17 Exotic species threat assessment in Sequoia, Kings Canyon, and Yosemite national parks

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Introduction

Introduced plants can bring about significant changes in ecosystems by changing structural attributes of native plant communities (physiognomy, species composition, genetic diversity) and the processes that support them (fire, nutrient cycling, hydrology, soil erosion, decomposition) (Macdonald et al. 1988). Nonnative plants are most likely to establish themselves in areas that have both a source of seeds and that undergo repeated disturbance. In parks and reserves, these include developed areas such as roads, trails, campgrounds, pack stations, water treatment facilities and residential areas (Macdonald et al. 1988; Cowie and Werner 1993). Viable plant parts are transported to these sites via clothing, animal fur and digestive systems, vehicle tires, heavy equipment, slope stabilization materials, and wind (Hodkinson and Thompson 1997; Ridley 1930; Schmida and Ellner 1983). In natural systems, river corridors and riparian areas are especially vulnerable (Macdonald et al. 1988; DeFerrari and Naiman 1994; and others) as they are subject to regular disturbance, water is an agent of disturbance and of propagule transport and moisture is readily available (Pysek and Prach 1994). Reserve managers must be armed with baseline information if they are to stem invasions from points of initial establishment, as well as to plan and implement adaptive management strategies to control invading species.

Yosemite National Park has battled a handful of invading plant species for several decades, including St.-John's-wort, bull thistle, and woolly mullein, using staff, volunteer, and biological control efforts. In fact, there was concern regarding exotic species in the park as early as 1865 when Frederick Law Olmsted, chairman of the Yosemite Commissioners, endorsed preventing the displacement of native vegetation with "common weeds ... of foreign origin," as had occurred in "large districts of the Atlantic states" (Olmsted 1865).

Sequoia and Kings Canyon national parks are in the earliest stages of an exotics control program. Neither Yosemite nor Sequoia-Kings Canyon had geographically broad survey results available to provide a synoptic picture of existing threats, nor sufficient information on the distribution, abundance, and invasiveness of species present, to form the basis for prioritization. This information is important for targeting limited funding and maximizing control effectiveness.

Study areas

Yosemite National Park, in the central Sierra Nevada, is over 300,000 ha (748,000 acres) in size and ranges in elevation from 640 m in the Merced River Canyon to nearly 4,000 m on Mount Lyell. This large elevational gradient and topographic heterogeneity support a diverse array of vegetation types, including foothill chaparral, oak woodland, upland hardwood forest, conifer forest and woodland,

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meadows, and alpine plant communities. Visitation is nearly 4 million per year, 52% of them visiting Yosemite Valley during their stay (National Park Service 2000, 3-97).

Sequoia and Kings Canyon national parks, two contiguous reserves, encompass nearly 350,000 ha (864,000 acres) on the western slope of the southern Sierra Nevada. They are administered jointly, and we treated them as one reserve in our surveys. Sequoia-Kings Canyon ranges in elevation from 400 to over 4,400 m, and there is greater representation of foothill and alpine areas. Visitation is closer to 1 million and is somewhat more evenly distributed across the roaded areas of the parks.

Objectives

Our aims were to capture the diversity, abundance, and distribution of exotic plant species in the parks; map their occurrence; summarize, from published sources, information on each species present; and categorize those species according to management priority. Additional objectives included describing patterns in the distribution of exotics and providing geographic information system (GIS) and tabular summaries of available information on species present.

Approach

Distributions of vascular plants, largely native, a few exotic, were documented previously in the parks in various data sets. These included sampling associated with vegetation mapping efforts, fire monitoring plots that document species composition prior to and several years after fire, and 0.1-ha natural resource inventory plots (Graber et al. 1993). The latter set comprises over 350 plots in Yosemite and over 650 in Sequoia-Kings Canyon. Because these data sets captured species distributions in random locations, predominantly undisturbed, throughout the parks, we chose to focus on disturbed areas along vector pathways.

We generally followed the approach of Hiebert and Stubbendieck (1993), which entails assembling information on exotic plant distributions and gathering information from published sources on species' impacts, potential invasiveness, and feasibility of control. In their approach, results are summarized along gradients of controllability and threat to categorize species for management priority. We surveyed to obtain distribution information, collected available information on species present, and considered regional distributions and expert opinion in categorizing species for management priority.

Methods

We identified likely areas of exotic establishment and then surveyed them. Targeted areas included campgrounds, developments, corrals, roads, and trails. In addition, some Sequoia-Kings Canyon surveys were done in low-elevation riparian areas, pastures, and, in one case, a historic site. Field crews defined the perimeter of target areas according to the extent of regular disturbance associated with them and made complete inventories of the exotic species inside the perimeter. Categorical data were collected on the distribution and abundance of each species within each site. We inventoried roads and trails using methods appropriate to their linear character and described characteristics for each inventory site location. Along linear features such as roads and trails, surveys were limited to the width of the disturbed area associated with the travel corridor.

We graphically compared exotic species richness across elevations, both within site types and across all sites. We used cluster analysis to compare and contrast species composition among sites.

An in-depth search was made of published sources (peer-reviewed articles, technical reports, and others) for biological characteristics (reproduction, dispersal mechanisms, etc.), patterns of invasiveness in other areas, and control techniques for each species encountered on surveys. We then weighed species attributes, local and

regional distribution information, potential impacts to park ecosystems, and controllability to place species in one of four management priority categories.

Results

Survey sites were well distributed across elevations and among types of sites (Figure 17.1). A total of 95 sites were surveyed in Yosemite, 80 in Sequoia-Kings Canyon (Table 17.1). Road segments surveyed in Yosemite were a standard 1 km in length, randomly selected from mapped segments. Somewhat fewer road segments were surveyed in Sequoia-Kings Canyon, but segments were longer.

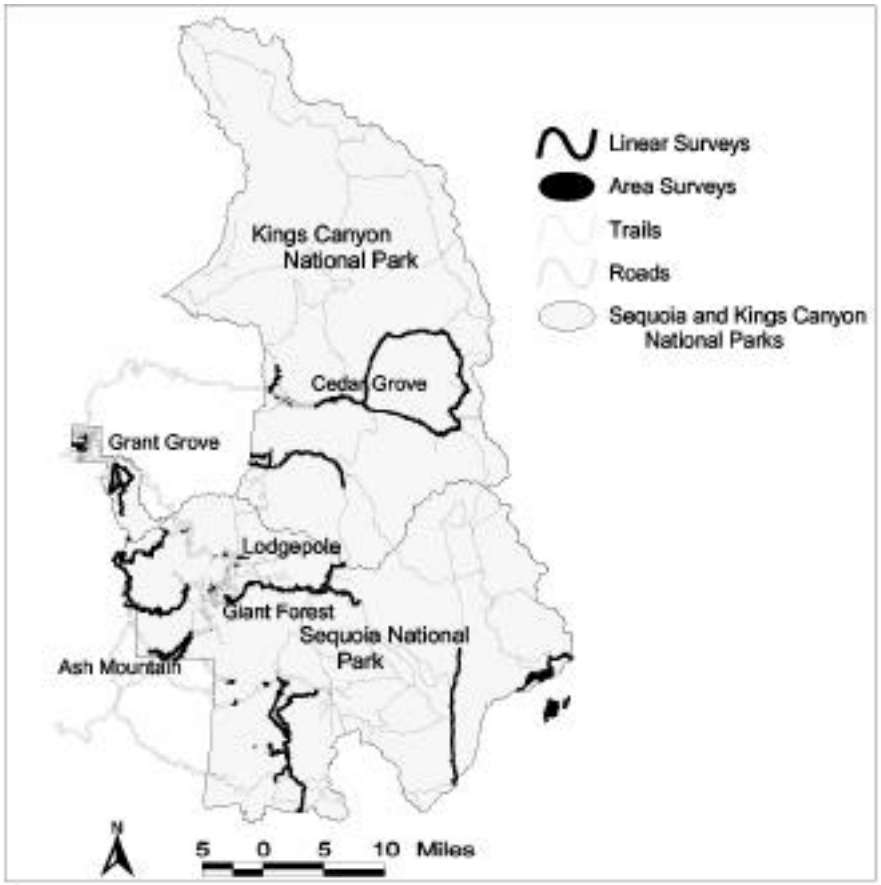

Figure 17.1. Exotic plant survey sites in Sequoia and Kings Canyon were well distributed across elevations and among types of disturbance.

Surveys documented 130 different species in Yosemite and 179 in Sequoia-Kings Canyon. There was a total of 211 exotic species encountered among the parks, with 98 species common to both Yosemite and Sequoia-Kings Canyon. Approximately the same number of species in each park (18 and 19, respectively) was listed as "most invasive" by the California Exotic Pest Plant Council (1999) or the Pacific Northwest

Exotic Pest Plant Council (1999). There were more species in developments and campgrounds than corrals and trails when all elevations were pooled.

Patch Type	*Yosemite*	*Sequoia/Kings Canyon*
Campground	14	14
Development	19	10
Corral	9	5
Road	25	8
Trail	28	26
Other	5	17
Total	95	80

Table 17.1. Number of exotic plant surveys completed in Yosemite, Sequoia, and Kings Canyon national parks between 1996 and 1999.

There was a trend of decreasing species richness with increase in elevation across all sites in both Yosemite and Sequoia-Kings Canyon (Figure 17.2). This pattern held for all sites together and for each type of site in each park. Factors that might influence this include temperature and moisture gradients across elevations, the time since species reached the parks, which species have arrived and/or level of visitation at various elevations. However, in developments, where we have extensively altered the native vegetation and thus minimized its influence, the incidence of exotics probably more strongly reflects climatic differences among sites across elevations than biotic influences.

Threat assessment

In the Hiebert and Stubbendieck (1993) approach for ranking introduced plant species for management, high priority is given to species that have a substantial impact on park resources and are easily managed. Low priority is assigned to species that cause little impact, are difficult to control, or both. Characteristics that affect controllability include extent of distribution and the existence of effective control techniques. Species life history characteristics and invasiveness in similar habitats elsewhere reflect potential for impacts to ecosystems.

Similar to this approach, we developed four management priority categories. *Category 1 species* are exotics that are currently restricted to a relatively small number of sites in each park and have either been shown to greatly affect native vegetation or have a high probability of causing serious impact. *Category 2 species* are exotics that generally have an impact on native vegetation and are restricted to a relatively small number of sites as well. *Category 3 species* are exotics that have been shown to have a great impact on native vegetation but are broadly distributed in the parks and are apparently increasing their ranges within the parks. *Category 4 species* are those species detected by the surveys but which are considered low priorities for control.

All exotic species documented during the surveys were grouped into one of the four management priority categories based on their attributes, potential impacts, and geographical extent. In addition to considering all published sources specific to particular exotic species, a number of ecological, biological invasion, weed, botanical, agronomic, and range science sources were considered in the ranking of the exotic species. Synthesis of this information provided a frame of reference to rank species

for which there is little published data and to anticipate synergistic responses between species such as occurs in mixed swards of legumes and grasses.

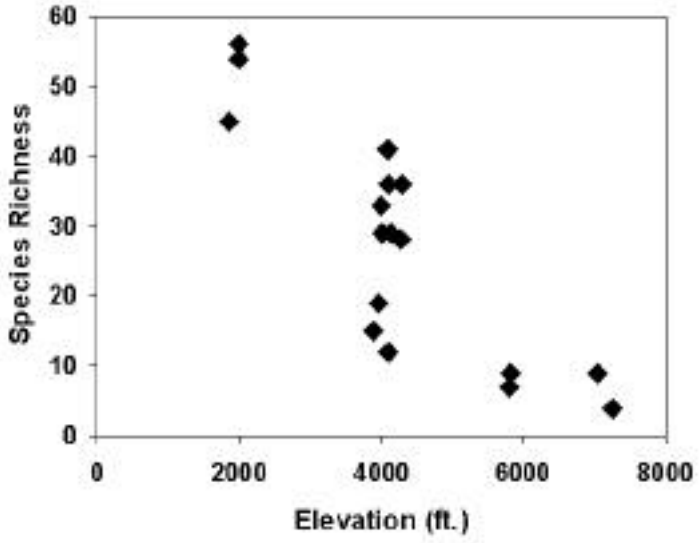

Figure 17.2. Species richness declined with elevation in developments surveyed for introduced plant species in Yosemite, 1998 and 1999.

In order to organize species by possible management strategies, we grouped them as well into tactical classes (Table 17.2). The tactical classes contain species with broadly similar ecological characteristics that may require similar management techniques or approaches. These classes are wildland species, legumes, fruit and nut species, and ornamentals. Species are further organized into grass and non-grass categories. Of the localized wildland species, 20 were placed in Category 1 and zero in Category 2. Of the broadly distributed non-grass species, both bull thistle *(Cirsium vulgare)* and woolly mullein *(Verbascum thapsus)* are Category 3 species by definition. There are nine Category 1 legumes, most of which were in Sequoia. Fruit and nut species, also mostly in Sequoia, fell into Categories 1 and 2. Of the grasses, two are Category 3 because they are listed as "most invasive" by at least one of the pest plant councils but are very broadly distributed in the parks. Both of them, Kentucky bluegrass *(Poa pratensis)* and cheatgrass *(Bromus tectorum),* occurred in both parks. The total number of species that fell into Categories 1, 2, or 3 was 90, out of 211 species documented.

We created GIS themes from global positioning system (GPS) field data of survey locations and species distributions. These can be queried by site for a species list of the site or by species for a map of all sites where that species occurred. Information on species biology was provided in tabular form for use by park staff, in conjunction with distribution information, for planning control programs.

	Management Priority Category			
	1	***2***	***3***	***4***
Non-grass species				
Wildland species	20	0	2	*
Legumes	9	0	0	7
Fruit & nut species	8	5	0	1
Ornamentals	18	2	0	2
Grass species				
Wildland species	11	13	2	34

Table 17.2. Number of exotic plant species in Yosemite, Sequoia, and Kings Canyon national parks assigned to management priority categories by tactical class. Species are limited to those detected on surveys of disturbed areas between 1996 and 1999. *Note: other than legumes, fruit/nut species and ornamentals, 95 Category 4 non-grasses were species of disturbed areas, waste places, fields, roadsides, lawns or gardens. A portion may be wildland species as well.

Italian thistle *(Carduus pycnocephalus)* is an example of a Category 1 species. It was found at one site in Yosemite and nine sites in Sequoia-Kings Canyon, but has extensive distribution in the state. Vectors that spread Italian thistle include ants, hay, soil, vehicles, and wind. Seed viability is greater than 10 years and it is on the California and Pacific Northwest Exotic Pest Plant Council list of "lesser invasives."

Johnsongrass *(Sorghum halepense)* is an example of a Category 2 species. It is spread by a wide variety of means, can produce up to 25,000 seeds per plant, and has a seed viability of more than six years. It reproduces by seed and rhizomes annually and is considered highly invasive in the Pacific Northwest. Johnsongrass was not recorded in Yosemite and was found in only one location in Sequoia-Kings Canyon, but it has an extensive statewide distribution.

An example of a Category 3 species is bull thistle *(Cirsium vulgare).* It is a biennial that reproduces by seed, has high seed output, moderate seed viability and is listed as a "lesser invasive" in California and the Pacific Northwest. It is broadly distributed in both parks. It was found at over 33 locations in Sequoia-Kings Canyon and is known to be distributed in Yosemite at elevations ranging from at least 4,000 ft to over 8,000 ft at many locations. We found it at 37 locations in Yosemite.

Recommendations

Both the field data and the literature suggest that additional information and procedures may be necessary for the effective management of exotic species in the Sierra Nevada national parks. Our recommendations along these lines can be grouped into three general categories.

Surveys

- Survey all low- and mid-elevation riparian areas in the parks and survey high-elevation riparian areas near private lands or areas grazed by domestic animals.
- Survey all meadows to determine the extent of invasion (especially that of *Poa pratensis* and *Poa palustris).*

- Survey additional disturbed areas in the parks, including road and trail corridors, to further document current distributions.
- Survey boundary areas (including private lands inside the parks) to detect invasions from adjacent habitats.
- Maintain all of the survey data in a GIS.

Research

- Conduct research on the Category 3 species to determine their extent, growth rates, dispersal vectors, and impacts on native species.
- Model the invasion potential of Category 1 species.

Procedures

- Establish rapid-response procedures for exotic species management.
- Establish procedures for managing areas of natural and (especially) anthropogenic disturbances to prevent invasion by exotic species.
- Require that all pack animals used in the parks be fed certified weed-free feed.
- Eliminate grazing by domestic animals in areas invaded by non-native Kentucky bluegrass (*Poa pratensis* ssp. *pratensis*) to avoid contributing to its spread.
- Require the use of native grasses in lawns and prohibit the introduction of the herbicide-resistant cultivars now in development.

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