</i> L.	English daisy					
<i>Brassica nigra</i> (L.) Koch	black mustard				M	
<i>Briza maxima</i> L.	big quaking grass				L	
<i>Briza minor</i> L.	little quaking grass					
<i>Bromus arenarius</i> Labill.	Australian chess					
<i>Bromus catharticus</i> Vahl	rescue grass					
<i>Bromus diandrus</i> Roth.	ripgut grass				M	
<i>Bromus hordeaceus</i> L.	soft chess				L	
<i>Bromus inermis</i>	smooth brome					
<i>Bromus madritensis</i> L. ssp. <i>madritensis</i>	foxtail chess				L	
<i>Bromus madritensis</i> L. ssp. <i>rubens</i> (L.) Husnot	red brome				H	
<i>Bromus sterilis</i> L.	poverty brome					
<i>Bromus tectorum</i> L.	cheat grass	Trans.	Top 19	3	H	
<i>Bromus trinii</i> Desv.	Chilean chess					
<i>Capsella bursa-pastoris</i> (L.) Medikus	shepherd's purse					
<i>Carduus pycnocephalus</i> L.	Italian thistle		Top 19	1	M	C
<i>Carthamus tinctorius</i> L.	safflower					
<i>Carya</i> sp. Nutt.	hickory			2		
<i>Catalpa bignonioides</i>	southern catalpa			1		

Scientific Name	CommonName	Trans. Spp.	Top 19 (SEKI)	Top 78 (Gerlach)	Cal- IPC	CDFA
<i>Centaurea melitensis</i> L.	tocolote				M	C
<i>Centaurea solstitialis</i> L.	yellow star thistle	Trans.	Top 19	1	H	C
<i>Cerastium fontanum</i> Baumg. ssp. <i>vulgare</i> (Hartman) G	big chickweed					
<i>Cerastium glomeratum</i> Thuill.	mouse-ear chickweed					
<i>Chamaesyce maculata</i> (L.) Small	spotted spurge					
<i>Chamomilla suaveolens</i> (Pursh) Rydb.	pineapple weed					
<i>Chenopodium album</i> L.	lambs quarters		Top 19			
<i>Chenopodium botrys</i> L.	Jerusalem oak					
<i>Cirsium vulgare</i> (Savi) Ten.	bull thistle		Top 19	3	M	C
<i>Cistus</i> sp. L.	rock rose			1		
<i>Convolvulus arvensis</i> L.	bindweed		Top 19	1		C
<i>Coronopus didymus</i> (L.) Smith	swine cress					
<i>Cotula australis</i> (Sieber) Hook. f.	brass buttons					
<i>Crassula tillaea</i> Lester-Garl.	moss pygmyweed					
<i>Crypsis schoenoides</i> (L.) Lam.	swampgrass					
<i>Cynodon dactylon</i> (L.) Pers.	bermuda grass				M	C
<i>Cynosurus echinatus</i> L.	hedgehog dogtail				M	
<i>Dactylis glomerata</i> L.	orchard grass			1	L	
<i>Descurainia sophia</i> (L.) Webb	herb sophia			1	L	
<i>Digitalis purpurea</i> L.	foxglove		Top 19	1	L	
<i>Digitaria sanguinalis</i> (L.) Scop.	crabgrass					
<i>Diospyros</i> sp. L.	persimmon			2		
<i>Echinochloa crus-galli</i> (L.) P. Beauv.	barnyard grass			2		
<i>Eragrostis cilianensis</i> (All.) Janchen	lovegrass					
<i>Erodium botrys</i> (Cav.) Bertol	long-beaked filaree					
<i>Erodium brachycarpum</i> (Godron) Thell.	white-stemmed filaree					
<i>Erodium cicutarium</i> (L.) L'Her.	red-stemmed filaree				L	
<i>Erodium moschatum</i> (L.) L'Her.	musky stork's bill					
<i>Eucalyptus citriodora</i> Hook.	lemon-scented gum			1		
<i>Euphorbia peplus</i> L.	petty spurge					
<i>Festuca arundinacea</i> Schreber	tall fescue			1	M	
<i>Festuca pratensis</i> Hudson	meadow fescue			2		
<i>Ficus carica</i> L.	edible fig		Top 19	1	M	
<i>Filago gallica</i> L.	narrowleaf cottonrose					
<i>Galium murale</i> (L.) All.	tiny bedstraw					
<i>Galium parisiense</i> L.	wall bedstraw					
<i>Gastridium ventricosum</i> (Gouan) Schinz & Thell.	nit grass					
<i>Genista monspessulana</i> (L.) L. Johnson	French broom	Trans.	Top 19	1	H	C
<i>Geranium dissectum</i> L.	cutleaf geranium				M	
<i>Geranium molle</i> L.	dove's foot geranium					
<i>Gnaphalium luteo-album</i> L.	cudweed, everlasting					

Scientific Name	CommonName	Trans. Spp.	Top 19 (SEKI)	Top 78 (Gerlach)	Cal-IPC	CDFA
<i>Hedera helix</i> L.	English ivy			1	H	
<i>Hedypnois cretica</i> (L.) Dum. - Cours.	cretanweed					
<i>Heliotropium curassavicum</i> L.	heliotrope					
<i>Herniaria hirsuta</i> L. ssp. <i>cinerea</i> (DC.) Cout.	rupture wort					
<i>Heteromeles arbutifolia</i> (Lindley) Roemer	toyon			1		
<i>Hirschfeldia incana</i> (L.) Lagr. - Fossat	shortpod mustard				M	
<i>Holcus lanatus</i> L.	common velvet grass		Top 19	2	M	
<i>Hordeum marinum</i> Hudson ssp. <i>gussoneanum</i> (Parl.) Th	mediterranean barley				M	
<i>Hordeum murinum</i> L. ssp. <i>leporinum</i> (Link) Arcang.	leporinum barley				M	
<i>Hordeum murinum</i> L. ssp. <i>murinum</i>	wall barley				M	
<i>Hypochaeris glabra</i> L.	smooth cat's ear				L	
<i>Iris</i> sp. L.	iris			2		
<i>Juglans californica</i> S. Wats.	southern California walnut			1		
<i>Juglans regia</i> L.	English walnut			1		
<i>Lactuca serriola</i> L.	prickly lettuce					
<i>Lagerstroemia</i> sp.	crape myrtle					
<i>Lamarckia aurea</i> (L.) Moench	goldentop					
<i>Lamium amplexicaule</i> L.	common henbit					
<i>Lamium purpureum</i> L.	dead nettle					
<i>Lathyrus latifolius</i> L.	perennial sweet pea		Top 19	1		
<i>Leucanthemum vulgare</i> Lam.	ox-eye daisy				M	
<i>Leucojum aestivum</i> L.	summer snowflake			2		
<i>Ligustrum sinense</i> Lour.	Chinese privet			1		
<i>Lolium multiflorum</i> Lam.	Italian ryegrass				M	
<i>Lolium perenne</i> L.	perennial ryegrass			2		
<i>Lolium temulentum</i> L.	ryegrass					
<i>Lychnis coronaria</i> (L.) Desr.	rose campion					
<i>Lythrum hyssopifolium</i> L.	hyssop loosestrife				L	
<i>Malus sylvestris</i> Miller	apple			1		
<i>Malva neglecta</i> Wallr.	common mallow					
<i>Malva parviflora</i> L.	cheeseweed					
<i>Marrubium vulgare</i> L.	horehound		Top 19	1	L	
<i>Medicago lupulina</i> L.	black medik					
<i>Medicago polymorpha</i> L.	California burclover				L	
<i>Medicago sativa</i> L.	alfalfa			1		
<i>Melilotus alba</i> Medikus	white sweetclover			1		
<i>Melilotus indica</i> (L.) All.	sourclover			1		
<i>Melilotus officinalis</i> (L.) Pall.	yellow sweetclover			1		
<i>Mentha pulegium</i> L.	pennyroyal			1	M	
<i>Mentha spicata</i> L. var. <i>spicata</i>	spearmint			1		
<i>Mollugo verticillata</i> L.	carpet-weed, indian chickweed					

Scientific Name	CommonName	Trans. Spp.	Top 19 (SEKI)	Top 78 (Gerlach)	Cal- IPC	CDFA
<i>Morus alba</i> L.	white mulberry			1		
<i>Nerium oleander</i> L.	oleander			1		
<i>Nicotiana acuminata</i> Hook. var. <i>multiflora</i> (Philippi) Reiche	many-flowered tobacco					
<i>Oenothera laciniata</i> Hill	evening primrose					
<i>Olea europaea</i> L.	olive			2	L	
<i>Opuntia</i> sp.	Prickly Pear Cactus					
<i>Oxalis corniculata</i> L.	creeping woodsorrel					
<i>Oxalis pes-caprae</i> L.	Bermuda buttercup			1	M	
<i>Panicum dichotomiflorum</i> Michaux	fall panicgrass					
<i>Parthenocissus vitacea</i> (Kner) Hitchc.	woodbine					
<i>Paspalum dilatatum</i> Poiret	dallis grass					
<i>Paspalum notatum</i> J. Fleugge	bahiagrass					
<i>Petrorhagia dubia</i> (Raf.) G. Lopez & Romo	hairypink					
<i>Phalaris arundinacea</i> L.	reed canary grass	Trans.	Top 19	1		
<i>Phalaris minor</i> Retz.	littleseed canarygrass			2		
<i>Phalaris paradoxa</i> L.	hood canarygrass			2		
<i>Phleum pratense</i> L.	cultivated timothy					
<i>Phyla nodiflora</i> (L.) E. Greene var. <i>nodiflora</i>	turkey tangle fogfruit					
<i>Physalis philadelphica</i> Lam.	tomatillo					
<i>Pinus sabiniana</i> Douglas	gray pine					
<i>Piptatherum miliaceum</i> (L.) Cosson	smilo grass			2	L	
<i>Plantago lanceolata</i> L.	English plantain				L	
<i>Plantago major</i> L.	common plantain					
<i>Poa annua</i> L.	annual bluegrass					
<i>Poa bulbosa</i> L.	bulbous bluegrass			2		
<i>Poa compressa</i> L.	Canadian bluegrass			2		
<i>Poa palustris</i> L.	fowl bluegrass			1		
<i>Poa pratensis</i> L. ssp. <i>pratensis</i>	Kentucky bluegrass			3	L	
<i>Polycarpon tetraphyllum</i> (L.) L.	four-leaved allseed					
<i>Polygonum arenastrum</i> Boreau	common knotweed					
<i>Polygonum argyrocoleon</i> Kunze	silversheath knotweed					
<i>Polygonum convolvulus</i> L.	black bindweed					
<i>Polypogon australis</i> Brongn.	Chilean rabbitsfoot grass			1		
<i>Polypogon interruptus</i> Kunth	ditch beard grass			1		
<i>Polypogon maritimus</i> Willd.	Mediterranean beard grass					
<i>Polypogon monspeliensis</i> (L.) Desf.	annual beard grass			2	L	
<i>Prunus persica</i> (L.) Batsch	peach			2		
<i>Punica granatum</i> L.	pomegranate			2		
<i>Pyracantha angustifolia</i> (Franchet) C. Schneider	firethorn			1	L	
<i>Ranunculus parviflorus</i> L.	smallflower buttercup			1		
<i>Ranunculus testiculatus</i> Crantz	curveseed butterwort		Top 19	1		

Scientific Name	CommonName	Trans. Spp.	Top 19 (SEKI)	Top 78 (Gerlach)	Cal-IPC	CDFA
<i>Raphanus raphanistrum</i> L.	wild radis					
<i>Raphanus sativus</i> L.	radish				L	
<i>Rosmarinus officinalis</i> L.	Rosemary					
<i>Rubus discolor</i> Weihe & Nees	Himalayan blackberry	Trans.	Top 19	1	H	
<i>Rubus laciniatus</i> Willd.	cut-leaved blackberry	Trans.		1		
<i>Rumex acetosella</i> L.	sheep sorrel				M	
<i>Rumex conglomeratus</i> Murray	clustered dock					
<i>Rumex crispus</i> L.	curly dock				L	
<i>Rumex dentatus</i> L.	toothed dock					
<i>Salsola tragus</i> L.	Russian thistle				L	C
<i>Schismus barbatus</i> (L.) Thell.	common Mediterranean grass				L	
<i>Scleranthus annuus</i> L. ssp. annuus	knawel					
<i>Senecio vulgaris</i> L.	old-man-in-the-spring					
<i>Setaria pumila</i> (Poiret) Roemer & Schultes	yellow bristlegrass					
<i>Setaria viridis</i> (L.) P. Beauv.	green bristlegrass					
<i>Sherardia arvensis</i> L.	field madder					
<i>Silene gallica</i> L.	common catchfly					
<i>Silybum marianum</i> (L.) Gaertner	milk thistle			1	L	
<i>Sisymbrium altissimum</i> L.	tumblemustard					
<i>Sisymbrium irio</i> L.	London rocket				M	
<i>Sisymbrium loeselii</i> L.	small tumbleweed mustard					
<i>Sisymbrium officinale</i> L.	hedge mustard					
<i>Sisymbrium orientale</i> L.	Indian hedge mustard					
<i>Soliva sessilis</i> Ruiz Lopez & Pavon	field burrweed					
<i>Sonchus asper</i> (L.) Hill ssp. asper	prickly sow thistle					
<i>Sonchus oleraceus</i> L.	common sow thistle					
<i>Sonchus tenerrimus</i> L.	slender sow thistle					
<i>Sorghum bicolor</i> (L.) Moench	sorghum					
<i>Sorghum halepense</i> (L.) Pers.	johnsongrass			2		C
<i>Spartium junceum</i> L.	Spanish broom	Trans.	Top 19	1	H	C
<i>Spergularia bocconii</i> (Scheele) Merino	sand spurrey					
<i>Spergularia rubra</i> (L.) J.S. Presl & C. Presl.	purple sand-spurry					
<i>Stellaria media</i> (L.) Villars	common chickweed					
<i>Tamarix</i> sp. L.	tamarisk	Trans.		1	H	B
<i>Tanacetum parthenium</i> (L.) Schultz-Bip.	feverfew			1		
<i>Taraxacum officinale</i> Wigg.	dandelion					
<i>Torilis arvensis</i> (Hudson) Link	spreading hedge-parsley				M	
<i>Torilis nodosa</i> (L.) Gaertner	knotted hedge-parsley					
<i>Tragopogon dubius</i> Scop.	yellow salsify			1		
<i>Tribulus terrestris</i> L.	puncture vine					C
<i>Trifolium campestre</i> Shreber	hop clover					

Scientific Name	CommonName	Trans. Spp.	Top 19 (SEKI)	Top 78 (Gerlach)	Cal- IPC	CDFA
<i>Trifolium dubium</i> Sibth.	little hop clover					
<i>Trifolium hirtum</i> All.	rose clover				M	
<i>Trifolium incarnatum</i> L.	crimson clover					
<i>Trifolium repens</i> L.	white clover			1		
<i>Triticum aestivum</i> L.	wheat					
<i>Urtica urens</i> L.	dwarf nettle			1		
<i>Verbascum thapsus</i> L.	woolly mullein		Top 19	3	L	
<i>Verbascum virgatum</i> Stokes	wand mullein			1		
<i>Veronica arvensis</i> L.	corn speedwell					
<i>Veronica persica</i> Poiret	Persian speedwell					
<i>Veronica serpyllifolia</i> L. ssp. <i>serpyllifolia</i>	thymeleaf speedwell					
<i>Vicia benghalensis</i> L.	purple vetch			1		
<i>Vicia sativa</i> L.	common vetch			1		
<i>Vicia villosa</i> Roth ssp. <i>varia</i> (Host) Corbiere	winter vetch			1		
<i>Vicia villosa</i> Roth ssp. <i>villosa</i>	hairy vetch					
<i>Vinca major</i> L.	greater periwinkle		Top 19	1	M	
<i>Vitis vinifera</i> L.	wine grape			1		
<i>Vulpia bromoides</i> (L.) S.F. Gray	brome fescue			2		
<i>Vulpia myuros</i> (L.) C. Gmelin <i>var. hirsuta</i> (Hackel)	foxtail fescue				M	
<i>Yabea microcarpa</i> (Hook. & Arn.) Koso-Polj.	California hedge parsley					

Appendix 2. The top 78 Species (Gerlach 2003)

The top 78 species from the USGS (Gerlach 2003) reports as management priorities for SEKI, arranged alphabetically by family. Gerlach (2003) separated these 78 species into three management categories.

Management Category 1: Exotics that are currently restricted to a relatively small number of sites in each park and have been shown either to greatly affect native vegetation or to have a high probability of causing serious impacts. They require immediate management action to isolate and eliminate their populations (54 species)

Family	Scientific Name	Common Name
Apocynaceae	<i>Nerium oleander</i> L.	oleander
Apocynaceae	<i>Vinca major</i> L.	greater periwinkle
Araliaceae	<i>Hedera helix</i> L.	English ivy
Asteraceae	<i>Carduus pycnocephalus</i> L.	Italian thistle
Asteraceae	<i>Centaurea solstitialis</i> L.	yellow star thistle
Asteraceae	<i>Silybum marianum</i> (L.) Gaertner	milk thistle
Asteraceae	<i>Tanacetum parthenium</i> (L.) Schultz-Bip.	feverfew
Asteraceae	<i>Tragopogon dubius</i> Scop.	yellow salsify
Bignoniaceae	<i>Catalpa bignonioides</i>	southern catalpa
Brassicaceae	<i>Descurainia sophia</i> (L.) Webb	herb sophia
Cistaceae	<i>Cistus</i> sp. L.	rock rose
Convolvulaceae	<i>Convolvulus arvensis</i> L.	bindweed
Fabaceae	<i>Genista monspessulana</i> (L.) L. Johnson	French broom
Fabaceae	<i>Lathyrus latifolius</i> L.	perennial sweet pea
Fabaceae	<i>Medicago sativa</i> L.	alfalfa
Fabaceae	<i>Melilotus alba</i> Medikus	white sweetclover
Fabaceae	<i>Melilotus indica</i> (L.) All.	sourclover
Fabaceae	<i>Melilotus officinalis</i> (L.) Pall.	yellow sweetclover
Fabaceae	<i>Spartium junceum</i> L.	Spanish broom
Fabaceae	<i>Trifolium repens</i> L.	white clover
Fabaceae	<i>Vicia benghalensis</i> L.	purple vetch
Fabaceae	<i>Vicia sativa</i> L.	common vetch
Fabaceae	<i>Vicia villosa</i> Roth ssp. <i>varia</i> (Host) Corbiere	winter vetch
Juglandaceae	<i>Juglans californica</i> S. Wats.	southern California walnut
Juglandaceae	<i>Juglans regia</i> L.	English walnut
Lamiaceae	<i>Marrubium vulgare</i> L.	horehound
Lamiaceae	<i>Mentha pulegium</i> L.	pennyroyal
Lamiaceae	<i>Mentha spicata</i> L. var. <i>spicata</i>	spearmint
Moraceae	<i>Ficus carica</i> L.	edible fig
Moraceae	<i>Morus alba</i> L.	white mulberry
Myrtaceae	<i>Eucalyptus citriodora</i> Hook.	lemon-scented gum
Oleaceae	<i>Ligustrum sinense</i> Lour.	Chinese privet
Oxalidaceae	<i>Oxalis pes-caprae</i> L.	Bermuda buttercup
Poaceae	<i>Agrostis gigantea</i> Roth.	redtop
Poaceae	<i>Arundo donax</i> L.	giant reed
Poaceae	<i>Dactylis glomerata</i> L.	orchard grass
Poaceae	<i>Festuca arundinacea</i> Schreber	tall fescue
Poaceae	<i>Phalaris arundinacea</i> L.	reed canary grass
Poaceae	<i>Poa palustris</i> L.	fowl bluegrass
Poaceae	<i>Polypogon australis</i> Brongn.	Chilean rabbitsfoot grass

Appendix 2. (continued)

Family	Scientific Name	Common Name
Poaceae	<i>Polypogon interruptus</i> Kunth	ditch beard grass
Ranunculaceae	<i>Ranunculus parviflorus</i> L.	smallflower buttercup
Ranunculaceae	<i>Ranunculus testiculatus</i> Crantz	curvseed butterwort
Rosaceae	<i>Heteromeles arbutifolia</i> (Lindley) Roemer	toyon
Rosaceae	<i>Malus sylvestris</i> Miller	apple
Rosaceae	<i>Pyracantha angustifolia</i> (Franchet) C. Schneider	firethorn
Rosaceae	<i>Rubus armeniacus</i> Focke	Armenian blackberry
Rosaceae	<i>Rubus laciniatus</i> Willd.	cut-leaved blackberry
Scrophulariaceae	<i>Digitalis purpurea</i> L.	foxglove
Scrophulariaceae	<i>Verbascum virgatum</i> Stokes	wand mullein
Tamaricaceae	<i>Tamarix</i> sp. L.	tamarisk
Urticaceae	<i>Urtica urens</i> L.	dwarf nettle
Vitaceae	<i>Ampelopsis arborea</i> Koehne	peppervine
Vitaceae	<i>Vitis vinifera</i> L.	wine grape

Management Category 2: Exotics that are generally predicated to have a lesser effect on native vegetation and are restricted to a relatively small number of sites. These predictions are based on very little data. In some park locations, Category 2 species can be eliminated along with Category 1 species without expending significant additional resources (20 spp).

Family	Scientific Name	Common Name
Ebenaceae	<i>Diospyros</i> sp. L.	persimmon
Iridaceae	<i>Iris</i> sp. L.	iris
Juglandaceae	<i>Carya</i> sp. Nutt.	hickory
Liliaceae	<i>Leucojum aestivum</i> L.	summer snowflake
Oleaceae	<i>Olea europaea</i> L.	olive
Poaceae	<i>Echinochloa crus-galli</i> (L.) P. Beauv.	barnyard grass
Poaceae	<i>Festuca pratensis</i> Hudson	meadow fescue
Poaceae	<i>Holcus lanatus</i> L.	common velvet grass
Poaceae	<i>Lolium perenne</i> L.	perennial ryegrass
Poaceae	<i>Phalaris minor</i> Retz.	littleseed canarygrass
Poaceae	<i>Phalaris paradoxa</i> L.	hood canarygrass
Poaceae	<i>Phleum pratense</i> L.	cultivated timothy
Poaceae	<i>Piptatherum miliaceum</i> (L.) Cosson	smilo grass
Poaceae	<i>Poa bulbosa</i> L.	bulbous bluegrass
Poaceae	<i>Poa compressa</i> L.	Canadian bluegrass
Poaceae	<i>Polypogon monspeliensis</i> (L.) Desf.	annual beard grass
Poaceae	<i>Sorghum halepense</i> (L.) Pers.	Johnsongrass
Poaceae	<i>Vulpia bromoides</i> (L.) S.F. Gray	brome fescue
Punicaceae	<i>Punica granatum</i> L.	pomegranate
Rosaceae	<i>Prunus persica</i> (L.) Batsch	peach

Appendix 2. (continued)

Management Category 3: Exotics that have been shown to have a great effect on native vegetation, are broadly distributed in the parks, and are apparently increasing their ranges within the parks. Category 3 dicot species cannot be eliminated without expending a significant amount of park resources. Category 3 grass species will be impossible to eliminate, and management efforts should focus on sites of great importance and on reducing seed dispersal (4 spp).

Family	Scientific Name	Common Name
Asteraceae	<i>Cirsium vulgare</i> (Savi) Ten.	bull thistle
Poaceae	<i>Bromus tectorum</i> L.	cheat grass
Poaceae	<i>Poa pratensis</i> L. ssp. <i>pratensis</i>	Kentucky bluegrass
Scrophulariaceae	<i>Verbascum thapsus</i> L.	woolly mullein

Appendix 3. The Top 19 Species in the SEKI Weed Management Plan

Appendix 3. The top 19 species cited in the SEKI Weed Management Plan that the park is actively managing, arranged alphabetically by species. This table also lists each species' priority for management in the 2010 field season.

Scientific Name	Common Name	Management Priority
<i>Arundo donax</i>	giant reed	Med-High
<i>Bromus tectorum</i>	cheatgrass	High
<i>Carduus pycnocephalus</i>	Italian thistle	High
<i>Centaurea solstitialis</i>	yellow star thistle	High
<i>Chenopodium album</i>	lamb's quarters	Med-High
<i>Cirsium vulgare</i>	bull thistle	High
<i>Convolvulus arvensis</i>	bindweed	Med-High
<i>Digitalis purpurea</i>	foxglove	High
<i>Ficus carica</i>	edible fig	Med-High
<i>Genista monspessulana</i>	French broom	Med-High
<i>Holcus lanatus</i>	velvet grass	High
<i>Lathyrus latifolius</i>	perennial sweet pea	Med-High
<i>Marrubium vulgare</i>	horehound	Med-High
<i>Phalaris arundinacea</i>	reed canarygrass	High
<i>Ranunculus testiculatus</i>	bur buttercup	High
<i>Rubus armeniacus</i>	Armenian blackberry	High
<i>Spartium junceum</i>	Spanish broom	Med-High
<i>Verbascum thapsus</i>	woolly mullein	Med-High
<i>Vinca major</i>	greater periwinkle	Med-High

Appendix 4. The Nine Transformer Species Designated in this Report

The 9 species designated in this NRCA report as “transformer” species, arranged alphabetically by species. These species are capable of not only displacing native plants, but can also significantly alter ecosystem processes.

Scientific Name	Common Name
<i>Arundo donax</i>	giant reed
<i>Bromus tectorum</i>	cheatgrass
<i>Centaurea solstitialis</i>	yellow star thistle
<i>Genista monspessulana</i>	French broom
<i>Phalaris arundinacea</i>	reed canarygrass
<i>Rubus armeniacus</i>	Armenian blackberry
<i>Rubus lacinatus</i>	cut-leaved blackberry
<i>Spartium junceum</i>	Spanish broom
<i>Tamarix</i> sp.	tamarisk

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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