EXOTIC PLANT MANAGEMENT PLAN

and

ENVIRONMENTAL ASSESSMENT

Redwood National Park

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INTRODUCTION

The flora of Redwood National Park includes at least 190 exotic species, most of which entered the park and became established within the past 150 years. (The term "exotic" is defined as "a species occurring in a given place as a result of direct or indirect, deliberate, or accidental actions by humans" (USDI 1991) and is used synonymously with "alien", "non-native" and "introduced".) There is potential for many more exotic plant species to enter the park in the future, and for present populations to increase in number, area covered and density.

Many exotic plants are ecologically harmful. They can alter the natural and/or historic scene and impair the natural function of many native plant communities. The presence and spread of exotic plant species is a significant concern to park management. The National Park Service is mandated to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations. Furthermore, the natural resources policies of the park service are "...to maintain, rehabilitate, and perpetuate their inherent integrity" (USDI, 1991).

Exotic plant management is a necessary part of each park's responsibility to protect our natural heritage. An exotic plant management program requires both a guiding plan and long-term, steadfast commitment. Short-term lapses can allow populations of invasive species to expand quickly and to negate previous control efforts. The threat of exotic species will not disappear. The keys to successful control are a systematic approach and consistent follow-up. Anything less will only provide the park with knowledge of an increasing problem.

EXOTIC PLANT MANAGEMENT PLAN

The Redwood National Park (REDW) Exotic Plant Management Plan was developed following National Park Service (NPS) guidelines for natural resource management and integrated pest management (IPM) procedures. According to the guidelines, "Management of populations of exotic plant and animal species, up to and including eradication, will be undertaken wherever such species threaten park resources or public health and when control is prudent and feasible" (USDI 1988). Managers will take action whenever such species interfere with natural processes and the perpetuation of natural features or native species, especially those that are endangered, threatened, or otherwise unique. IPM procedures have been and will continue to be used to determine when to control the exotic plants and whether to use mechanical, physical, chemical, cultural, or biological means, or a combination of these.

Program Objectives:

1.Complete and maintain a checklist of all known exotic plant species within the park.

2.Categorize the checklist according to the potential ecological and biological threat that each species represents. Specifically identify each species as either innocuous ("...does not significantly harm park resources and does not require management"), disruptive ("...has species-level, community-level, or ecosystem-level effects significantly altering natural processes..."), or potentially disruptive (will develop species-level, community-level, or ecosystem-level effects if present populations are not controlled).

3.Prioritize and select species to be considered for management action based on their disruptive nature, distribution and the feasibility of successful control.

4.Complete field surveys and distribution maps of each exotic species identified as a high priority for control. Estimate individual numbers, population centers, and spreading centers. Incorporate distribution information into the park GIS.

5.Recommend specific control methods for selected species based on current knowledge of their biology and ecology, habitat, and the economic feasibility of control.

6.Identify zones within REDW to be designated as "Special Ecological Areas". These areas will be managed to allow natural ecological processes to occur without the presence of exotic species.

7.Cooperate with other government agencies (California State Parks, California Department of Transportation, California Department of Food and Agriculture, U.S. Forest Service), private land management organizations (The Nature Conservancy), public interest groups (California Native Plant Society, California Exotic Pest Plant Council), and universities (Humboldt State University) to coordinate exotic plant control on a larger scale. Exchange

information and support research where controls methods are still costly or unknown.

8.Provide public information on the control program to ensure public understanding, and to encourage involvement and support in the park's efforts.

9.Develop and maintain a comprehensive information base about each disruptive and potentially disruptive exotic species.

10.Establish a monitoring system, and consistently monitor populations of disruptive and potentially disruptive species to determine population growth trends, possible range expansions, and the effectiveness of control programs. Monitoring will be repeatable and quantitative, and will include map and GIS updates when necessary.

11.Identify priority species and control areas, and initiate control actions. Initiate pilot projects to refine the effectiveness of control techniques. Revise control actions as new information becomes available on effective and efficient methods for total control and/or eradication of each species.

12.Coordinate exotic removal efforts with prescribed fire, vegetation management, and general resources management projects whenever possible.

General Management Strategy

In accordance with NPS policy, "...high priority will be given to the management of exotic species that have a substantial impact on park resources and that can reasonably be expected to be successfully controlled" (USDI 1988). Prioritization depends upon two independent factors: 1) the degree and kind of biological/ecological/management threat; and 2) the cost and expectation of control, based on the current population distribution of the exotic species. Each factor must be considered in planning a suitable course of action.

A list of the biological/ecological/management threats for a given exotic plant species can be developed based on the collective experience of park staff, and from information acquired from scientific and special interest group literature. Numbers and locations of plants change with time, requiring consistent inventory and monitoring. Early removal of isolated individuals and small populations minimizes seed dispersal and adverse impacts to native plant communities. Prevention is far less costly than massive eradication and restoration efforts at a later date. If massive eradication is necessary, projects must be well-planned to include follow-up to avoid re-infestation. Park staff should be kept informed and alerted to all potentially disruptive species.

The feasibility of managing or controlling each species has to be considered. Given limited resources, the most cost effective methods must be selected. However, although labor and equipment costs are taken into account, they should not deter management of exotics posing a critical threat, such as displacement of a sensitive species. Many exotic species have become naturalized in native plant communities, and function as native species without obviously altering ecosystem functions. These species are widespread throughout the region, and attempts

to control them in REDW would be impractical due to constant reintroduction from surrounding lands. Therefore, unless such plants pose a particular threat (as described under threats assessment), they are considered innocuous and are monitored to assess future potential for impact to the ecosystem. These naturalized species would be controlled if and when effective control methods become available.

Exotic plants posing major biological/ecological/management threats are identified in this plan, and the most disruptive have been designated as high priority species for management action. An appropriate course of action for each high priority species is determined by the number and location of plants in REDW and the region. This plan has four categories of population distribution/density with corresponding management actions:

1.*Present in region but not in park*. Contact cooperating agencies and landowners. Track spread if near park. Prevention of species establishment inside the park eliminates the need for control actions (Appendix F).

2.*Present in park as individuals or small, localized populations*. Remove by hand, and maintain a record of actions. Monitor the removal sites, following up with additional removal as needed. This kind of diligence keeps control costs low.

3.*Present as large infestations in parts of park. Native plant communities are disrupted and native species displaced from infested areas*. Remove outliers first. If possible, eliminate the exotic seed bank in outlier areas after mature plants have been removed to deter re-establishment. Map large infestations. Plan larger attack projects. Resources permitting, implement one or more large-scale projects, aimed as follows:

a.Contain spread to within infested areas.

b.Reduce the number and size of infestations, restore native species to bared sites, and follow a strategy that minimizes dispersal and re-infestation. In general, treat the smallest, furthest outlying areas first.

c.Eliminate the larger infestations, moving from the fringes toward the source of seed dispersal.

4.*Present as continuous infestations within and beyond park boundaries. Displaces many or all native plants in areas of infestation*. Complete control may be possible, but only by a coordinated, comprehensive effort between REDW and neighboring agencies and land managers. Extensive planning and provision for public comment will be needed. New and applied research may be required before control is possible or cost effective. Ways to share costs of eradication on a regional scale will be pursued. If costs are unreasonable, it may be possible only to restore and protect certain critical park areas from infestation. Control steps will be similar to 3.

Exotic species will be monitored by quadrat and line-point sampling (USDI 1991, 1994) to follow trends in prairies and oak woodlands, right along with native species. Photo

documentation will be used both to follow rates of spread and the effectiveness of management actions. Ground level photographs will be used to document growth or eradication of individual plants and groups of plants and to illustrate control actions. Aerial photographs will be used to locate and track infestations over larger areas. Distributions of priority species will be systematically mapped and tracked using the GIS.

A clear knowledge of the locations, areal extent, and rate of spread of exotics is needed to plan and carry out effective controls. Records of all monitoring, project planning, control and follow-up actions and costs will be maintained for review, and project and control treatments will be evaluated for effectiveness.

Responsibilities for Exotic Plant Management

The Vegetation Management Branch of the Research and Resources Management Division has primary responsibility for the overall direction and coordination of the Exotic Plant Management program. Successful implementation of the program requires intra- and interdivisional cooperation. Key responsibilities of the Exotic Plant Management program are listed below:

1.Public Information and Education	Interpretation Protection
2.Employee Education and Information	Administration Interpretation Protection Maintenance Research and Resources Management
3.Planning, Coordination, and Implementation of Major Exotic Plant Control Efforts	Research and Resources Management - Management Support Branch - Vegetation Management Branch
4.Prevention and Maintenance of Exotic Plant Spread	Maintenance - Roads and Trails - Custodial and Grounds
5.Reporting	Individual Offices Park Residents Research and Resources Management - Vegetation Management Branch

Summary of specific responsibilities:

Public Information and Education
All staff should be able to explain the basic purpose, goals of the program to the public. All staff should know where to refer the public for further information. In addition, Interpretation

and Protection personnel should be familiar with the ecological purpose of the program during public contacts.

Employee Information and Education

All park employees, concessionaires, and volunteers will receive a brief introduction to the exotic plant management program. Presentations will be given at seasonal orientation and new employee orientation to insure a knowledge and understanding of the importance of exotic plant management in REDW. A brief description of the program will be included in the new employee orientation packet, including a notebook detailing the most noxious species in the park, their appearance and management, and method for documenting new populations and individual control activities.

Implementation of Control Activities

The Resources Management Support branch will be responsible for primary implementation of control activities, with direction from Vegetation Management staff. Preferred techniques, timing, and other aspects of these activities will be outlined by Vegetation Management staff. Control activities directly related to routine maintenance, such as roadside and trailside brushing, will be the responsibility of the Roads and Trails branch. Revegetation activities which either reduce or eliminate exotic species will also continue to be the responsibility of the Vegetation Management branch. Maintenance standards for vehicle cleanliness will be developed and implemented by the Maintenance division to prevent the spread of exotic seeds and plant materials into uninfected areas. The Administration division will check all pertinent contract specifications to prevent the establishment and spread of existing and new exotic plant species into REDW.

EXOTIC SPECIES THREAT ASSESSMENT

Exotic Species Checklist

The Redwood National Park plant species list and herbarium specimens were reviewed and the native or exotic status of each species was determined using The Jepson Manual: Higher Plants of California (Hickman, 1993). This search identified over 190 exotic plant species representing 25 percent of the total number of plant species found within the park (Appendix A and B). The number of exotic species and dominance by exotics varies widely by plant community within REDW. So far, less than 1 percent of the plant coverage within the old-growth redwood forests is from exotic species. In contrast, the Bald Hills prairies have an extensive list of exotic plant species, with a relative cover of 50 to 75 percent (USDI, 1992). Therefore, priorities for control differ in separate sections of the park, and are based on the general management strategies outlined on page 4.

Prioritization and Determination of Innocuous or Disruptive Status

Management threats posed by each of the 190 exotic plant species were determined by park staff based on each species' existing park distribution and the availability of habitat for future invasion. The potential biological and ecological threats to the park were determined by reviewing pertinent literature regarding life form, reproductive patterns, methods of spread, etc. (Appendix C). The exotics with the highest management threat (totalling 38 species) were then listed with their corresponding threat characteristics (Appendix D). The remaining species are considered to be **innocuous** at this time.

Exotic species that pose a critical threat because of their ability to displace rare, threatened, or park sensitive species (Threat #1) or can cross-pollinate and produce viable offspring with native species (Threat #2) were automatically delineated as **disruptive**. The remaining species were then classified as either disruptive or potentially disruptive based on a) the number of threat characteristics each exhibited, b) their ability to rapidly displace native species in areas that have remained relatively exotics free, and c) they can be controlled through long-term efforts. The fact that certain species are selected does not exclude other species from consideration or eventual management. What it means simply is that efforts will be budgeted and directed toward the most immediate threats and potential future threats addressable through management actions.

Four species (Appendix E) have been selected for immediate action. These *high priority* species have one or both of the following characteristics of particular concern to REDW:

1. Displacement of rare, endangered, or sensitive species. This is a critical threat with action mandated by the Endangered Species Act.

2. Cross-pollinates with native species, producing viable offspring. This is in direct conflict with NPS management policies regarding the preservation of genetic integrity.

SPECIAL ECOLOGICAL AREAS

Definition and Management Objectives

In order to more effectively manage areas of REDW that are still relatively intact in terms of vegetation communities and native species interactions, the park proposes to use a Special Ecological Area approach. These Special Ecological Areas (SEAs) are useful for intensively managing specific areas within the park for the control and removal of exotic species. Hawaii Volcanoes National Park adopted this approach to exotic plant management in 1985, and found that "the most intact, diverse, unique, and valuable research and interpretive sites in the park can be protected from the impacts of exotic plant species" (Tunison and Stone, 1993). SEAs should be representative of ecosystem function, natural (unimpaired) processes including hydrology and geomorphology, and native wildlife (because of their inherent resource value). These areas will be officially designated by a Superintendent's Order under 36 CFR section 1.5.

The SEA approach is particularly effective where exotic species are widely distributed, making parkwide control impossible without marked funding increases. In these situations, areas are selected that are manageable, have a high native species diversity, and low numbers of exotic species. Management efforts begin with the removal of high priority species (disruptive species), followed by lower priority (potentially disruptive and innocuous) species as time/labor/funding allows. SEAs can be expanded as control is attained in the original area, which should be at least 10 acres in size. This approach only works if re-invasion rates are manageable and the park has human resources committed to permanent control efforts. As each SEA becomes exotics-free, it may be expanded to encompass more area. Additional zones in the park may be added to the SEA list as labor becomes available to manage and maintain them.

Selection of Sites

The designation of appropriate Special Ecological Areas in Redwood National Park is based on the following selection criteria:

1. Representativeness and/or rarity of vegetation.
2. Vegetation integrity.
3. Plant species diversity/richness.
4. Manageability.
5. Presence of rare flora and, to the extent known, rare fauna.
6. Interior to edge ratio / preserve design criteria.
7. Degree of immediacy of threats of exotic biota.
8. Research and interpretive values.

Based on these criteria, the following areas are proposed as SEAs for REDW (see Figure 1):

Little Lost Man Creek

1. Highly representative of old growth redwood vegetation
2. Low density of exotic species overall; native vegetation is relatively intact
3. High degree of plant species diversity and richness
4. Reasonably manageable - accessible from basin bottom and top, fairly intact, large
5. No known rare flora, rare fauna (spotted owl, murrelet) present
6. Has a good buffer zone with relatively intact vegetation
7. Small populations of exotic species (road corridor area)
8. High research and interpretive value

Tall Trees Grove

1. Superlative alluvial flat coast redwood grove, with the tallest individual trees measured in the world.
2. Low density of exotic species overall; native vegetation is relatively intact
3. Moderate degree of plant species diversity and richness.
4. Reasonably manageable, depending on the boundaries we delineate
5. No known rare flora, probable rare fauna (spotted owl, murrelet)
6. Minimal buffer zone of intact vegetation
7. Small populations of exotic species; effective management possible
8. High research and interpretive value

Lady Bird Johnson Grove

1. Highly representative of old growth redwood vegetation
2. Low density of exotic species overall; native vegetation is relatively intact
3. High degree of plant species diversity and richness, with ecotonal changes in species composition between the foggy coastal slope and drier ridgetop areas.
4. Reasonably manageable, depending on the boundaries we delineate
5. No known rare flora, probable rare fauna (spotted owl, murrelet)
6. Moderate buffer zone of intact vegetation (Little Lost Man RNA)
7. Small populations of exotic species; effective management possible
8. High interpretive value

Little Bald Hills

1. Representative of serpentine and uplifted marine terrace vegetation -- this is a unique type in REDW, and is fairly limited in distribution throughout the region.
2. Native vegetation above Murphy Ranch fairly intact as a result of soil limitations.
3. High degree of plant species diversity and richness.
4. Good access from trail system, easy maneuverability around area.
5. No known rare flora or fauna.
6. Minimal buffer zone of intact vegetation -- dependant on final defined boundaries.
7. Threats from exotic grasses invading from Murphy Ranch and horse trail.
8. High research and interpretive value.

TABLE 1. Characteristics of Redwood National Park Special Ecological Areas.

Special Ecological Area	Proposed/ Managed	Area (hec)	Ecological Zone	Plant Community Vegetation Type	Selection Criteria	Rare flora Research value
Little Lost Man Creek	Proposed	800	Intact old growth	Full range of redwood forest types from low to high elevation	Intactness Representativeness Potential for Interpretation Plant species richness	
Tall Trees Grove	Proposed	45	Intact old growth	Alluvial flat redwood forest	Intactness Representativeness Potential for Interpretation Plant species richness	
Lady Bird Johnson Grove	Proposed	75	Intact old growth	Upland coastal redwood forest	Potential for Interpretation (about vegetation management and exotics control techniques	
Little Bald Hills	Proposed	140	Intact serpentine association	Serpentine/ uplifted marine terrace vegetation with Jeffrey Pines	Plant species richness	

Management Threats

Exotic plants along road edges, on landslides and rock outcrops

Exotic plants along Redwood Creek, in adjacent second-growth forests

Exotic plants along Bald Hills road moving into the grove area

Exotic grasses encroaching from the trail and campsite (old Murphy Ranch site)

Figure 1. Special Ecological Areas in Redwood National Park

GENERAL MANAGEMENT TECHNIQUES

All control techniques described by REDW, The Nature Conservancy, and other resource management agencies were surveyed for each high priority species. The most promising control techniques are being tested and developed for use at REDW.

Following IPM guidelines, the following classes of control techniques are options in REDW's exotic plant control plan:

NO ACTION:

The threat of the species is found to be insignificant (the species is considered to be innocuous), or no further action is needed to achieve or maintain control of the species.

MECHANICAL CONTROL:

Heavy equipment: Machinery such as bulldozers, backhoes, cable yarders and loaders may be used in areas where exotic plant density is high, native species are absent, and impacts to other natural or cultural resources are negligible.

Power tools: Chain saws, weed whips.

Hand tools: Shovels, pulaskis, loppers, weed wrenches, grip hoists, machetes.

Manual removal: Manual removal of herbaceous and shallowly-rooted exotic species (i.e. foxglove [*Digitalis purpurea*]) is cost effective and can control some species.

Draught animals: Mules, horses can be used for plowing or pulling out large individual plants.

Prescribed Fire: Prescribed burns are used for controlling exotic plants in a variety of vegetation communities throughout the United States. Control of fire frequency, time, duration, and intensity provide opportunities for control of exotic species. The composition of the native flora may also be manipulated to re-establish and support its natural resistance to invasion by non-natives. In REDW, prescribed burning plans and techniques are being developed for the management of oak woodlands and prairie grasslands (USDI 1992, 1994).

As with all exotic species control activities, the potential for the use of prescribed fire as a tool depends upon a consistent, long term commitment by management personnel to initiate and complete control activities. For example, infrequent or inconsistent burns risk increasing the distribution and dominance of Scotch broom (*Cytisus scoparius*). Therefore, the prescribed fire program will continue to be closely coordinated with the exotic plant management program to achieve overall vegetation management objectives.

The vegetation management objectives of each prescribed burn will include an assessment of

potential effects on exotic species present within each burn, and these exotics will be monitored to determine effectiveness of the burns. Burn plans will be revised following assessment if this is deemed necessary to improve control of exotic species. Personnel working in exotic plant management will work closely with prescribed burn staff to accomplish the multiple objectives of each burn. In addition, rehabilitation of fires and firelines within REDW will be planned carefully to avoid the establishment and spread of exotic species from surrounding areas.

Cautions for mechanical control methods: Some exotic species, such as Scotch broom, deposit long lived seeds into the soil and these seeds may be in mud from infested locations. Before departing an infested worksite, crews will be directed to clean their boots, tools, tires and machinery in order to prevent seed dispersal.

People, equipment, noise and smoke may disturb rare, threatened and endangered wildlife, including the spotted owl, marbled murrelet and snowy plover. Therefore, all plans to use mechanical controls will be reviewed and carefully timed to avoid any adverse impacts to sensitive species, in compliance with NPS policy and the Endangered Species Act.

CULTURAL CONTROL:

Human activities will be planned and supervised, insofar as possible and considering other needs, to minimize opportunities for colonization by exotics, by appropriate techniques. For example, changing the time of year of activities that disturb soil may alter species composition after the disturbance.

Cleanliness: Vehicles and equipment have the potential to disperse exotic seeds great distances. There may be long lived seeds of species, such as Scotch broom, in mud, debris and crops from infested locations. If just one seed germinates and the plant matures to reproductive age, it can start a new population. Before working in a vulnerable ecosystem, such as the Bald Hills prairies, earth moving equipment used for any purpose, including road construction, maintenance and watershed rehabilitation, will be thoroughly cleaned and inspected by park staff to prevent seed dispersal.

Disposal of Plant Debris: Exotic plants that have been removed from the ground will either be left on site for consumption during a prescribed burn, or will be carefully moved to another area for pile burning at a later date. Efforts will be made to avoid adding a burden to the park's solid waste management by either burning or mulching the plant debris. Extra care will be taken in cases where the material is moved off-site to avoid contaminating additional areas with seed or rhizomatous materials.

Information: Information will be provided to the public and park employees in the form of signs, interpretive displays, brochures, and programs on the threat of exotic species and the need to control them. This will help to limit the spread of exotics to and from other lands. These will include information on how to differentiate exotics from native species with the same general appearance.

Developments and Cultural Landscapes: If exotic species are features of park developments or National Register eligible cultural landscapes, staff will determine the ecological risk of these species (i.e. will they spread into adjacent landscapes or create undesirable wildlife/human interactions) and the cost of maintaining the cultural landscape and preventing their spread outside this boundary. Exotics judged to pose no significant threat or nuisance in surrounding natural areas will be exempt from control efforts within the boundaries of developments and cultural landscapes. Exotic species judged to pose a threat or nuisance will be managed as appropriate, taking cultural and historic resource needs into account, to prevent further natural resources management problems.

BIOLOGICAL CONTROL:

Biological Enemies: Certain insects or pathogens (e.g., fungus, bacteria) attack specific species and limit their growth or reproduction. Introductions will be carefully controlled so as not to harm other native species or species of economic importance, and will only be introduced after several years of scientific evaluation.

Vegetation succession: Canopy closure by native evergreens and/or hardwoods will suppress or eliminate shade-intolerant exotic species. Succession can be encouraged.

CHEMICAL CONTROL:

Soil chemistry: Soils will be managed to restore particular conditions needed by native plant communities, or to selectively target exotics within a plant community when the native plants are genetically adapted to tolerate naturally varying levels of chemical constituents (e.g. salinity or acidity), and the exotics are not.

Herbicides: Herbicide applications will be considered for control of exotics following evaluation of alternative mechanical, physical, cultural, or biological means. If it is determined that these options are either not acceptable or not feasible, chemical herbicides might be approved for use.

Herbicides will not be considered for control of exotics in natural vegetation unless other control techniques prove ineffective. If herbicides are used, they will be applied in strict accordance with IPM guidelines under the supervision of the park IPM coordinator (USDI, 1991). To the extent possible, herbicides will be used only as a last resort.

MONITORING

The effect of all control activities, including "no action," will be monitored to determine the need for changes in control techniques (e.g., initiation, re-initiation, or refinement). Monitoring techniques, control objectives, and success criteria will be developed specific to each species being managed. Subsequent control efforts should require only the survey of the area by one individual who can maintain control without any additional support.

Monitoring techniques may include any or all of the following:

-- Aerial surveys and photography. Permanent photopoints will be established and photographs will be taken so that the physiological and morphological stage of the species of greatest concern is the same each time.

-- Roadside and trail surveys for exotics.

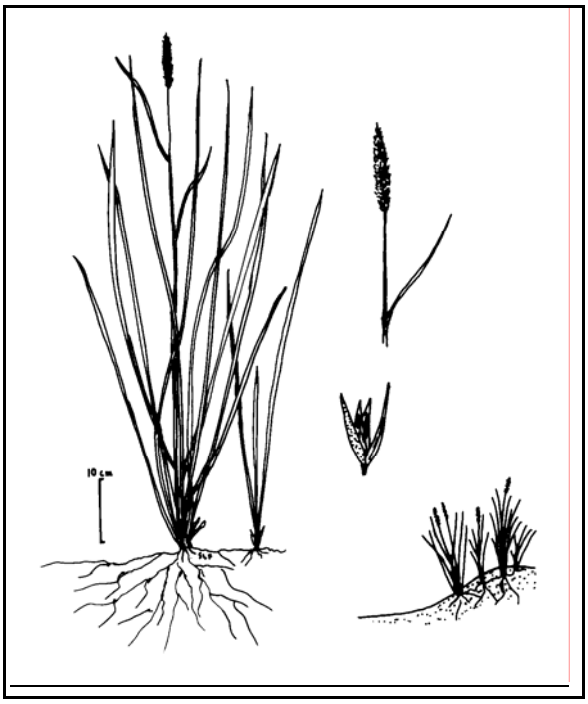
-- Mapping of the distribution and acreage of exotics. Mapping and tracking of high priority species will be performed on the park GIS in order to analyze and communicate the problem, and to determine funding and effort required for control.

-- Quadrat and line-point sampling will be used to follow trends in REDW prairies, oak woodlands and other native plant communities. This information will serve multiple management objectives.

The re-establishment of native species will complement the control efforts by supporting control of the habitat to the exclusion of exotics. Once control techniques are refined and exotic species are under control, areas will be revegetated with native species, if necessary, to restore original ecological function and to impart resistance to re-invasion of exotics.

Ammophila arenaria

(European Beachgrass)



THREATS:

Native coastal sand dune ecosystems around the world are threatened by the introduction and establishment of *Ammophila arenaria*. *Ammophila* forms a dense, expanding mat of grass, rhizomes, and roots which displaces and prevents the establishment of native dunemat species. It alters physical processes in foredunes, capturing sand, steepening sand slopes and preventing adequate sand movement from beach to interior dunes (Barbour and Johnson, 1977). In Oregon, it has severely reduced the sand supply from beach to large inland dune communities. Along the mid-Atlantic coast of the United States it greatly alters beach profiles and subsequently changes the impact and effect of storms on the coastline (Dolan et al., 1973).

In REDW, there are large stands of *Ammophila* along the beaches. Stands on Freshwater Spit threaten present populations and habitat of two candidate sensitive plants, Wolf's evening primrose (*Oenothera wolfii*) and pink sand verbena (*Abronia umbellata* ssp. *breviflora*). The dense grass eliminates areas of open sand which can be used as nesting sites by the western snowy plover, a federally listed threatened species.

MANAGEMENT OPTIONS:

No Action:

Loss of habitat for the native dunemat community, and consequent loss of native plant species, including two sensitive species; loss of nesting sites for the western snowy plover.

Mechanical Control:

Manual removal (digging): This has been effective in controlling the spread of small stands of *Ammophila*, but is labor intensive. In 1988, lines were dug out of *Ammophila* patches on Freshwater Spit in REDW using various hand tools. The lines were four feet wide and two feet deep, and rhizomes and roots were sifted out of the sand by hand afterward. As of May 1994, *Ammophila* had not reestablished in these sites.

Heavy Equipment (plowing): In 1992, a 2.5 cubic yard loader was used experimentally to plow up *Ammophila* in REDW. This technique tended to mix large amounts of sand with the grass. Removal of the mixed material became difficult because of the increased volume and weight, and the mixture has grown into a healthy population away from the beach. Mixing also made

subsequent removal by other manual techniques more difficult. It was noted, however, that the *Ammophila* in the loader's bucket was easily removed from the sand, unlike removal from undisturbed sand dunes. As a result of this observation a wide blade 8-10 inches wide could be pulled below the mats of *Ammophila*, which would release the roots. The blade could be pulled by a mule or small bulldozer, and the stems would be pulled out by hand by a crew of laborers following the plow. This would have to be followed up by additional removal or chemical treatments in order to be effective.

Chemical Control:
Sea water is a potential control for *Ammophila*. It crosses the coastal strand from time to time via wave action. Sea water contains approximately 3.5 percent salt. According to Huiskes (1979), *Ammophila* tolerates salt concentrations no greater than 1.5-2.0 percent, whereas the native dunegrass, *Elymus mollis*, can withstand concentrations of 12 percent or more. Baye (1990) found this technique to be successful in both eliminating spread and killing stands of *Ammophila*. In REDW, sea water has been applied to stands of *Ammophila* on a trial basis, with limited results due to lack of appropriate equipment. Further experimentation will include timing the applications in late spring to coincide with the end of the rainy season and the onset of the growing season for *Ammophila* (this technique is not effective during the dormant winter months). The intent will be to replace fresh water deep within the root zone with a column of sea water. If sea water prevents or slows growth of *Ammophila*, it would facilitate removal and gradual elimination of stands by chemical or mechanical means. The sea water may be pumped from the surf line with pumps designed for marine use.

Other herbicides have been used on small populations of *Ammophila* on the Mendocino coast, but these have been found to be ineffective for broadscale use over the long term, due to frequent resprouting from rhizomes.

Cultural Control:
None.

Biological Control:
None.

RECOMMENDATIONS:

Emphasis should be placed on removing outlier populations at all locations, and quiet sandy areas of the coast which are potential nesting habitat for snowy plover, from about April to August. Quiet locations with small colonies of *Ammophila* must be treated to avoid loss of this habitat, and treatment methods should be used to avoid disturbing the birds during the nesting season.

The technique of cutting with a wide, sub-surface blade (winged subsoiler) should be tested, and developed further, if effective. Application of sea water should be evaluated further as a way to slow or prevent reestablishment of *Ammophila* and to supplement mechanical follow-up techniques. Large populations should be removed following treatment of the outliers, and the smaller populations can be removed using hand tools and manual labor forces. These techniques

are flexible enough to allow protection of sensitive species and to prevent disturbance of the native dunemat community.

The Nature Conservancy (TNC) recommends that monthly treatments in manual removal areas be conducted in the first year, followed by decreased frequency in subsequent years. Control activities must be continued until no sprouts can be found for three years. Baye (1990) recommends treatment with sea water twice in the first year, followed by a third treatment during the second summer.

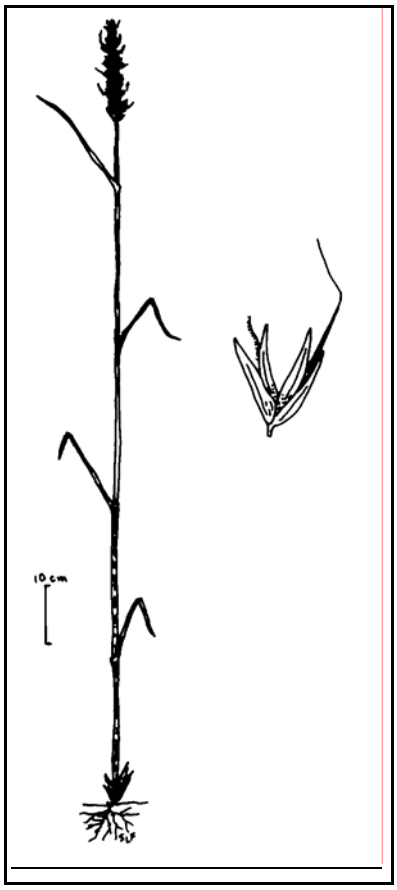
REDW's *Ammophila* management and monitoring should be closely coordinated with the California State Parks. *Ammophila* is a serious problem of mutual concern. If *Ammophila* is to be controlled throughout REDW and the State Parks, it will require a coordinated, comprehensive effort between the agencies, with ample project planning, funding and public review. Due to the scale of infestations, development and use of mechanized technology for large-scale removal is warranted.

Monitoring:
Each year, after control is established, the whole coast of REDW and all adjoining California State Parks must be surveyed to prevent the spread and reestablishment of *Ammophila*. Surrounding beach strand areas will continue to contribute to the spread of this species into the parks.

Ammophila distributions and densities will be mapped annually and entered into the park GIS. The GIS will be used to track trends and to develop cost estimates for control projects.

Arrhenatherum elatius

Tall Oatgrass



THREATS:

Arrhenatherum elatius (tall oatgrass) is a tall, tussock-forming, perennial bunchgrass native to the Mediterranean region. Probably introduced into the Bald Hills in the late 1800's or early 1900's, it was primarily used for hay production, and became a permanent part of the "new" flora in the Bald Hills. However, *Arrhenatherum* is not very tolerant of intense grazing, so was suppressed in many areas and unable to invade and spread into the prairies and oak woodlands. When cattle were removed from the park in 1982, and in the absence of other types of disturbance (i.e. fire), tall oatgrass began to spread rapidly.

One of the stated management goals for the Bald Hills is to maintain the diversity of plants and animals that prevailed when the area was first visited by Europeans (USDI, 1992). Although there are many naturalized, non-native species in the Bald Hills, *Arrhenatherum* is of special concern because of its ability to invade and possibly out-compete and suppress other species, especially native grasses such as California oatgrass (*Danthonia californica*) in the prairies, and *Melica*, *Festuca*, and *Bromus* species in the oak woodlands. Permanent monitoring plots in the prairies have shown increases in percent cover of tall oatgrass, while California oatgrass has simultaneously decreased. Within the oak woodlands, a distinct plant community exists that is dominated by *Arrhenatherum*. Studies on tall oatgrass show it to be a late successional species in abandoned fields or waste places that can be highly competitive, locally abundant, and long-lived (Grubb, 1982; Mahmoud and Grime, 1976).

Further problems associated with the spread of *Arrhenatherum* concerns its unpalatability to the resident elk herds (*Cervus elaphus* ssp. *roosevelti*). The Bald Hills provide one of the few examples of a healthy, endemic Roosevelt elk population in California. Since cattle were removed from the park in 1982, the herd has been increasing in number. A study on elk movement patterns and habitat use in the area showed that elk use the prairies extensively and in greater proportion than expected. It is anticipated that as second growth forests mature and ground forage in these areas decreases, elk will use the forests less, increasing the already high use of the prairies and oak woodlands. An analysis of the Bald Hills elk diet through pellet analysis showed that the elk were not eating tall oatgrass (Grenier et al., 1991). If *Arrhenatherum* is allowed to increase and spread, preferred elk forage may become further limited.

It would be impractical and impossible to extirpate tall oatgrass from the Bald Hills. Management concerns should focus on preventing its spread into new areas, and devising strategies to reduce its dominance in heavily invaded areas. For example, cattle were removed from Coyote Creek basin in the fall of 1991. Sampling conducted in the summer of 1992 indicated that *Arrhenatherum* was not present in significant numbers (< 7% cover in 13 sites sampled) (unpublished data, 1993). Its presence, however, in 8 of 13 sites suggest that if some form of disturbance is not returned to the area, tall oatgrass may begin to spread as rapidly here as it has in the rest of the Bald Hills.

MANAGEMENT OPTIONS:

No Action:
Arrhenatherum will probably become the dominant grass species throughout the Bald Hills. Native grasses will continue to decline in dominance. Preferred elk forage may be reduced. Redwood National Park's management goals for the Bald Hills will not be met.

Mechanical Control:
Prescribed Fire: Prescribed burning in Childs Hill prairie has shown fall burning every 3 years to be effective in reducing the spread of tall oatgrass. In plots burned four times since 1982, tall oatgrass cover never exceeded 3.25%. In unburned plots, tall oatgrass cover has increased to 31.14%, indicating that fall burning can be effective in controlling the establishment and spread of *Arrhenatherum*. The prescribed burn program at Redwood National Park has currently targeted burning the Coyote Creek addition by 1995.

In areas where *Arrhenatherum* has already become established, the emphasis should be on reducing its' cover and promoting native species dominance. Prescribed burn results from a Master thesis study indicate that there is no change in the percent cover of tall oatgrass one year after fall burning (Arguello 1994). Spring burning was also tested with similar results, no effect (Arguello 1994). The frequency of burns needed to control tall oatgrass should be investigated. Reseeding or transplanting natives should also be investigated as ways to promote native species.

Other techniques: Other techniques are available to promote native grasses in *Arrhenatherum* dominated areas. Mowing, discing to a depth of six inches, hand-hoeing, scraping off the vegetation with a D-4 bulldozer followed by reseeding or transplanting have been discussed as possible alternatives to burning. These alternatives could only be used on a limited basis and are not practical over large areas of *Arrhenatherum* dominated areas.

Chemical Control:
Tall oatgrass is sensitive to herbicides. Several studies conducted in Europe have demonstrated dramatic results from the use of non-selective herbicide, glyphosate. If this herbicide is used as a control method, it would have to be applied on *Arrhenatherum* only. Wick applicators are available that are designed to deliver an herbicide to a specific plant, and tall oatgrass, because of its height (up to 6 feet tall) could be targeted easily by these applicators. Wick applicators can be hand held or mounted on machines for faster application.

Cultural Control:
None.

Biological Control:
Selective grazing of areas with *Arrhenatherum* may be effective in reducing the high percent cover of this species, making re-establishment of native grass species more likely. Grazing (by cattle) would have to be carefully timed and monitored to reduce impacts caused by trampling and erosion. Grazing could be followed up by seeding with native grass species to insure preferred species composition changes over time.

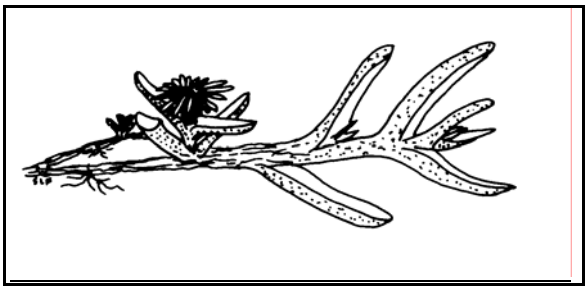
RECOMMENDATIONS:

Prescribed burning in the fall may be sufficient to prevent further establishment of *Arrhenatherum*. If so, chemical control would be unnecessary except where tall oatgrass is presently established.

Prescribed burning and reseeding or transplanting with native species should be investigated in areas where tall oatgrass dominates. Reseeding over large areas would be costly. Investigations should be made of the frequency of burning needed to control tall oatgrass so that burns can be scheduled frequently enough to meet control objectives. Herbicide use and selective grazing should also be investigated to determine their effectiveness as a control method.

Carpobrotus chilensis

(Sea Fig, Ice Plant)



THREATS:

Carpobrotus chilensis forms dense mounds covering dunes along the coastal strand. These mounds crowd out native plant species, causing a decline in native species diversity. *C. chilensis*, along with other species in the Aizoaceae family, are extremely salt tolerant and can utilize salt water for metabolic function. The salt is absorbed into the plants' tissues and exuded into the sand around the plant, making the site unavailable for native plant species. *C. chilensis*, in conjunction with *Ammophila arenaria* and *Lupinus arboreus*, can completely overtake the coastal strand and dune mat plant communities of REDW. *C. chilensis* populations on Freshwater Spit threaten populations and habitat of two candidate sensitive plants, Wolf's evening primrose (*Oenothera wolfii*) and pink sand verbena (*Abronia umbellata* ssp. *breviflora*).

MANAGEMENT OPTIONS:

No Action:
Loss of native sand dune species diversity and habitat, including park sensitive species.

Mechanical Control:
Hand pulling is very effective for pulling out the entire plant. The root system must be removed as well as the above-ground portions of the plant.

Chemical Control:
None.

Cultural Control:
Visitors, park staff, and Caltrans personnel should be educated about REDW's efforts to control this plant and prevent its spread along the coastal strand. They may inadvertently introduce this plant from other areas.

Biological Control:
None.

RECOMMENDATIONS:

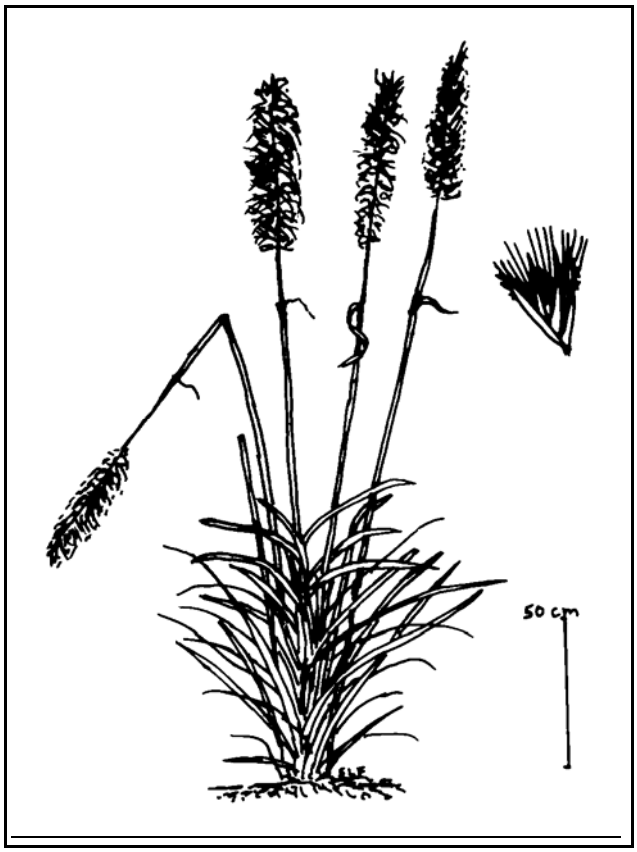
All existing plants were pulled out along Freshwater Spit in the summer of 1994. Other populations in the park will be identified and removed as discovered. The entire beach strand of REDW is a potential site for the establishment of this and other coastal exotic species, making annual surveys a priority. This is particularly important because many of the beach strand exotic

species are spread during winter storms, making widespread establishment likely without constant diligence.

Monitoring:
Spring surveys of susceptible coastal habitats will be made annually, and newly discovered individuals will be removed at that time.

Cortaderia jubata

(Pampas Grass)



THREATS:

Cortaderia jubata plants can develop seeds without pollination, so that nearly all of the ovules produced can develop into viable seeds (Costas-Lippmann, 1979). This results in a huge seed output of millions of seeds per plant (Cowan, 1976) and is the chief reason for *Cortaderia*'s success as an invader. Even a few, widely dispersed plants can achieve rapid spread because the seeds are light and easily wind-dispersed.

Cortaderia is an aggressive colonizer which competes with native plants and alters the aesthetic character of REDW's vegetation communities. It establishes rapidly on open, bare ground and in several open plant communities. It is most conspicuous on roadsides, cutbanks, rock outcrops, landslide and earthflow scars, coastal dunes and bare alluvium throughout north coastal California, including REDW. It also colonizes newly logged forest and persists for a time in openings in the second growth. However, it is intolerant of deep shade, so diminishes as the forest matures. *Cortaderia* will not affect ecological processes within mature forests, but it takes refuge in openings and colonize new landslide scars as they occur. *Cortaderia* does not actively colonize the Bald Hills prairies. It may pose the greatest long-term ecological threat to coastal dune and shrub communities where shaded conditions will not develop over time.

MANAGEMENT OPTIONS:

No Action:

Cortaderia will continue to spread along roadsides and river corridors and onto adjacent park and private lands where soil disturbance and canopy elimination has occurred. However, *Cortaderia* is only successful in areas where sunlight is available, and mortality of mature plants occurs quickly following tree canopy closure. Watershed rehabilitation and second growth site canopies usually close within 10-20 years of disturbance, and the *Cortaderia* stands within these areas are greatly diminished by this natural process without intervention.

Mechanical Control:

Wire: Large individuals and large numbers of small plants can be eliminated using a thin wire

line wrapped around the base of the plant or clump, which removes both the above-ground and root portions of the plant at the same time. The line should be pulled taught and kept taught, until the line is pulled - preferably quickly with a vehicle.

Heavy equipment: Dense stands of *Cortaderia* have been successfully removed from the Golden Gate National Recreation Area using heavy equipment (Nelson, 1991). The entire root crown must be removed to avoid subsequent sprouting, although it is not necessary to dig up all lateral roots.

Mowing: *Cortaderia* plants and flowers are conspicuous along sunny road corridors. Their height and spread are minimized by mowing during routine road maintenance. Roadsides should be mowed at least twice per year, with mowing timed in late spring and early winter. This timing effectively prevents both flowering and seed dispersal.

Manual method: Plumes of plants along road edges can be cut off to avoid seed dispersal into surrounding disturbed sites. Small plants can be pulled or dug out. Large plants can be dug out with a pulaski and shovel. The leaves can cause cuts; tops of large plants should be wrapped up and out of the way for a safe and easy approach to the roots, before the plants are dug out.

Chemical Control:
Cortaderia jubata populations in the Golden Gate National Recreation Area have been effectively controlled by using herbicide applications (Nelson, 1992). Both foliar and stump applications were made with a diluted herbicide, resulting in mortality of 80% of the individuals within one month of treatment. Following mortality, the dead stumps were removed by hand. This method will only be used if other methods prove ineffective or prohibitively expensive.

Cultural Control:
Roadside maintenance: *Cortaderia* is shade intolerant. It can be discouraged by managing road corridors so as to speed closure of a tree canopy. Thinning roadside trees helps encourage height and diameter growth and contributes stability to the remaining trees. Long term costs will be less, both for road and forest maintenance and exotic plant control, if this procedure is followed.

Biological Control:
None.

RECOMMENDATIONS:

Every opportunity should be taken to control *Cortaderia* before it becomes well-established. Control of *Cortaderia* should be considered in all road maintenance activities, including experimentation with appropriate herbicides. REDW should encourage the California State Parks, California Department of Transportation and County Road Maintenance Divisions to utilize maintenance techniques unfavorable to *Cortaderia*.

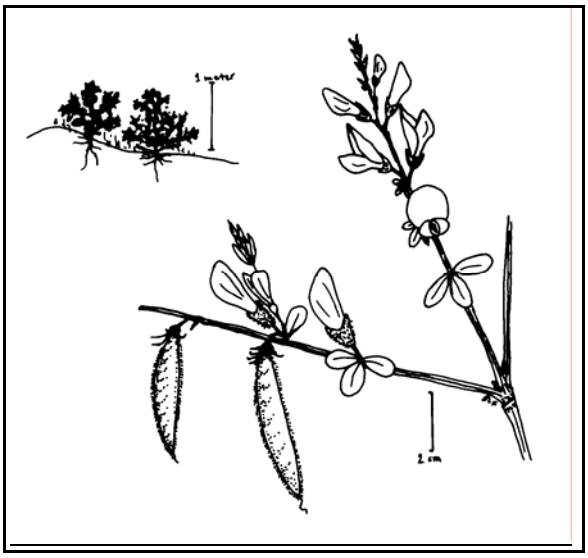
Cortaderia plants should be removed as soon as possible, while plants are few and small, from alluvial flats such as along Redwood Creek and the Tall Trees Grove. It is not possible to eliminate colonization and spread of *Cortaderia* to and from the many landslides bordering

Redwood Creek. Therefore, a long-term need exists to maintain and protect the ecological and visual integrity of alluvial flats by removing *Cortaderia*.

Monitoring:
Cortaderia will be surveyed and distribution maps prepared in potentially sensitive coastal communities, including dunes and coastal shrub. Alluvial flat and roadside surveys will be continued throughout the park, and satellite populations of *Cortaderia* will be eliminated.

Cytisus scoparius
(Scotch Broom)

THREATS:



Cytisus scoparius endangers open grasslands and hillsides throughout California (Mountjoy, 1979). In REDW, it is a major threat to the ecology of the Bald Hills because it displaces most of the native plants, grows rapidly and produces prolific seed crops annually. Its seeds may remain dormant and viable for several decades, and are stimulated to germinate by fire or soil disturbance, and it causes a visual intrusion by contrasting in color and growth form with native vegetation. Consequently, removal of *Cytisus* is a high priority in REDW. Scotch broom is also a C-rated pest species by the California Department of Food and Agriculture (CDFA, 1993).

Cytisus colonizes bare ground areas and open plant communities. It is most conspicuous in flower along roadsides. Its common presence there may be because vehicles convey seed in mud and debris, and these sites are repeatedly disturbed. As a nitrogen-fixing legume, *Cytisus* is at a great advantage along roadsides because soils are poor and there is little competition. *Cytisus* poses a great threat to the Bald Hills prairies, into which it may gradually spread from roadsides, farm and logging trails and other avenues of traffic and disturbance. It also colonizes newly logged forests and persists for a time in the second growth. However, it is intolerant of shade, so diminishes in size and vigor as forests mature. *Cytisus* will not likely affect ecological processes in mature forests once the seed pool decays.

Cytisus' reserve of buried seed, prolonged seed dormancy, and release from dormancy are difficult challenges for long term management. Bossard (1993a), investigating *Cytisus* seeds, reported 98 percent viability, but more than 65 percent of seeds had an impervious coat that delayed germination for months or years. On germination, she observed that seedlings emerged most successfully from the upper 2 cm of soil, and none emerged from seed buried below 8 cm. Heating to 150°C or more for two minutes killed the seed. Temperatures greater than 100°C for one minute increased susceptibility to fungal pathogens. Temperatures greater than 65°C for two minutes increased seed germination without decreasing fungal resistance.

MANAGEMENT OPTIONS:

No Action:
Cytisus will eventually take over all open areas along roadsides and in grasslands. The plants will continue to produce substantial numbers of seeds, which remain viable for up to 80 years in

the soil seed bank. The aesthetic character and biological integrity of the Bald Hills prairies and other infested areas will be lost.

Mechanical Control:
Possible mechanical controls include pulling the plants and prescribed burning. Extracting the plants prevents reproduction but leaves buried seed. Prescribed burning may either kill the seeds or stimulate germination. It is anticipated that burning will both diminish the seed pool and produce additional plants to be extracted. Other physical methods, including girdling (with a blade or flame thrower) and above-ground cutting (with pruners, chainsaw or mower), have proven ineffective in REDW. With these latter methods, basal sprouting occurs making later removal more difficult with thickened stem growth at ground level.

Manual removal: Plants may be pulled up by a variety of means, depending on their size. The smallest plants can be pulled by hand. The larger a plant becomes, the larger the tool and the more time is required to extract it. Weed wrenches are quick and effective for pulling out small to medium-sized individuals, with the assistance of shovels and pulaskis for large plants. Large individuals have also been successfully removed by cinching rope around the base of plants and attaching the line to a vehicle or winch, and then pulling out the plant and roots.

Grip Hoist: In 1994, a grip hoist was used to remove very large plants (basal diameter > 8") from Elk Camp and lower Dolason prairies. The hoist removes the root system by slowly pulling on the stem base, and is quite effective on large isolated patches where other methods will not work. An "old-growth" *Cytisus* patch 30' x 150' in size was removed in two days using two grip hoists. (This patch would have taken at least two months to remove with one person using hand tools), so is obviously an excellent method for the central infestation areas in the Bald Hills.

Draught animals: A small mule was used in REDW in 1992. The mule removed large *Cytisus* plants using a 6-foot tall "A" frame which allowed the force on the plant to be closer to vertical. The frame was set over individual shrubs and a haul line was run from the mules' tackle up over the frame to the base of the shrub. A block and tackle was also useful for pulling up the larger shrubs with smaller mules. Larger mules may be able to remove plants without the help of any mechanical device. This is a time-consuming method because of the need to rig up each individual plant, but the mule took less time removing large plants than weed wrenching.

Heavy equipment: A front-end loader was used experimentally in REDW in 1994 to ascertain the value of using mechanization to remove large stands of *Cytisus*, and was found to be extremely effective. Large plants were removed along the Bald Hills and C-Line road corridors using a clam-shell bucket. The bucket was carefully lowered down over a group of plants until the jaws touched the ground. Then the clam shell was closed, and the plants and attached root systems were lifted vertically out of the ground. Removed plants were piled for later burning. These methods cause a certain amount of soil disturbance, which causes subsequent germination of *Cytisus* seeds. There is a risk in moving soil, because the buried seed may be spread to uninfected areas. When heavy equipment is used safeguards must be taken, such as cleaning off tires after work is completed, to avoid this possibility.

Timing: It is most cost effective to remove plants when they are small. Small plants are most easily spotted from about December to April, after the rain and snow have flattened the surrounding grass. Removal at this time is relatively easy because the soils are moist and soft. Larger plants can be spotted at any time, but removal should be done during winter or spring, up through about June (the end of the rainy season) so the soil is still soft. Later in the season as soils dry out, the plants become difficult to remove without breaking the stem from the roots. The roots can resprout many times after the above-ground portion of the plant has been removed, so care must be taken to remove the entire plant the first time.

Prescribed Fire: *Cytisus* is a high priority species that occurs in areas where prescribed burning occurs. The control and eradication of this species has been incorporated into the vegetation management goals of the REDW's Fire Management Plan, and prescriptions are being developed that specifically address the management of this species.

Fuel loadings in *Cytisus* stands will not support fire unless the mature plants are first pulled out and allowed to dry, and live fuel moistures in *Cytisus* do not support high enough fire intensities to kill the plant. Fires do, however, stimulate sprouting from the base which makes later removal more difficult. Therefore, the strategy at REDW is to remove the mature plants, followed by burning and subsequent control of seedlings and root sprouts.

For the Sierra Nevada, Bossard (1993a) concluded that prescribed burns of areas infested with *Cytisus* could greatly decrease the number of seeds on and in the soil. She suggested timing burns in late spring so that soil heating flushes germination just prior to summer drought, with consequent high drought mortality. This idea will be tested. However, in REDW, experimental spring burns have proven disadvantageous to the native bunchgrass, *Danthonia californica* (Arguello 1994). Any testing or wider use of spring burning will be constrained in REDW by the need to preserve this native species.

Chemical Control:

Herbicide application may be effective as a follow-up and in conjunction with other techniques to deplete the buried seed pool. Following mechanical removal or a prescribed burn, there is increased germination of *Cytisus* seeds. One possibility for dealing with the *Cytisus* seedlings may be to apply herbicide as part of a follow-up, perhaps in conjunction with grass seeding. On sites where *Cytisus* suppresses the native plants, grass seed could be applied in fall, following a prescribed burn. The seeded grass and/or released natives would compete with *Cytisus* and provide fuel for follow-up burns. A broadleaf selective herbicide applied locally in late spring would kill the *Cytisus* seedlings. Alternating repeated burning and herbicide applications might prove effective in depleting the buried seed pool.

Herbicide application has also proven effective in treating stumps of *Cytisus* immediately after cutting at the Golden Gate National Recreation Area (Nelson, 1992). The stumps died completely with no resprouting, which was beneficial in areas where soil disturbance had to be minimized to protect native plant species or cultural sites.

Cultural Control:

Cleanliness: *Cytisus* seeds can be transported great distances in mud and debris stuck to vehicles

and equipment. Before working in a vulnerable ecosystem, such as the Bald Hills prairies, earth moving and surveying equipment used for any purpose, including road construction, maintenance and watershed rehabilitation, should be thoroughly cleaned and inspected by park staff to prevent seed dispersal.

Road maintenance: *Cytisus* can spread rapidly along sunny road corridors. This spread can be minimized by removing *Cytisus* plants while managing the road edge so as to speed closure of a tree canopy along forested sections. Thinning roadside trees helps encourage height and diameter growth of the remaining trees, and contributes to their stability. Long term costs will be less, both for road and forest maintenance and exotic plant control, if this procedure is followed.

Biological Control:

Insects: Twig mining moths (*Leucoptera spartifoliella*) have been found on plants in REDW. The small white moth is 1/4-1/2" long and can be seen flying around the broom at dusk in May and June when it lays its eggs on the new vegetative growth. The *Leucoptera* larvae mine directly from the eggs into the stems, tunnel throughout the stem and complete development in April or May the following year. Emerging from their tunnels, they spin white silken cocoons on the underside of twigs (Andres, 1979). Moth-infested broom plants bear a number of dead and dying twigs, but the moth has not solved the Scotch broom problem (Andres, 1979).

RECOMMENDATIONS:

As part of the exotic plant control strategy for *Cytisus*, management activities will focus first on eliminating small individuals and outlier populations to minimize seed production and dispersal. This will be followed by eradication of main populations and control of germinated seedlings.

All extraction techniques are recommended, providing there is care and attention to avoid seed dispersal. Entire plants can be uprooted during the winter through early summer while soils are still moist and soft. *Cytisus* can be removed by any mechanical technique that pulls the shrub and roots from the ground, insuring elimination of the entire plant. The sprouting ability of *Cytisus* creates a secondary threat, so removal techniques must insure that the whole plant has been eliminated in a single control operation to maximize cost effectiveness.

Germination of *Cytisus* seeds is stimulated by heat or soil disturbance. Seeds within the soil will germinate after fire and after opening a stand and exposing the soil to greater heating by the sun. This increases the number and density of plants for future removal, but will also begin to address the problem of a persistent viable seedbank. Effects of the timing and intensity of prescribed burns should continue to be investigated.

Cytisus deposits long-lived seeds into the soil which may be carried in mud from infested worksites. Before departing an infested worksite, crews should clean their boots, tools and machinery to prevent seed dispersal. Other techniques for elimination of the seedbank will be explored by park staff and by maintaining contact and cooperation with other land managers and research scientists.

Control of *Cytisus* should be considered in all road maintenance activities. REDW should encourage the California State Parks, California Department of Transportation and County Road Maintenance Divisions to utilize techniques of roadside vegetation management that maintain safety while minimizing opportunities for survival and reproduction of *Cytisus*.

Monitoring:
Surveys of *Cytisus* control sites will be conducted every spring or early summer. Sprouting stumps must be removed with hand tools, and new seedlings removed by hand.

Spread of *Cytisus* seed by vehicles, tools and feet is a continuing possibility. All park staff will be alerted to report (and pull up, if possible) any *Cytisus* observed along roads and trails in critical locations, such as the Bald Hills prairies. Regular monitoring will occur along roads, which are always vulnerable to infestation by transported seed. In addition, gullies in prairies below roads will be carefully checked, as seed can wash into them and start new infestations out of range of vehicles and equipment.

Cytisus is a major problem that requires careful tracking and project planning. Therefore, the distribution of *Cytisus* will be mapped and tracked on the GIS. Permanent photopoints will be established along the Bald Hills road and in areas presently infested with *Cytisus* to provide long-term visual documentation of the occurrence and spread/decline of this species.

Genista monspessulana

(French Broom)

THREATS:

French broom came from the Mediterranean region and was sold in California as early as 1871 as a landscaping plant (McClintock, 1985). It has silky-hairy tri-foliate leaves and showy yellow flowers, and is the most widespread exotic broom in the state. It is cited as a pest species by the California Department of Food and Agriculture (CDFA, 1993) because of its ability to form dense, impenetrable thickets which eliminate any other vegetation. In REDW, *Genista monspessulana* occurs along the Smith River corridor and adjacent river terraces, in a few localized old pastures in Orick, and in isolated patches along the Bald Hills Road. It grows in fairly dense shrub stands in open areas, and thins out as the overstory density increases. It is also found intermixed with *Cytisus scoparius* in open fields near Jedediah Smith Redwoods State Park.

Genista poses a major threat to the REDW ecosystem because of its potential to spread from river corridors and roadsides into grasslands and disturbed open areas. Seeds can be carried in the mud on vehicles, by birds, and can be transported within river sediments. There is a high potential for the establishment of this species into Redwood Creek basin and the Bald Hills prairies where soils and overstory integrity have been altered by past land use practices. *Genista* forms heavy infestations to the south of REDW along highway 101, so the spread of this species can occur from the north and south into more areas of the park.

Ecologically, *Genista* is very similar to *Cytisus scoparius* in habit and control methods. It is considered to be more aggressive than scotch broom, so is a real concern due to the potential for establishment. Fortunately, *Genista* does poorly once it is overshadowed by a thick forest canopy, and dies out within a few years. However, its seeds, like those of scotch broom, remain viable in the soil seed bank for long periods of time, so that future forest canopy disturbance through natural blowdown or possible prairie clearing can result in the germination of these seeds many years after the original infestations have been removed.

MANAGEMENT OPTIONS:

No Action:
Continued spread and establishment along the Smith River corridor and adjacent forested terraces. Further encroachment into Jedediah State Park, undermining their active control

program. Possible spread along road corridors into the Redwood Creek basin and Bald Hills prairies. The aesthetic character and biological integrity of these infested areas will be lost.

Mechanical Control:
Possible mechanical methods include pulling the plants, prescribed burning, mowing, weed-eating or otherwise decapitating seedlings following removal of seed-producing plants, and manipulating soils to remove the seed bank quickly and effectively.

Manual removal: Like scotch broom, french broom has to be pulled out roots and all to effectively kill it. Any roots or woody stems left in the ground will resprout following a period a recovery, which makes cutting at ground level impractical unless herbicides are applied on the stumps. Weed wrenches are the tool of choice, but a pulaski and/or shovel should also be available in case roots remain after the main plant is removed. In other cases, the stem is too thick or branches are growing too low on the stem to afford a good grip with a wrench, so other tools can play a critical role in the removal of this plant.

Hand hoeing and weed-eating: Young seedlings can be destroyed easily by hand hoeing or weed-eating which cuts off the plant tops. Hoeing also stirs the surface soil, drying out the root systems. These are relatively quick methods for eliminating dense seedling growth in areas where mature plants have already been removed. These techniques, like heavy equipment use, are non-selective and effect all plants growing at the site, so should only be used in areas where broom seedling densities are high in comparison to native vegetation. Again, larger plants with the potential to resprout should be completely removed with the root system intact.

Heavy equipment: Heavy equipment has not yet been used in REDW to manage *Genista*, but experimentation could occur in the future to ascertain the value of using mechanization to remove large stands of broom. Possibilities include using equipment with yarders for extraction, or using a small bulldozer or backhoe to scrape up the mature plants and roots. These methods would result in soil disturbance and subsequent germination of *Genista* seeds, which would then be pulled out by hand or cut off with a weed-eater. There is a risk in moving soil, because the buried seed may be spread to uninfected areas. If heavy equipment is used, techniques and safeguards must be developed to avoid this possibility.

Prescribed fire: *Genista* occurs in areas where prescribed burning may be used as a vegetation management tool. The control and eradication of this species will be incorporated into the goals of each burn plan, and burn prescriptions in french broom infested areas will specifically address the management of this species.

Fuel loadings in *Genista* stands may not support a hot enough fire to kill the plants outright, but would stimulate sprouting from the base. Therefore, all mature plants must be pulled out prior to broadcast burning. As with *Cytisus*, fire could greatly decrease the number of french broom seeds on and in the soil. Burns conducted in late spring could cause seeds to germinate just prior to summer drought, with consequent high drought mortality. These techniques will be tested to determine overall effectiveness in reducing the seed bank.

Chemical Control:

The herbicide Garlon has been found to be effective in reducing numbers of resprouting french broom plants after either cutting or burning (Bossard, pers comm). Broadcast herbicide application has not been found to be effective due to problems with non-specificity in spraying, and variable herbicide transport depending on the time of the year. Herbicide application may be effective in conjunction with other control techniques.

Cultural Control:
Cleanliness: *Genista* seeds can be transported great distances in mud and debris stuck to vehicles and equipment. Earth moving and surveying equipment being relocated to and from infested areas should be thoroughly cleaned to avoid seed dispersal.

Biological Control:
Vegetation succession: The overstory canopy in second-growth forests should be encouraged to close so that limiting light conditions will suppress french broom plants. This can be accomplished by selective thinning of smaller, less healthy trees that are competing with existing overstory trees. This option eliminates habitat that could be utilized by french broom, but only if the forest is expected to be managed toward old growth structure and function.

RECOMMENDATIONS:

These control methods may be used in conjunction with each other in heavily infested areas, or singly where simple treatment can be effective in eliminating the problem. Regardless, areas will have to be mapped and monitored vigilantly to prevent the re-establishment of this noxious species on park lands. Contact should be maintained with the CalEPPC french broom experimental control working group (Bossard, 1993b) to learn of any results they get concerning multiple treatments of this species at Jackson demonstration State Forest near Fort Bragg.

The extent of the current *Genista* population is unknown at this time. Field surveys should be conducted to determine this species' current range, and this information should be transferred to the park GIS. Control activities should be coordinated with ongoing management by the California Department of Parks and Recreation. Park staff should remain vigilant in preventing this species from becoming established in the Redwood Creek drainage and Bald Hills prairies.

Monitoring:
All control sites should be photo-documented, and control activities (time, labor costs, number of personnel, tools used, number and size of plants removed) should all be documented to provide a long-term assessment of the effectiveness of initial actions. Study plots could be established if treatment effects were significantly different from those found on the Marin Headlands at Golden Gate National Recreation Area and at the Jackson Demonstration Forest near Fort Bragg.

Hedera helix
(English Ivy)

THREATS:

Hedera helix forms a thick groundcover in forested areas, and vines creep rapidly up trees into the canopy. English ivy, a perennial, produces berries on an annual basis which are eaten by many bird species. The birds then spread the plant further into forested areas by defecating the seeds onto tree branches. The vines create the greatest problem by weighing down branches, which can lead to branch/trunk breakage on smaller diameter woody stems. Ivy can become established in old growth forests, threatening the integrity of these relatively exotics-free areas within REDW. If the above-ground portions are removed, sprouts appear rapidly from the roots and produce flowers within two years, making control difficult over the long term. *Hedera helix* presents a threat to the aesthetic character of infested areas.

MANAGEMENT OPTIONS:

No Action:
Continued spread and establishment, in sharp contrast with the native flora and aesthetic character of REDW.

Mechanical Control:
Cutting and Hand Removal: The above-ground portions of *Hedera helix* plants should be removed by cutting with hand tools and pulling the vines off trees. The exposed rooting stems should then be dug out to prevent sprouting.

Flaming: *Hedera helix* is controlled quite readily by singing the leaves to the point of wilting. A kerosene flamer with high-grade kerosene should be used, and the flamer should be held parallel to the ground. The ivy should by flamed only to the point of wilting, but does not need to be charred. Drawbacks to this method are that it is difficult to be selective with the flamer when the vines are inter-mixed with other vegetation, and the roots remain to sprout. Flaming is useful for controlling the spread of *Hedera*, and for making the root system more accessible for hand-removal or herbicide application.

Weed mat: Weed mat, a non-woven landscape fabric, has been used to test the feasibility of mechanically inhibiting growth following hand removal of the above-ground portions of *Hedera helix*. The fabric is permeable to air and water but is strong enough to prevent penetration by most herbaceous plant growth. Unfortunately, ivy has been found to creep along the ground

underneath the mat, sprouting out at seams and edges. Eventually it can completely cover the mat.

Chemical Control:
Herbicides have been used to successfully eradicate *H. helix* in many locations. Treatments are generally applied to the root system after the plant has resprouted following flaming or hand-removal. Treatments are applied two or three times as new sprouts appear. A broadleaf selective herbicide applied locally in late spring should kill the *Hedera helix* sprouts. The initial use of herbicide would be experimental, and applied only on small test areas.

Cultural Control:
None.

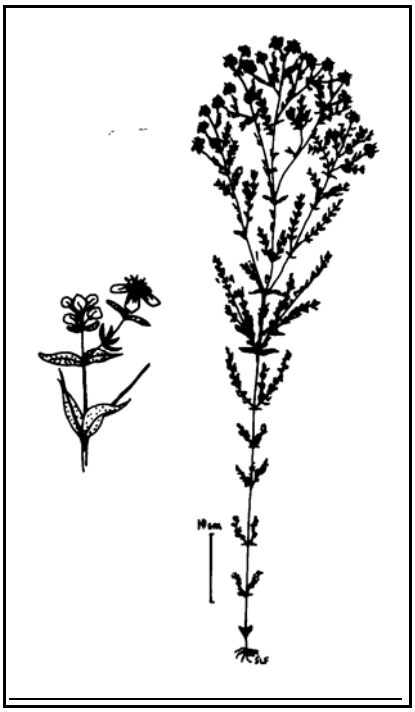
Biological Control:
None.

RECOMMENDATIONS:

Identify *Hedera helix* sites parkwide where populations are expanding and/or where patches are altering the natural vegetation. Use a combination of flaming and hand removal to control the spread of this species (particularly the climbing vines). Remove roots by hand or with herbicides when labor is available and as herbicides become approved for this use. Again, herbicides will only be used as a last resort if other methods prove to be ineffective in controlling and eliminating this species.

Monitoring:
All sites where *Hedera* has been removed must be monitored for at least three years, and any new growth should be removed immediately.

Hypericum perforatum
(Klamathweed)



THREATS:
Hypericum perforatum is a slightly woody perennial growing from a taproot that occurs throughout coastal and upland prairies, and along roadsides and disturbed sites. *Hypericum* colonizes open, bare ground and open plant communities, forming sparse stands which alter native species composition and function. It is able to produce seeds without fertilization, which makes isolated plants capable of spreading viable seeds further into the ecosystem. Seeds in the soil can remain dormant for at least a decade, and are stimulated to germinate by fire or soil disturbance which poses a long-term threat to native species cover in the prairies. The seeds are very small and are easily transported by wind and in mud and debris into previously uninfested areas.

Hypericum is toxic to livestock. While this is not an issue for Redwood National Park's wildlife, the park is obligated to reduce klamathweed populations within its boundaries to prevent further establishment onto adjacent private lands. *Hypericum* is conspicuous in all locations because of its bright yellow flowerheads and contrasting growth form, impacting the aesthetic qualities of the coastal and upland prairies.

MANAGEMENT OPTIONS:

No Action:
Hypericum will continue to spread along park roadsides and throughout the prairies. A substantial seed bank will develop in the soil, making future eradication efforts more difficult than they presently are. The aesthetic and biological character of the park's plant communities will be diminished.

Mechanical Control:
Possible mechanical controls include pulling the plants, cutting them at the base, and prescribed burning. Extracting the plants or cutting them at the base prevents reproduction but leaves buried seed. Prescribed burning may either kill the seeds or stimulate germination. It is anticipated that burning will both diminish the seed pool and produce additional plants to be extracted.

Plant Extraction: Plants may be pulled up by hand or with small weed wrenches, preferably when the soil is wet between December and June.

Prescribed Burning: The Bald Hills prairies, where the majority of *Hypericum* is located, are

scheduled to be burned on a frequent (bi-annual) rotation. Burning kills adult plants and also stimulates seeds to germinate, thereby reducing the long-term seed bank. Frequent fire can reduce the *Hypericum* populations in these areas significantly over time. Areas that are not scheduled to burn, such as roadsides and coastal areas, will continue to become further infested with this noxious species.

Chemical Control:
None.

Cultural Control:
Cleanliness: *Hypericum* seeds can be transported great distances in mud and debris stuck to vehicles and equipment. Before working in a vulnerable ecosystem, such as the Bald Hills prairies, earth moving and surveying equipment used for any purpose, including road construction, maintenance and watershed rehabilitation, should be thoroughly cleaned and inspected by park staff to prevent seed dispersal.

Road maintenance: *Hypericum* can spread rapidly along sunny road corridors. This spread can be minimized by removing plants while managing the road edge so as to speed closure of a tree canopy along forested sections. Thinning roadside trees helps encourage height and diameter growth of the remaining trees, and contributes to their stability. Long term costs will be less, both for road and forest maintenance and exotic plant control, if this procedure is followed.

Biological Control:
Insects: Defoliating klamath beetles (*Chrysolina quadrigemina*) have been found infrequently on plants in REDW. These beetles are species-specific biological control agents, affecting klamathweed only. *Chrysolina* larvae mine directly from the eggs into the leaves, causing eventual foliage and plant death. In areas where the beetles are established, they have been found to be 90%+ effective in killing adult plants. This rapid die off causes rapid mortality of the beetles, so that further eradication efforts need to be taken to remove the final individuals.

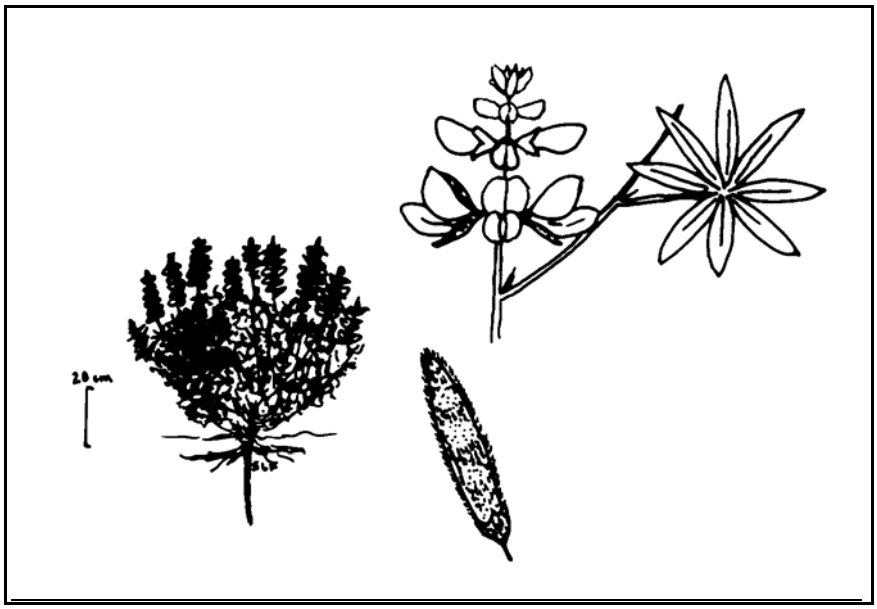
RECOMMENDATIONS:

Chrysolina quadrigemina beetles should be re-introduced into Redwood National Park where heavy infestations of *Hypericum perforatum* exist that will not be prescribed burned. These populations of *Hypericum* should be monitored to evaluate effectiveness of the treatment. Beetle populations should also be monitored to determine the extent of die-off due to starvation as *Hypericum* numbers decrease. In areas where prescribed burning is scheduled to occur, *Hypericum* populations should be evaluated pre and post-burn. If klamathweed populations are expanding in these units, beetles may be introduced to eliminate seed-producing individuals between burn cycles. Hand removal should only be undertaken in isolated areas where beetles and prescribed burning would not be effective treatments.

Monitoring:
All sites where *Hypericum* has been removed must be monitored to prevent future establishment and infestation of this pest species.

Lupinus arboreus

(Bush Lupine)



THREATS:

Lupinus arboreus is an exotic species along the coastal strand of northern California (it is native from the central California coast southward). It was introduced into this region to stabilize shifting sands, and forms dense shrub mounds bearing tall yellow flower spikes. These mounds shade out native plant species and cause a rapid decline in native species diversity and cover in infested areas. *L. arboreus* hybridizes with native species of *Lupinus*, causing contamination of the gene pool. The hybrids produce viable seeds which further disrupts the genetic integrity of the native species. *L. arboreus*, in conjunction with *Ammophila arenaria*, has completely overtaken the coastal strand and dune mat plant communities south of REDW (Clam Beach, Mad River Dunes Preserve), providing an excellent example of the potential for habitat loss if this species is not controlled.

MANAGEMENT OPTIONS:

No Action:
Probable loss of all native sand dune species and their habitat, including park sensitive species. Loss of genetic integrity of native *Lupinus* species.

Mechanical Control:
Hand pulling, weed wrenching or light cable yarding methods are very effective for pulling out the entire plant. The root system must be removed as well as the above-ground portions of the plant.

Chemical Control:
None.

Cultural Control:
Visitors, park staff, and Caltrans personnel should be educated about REDW's efforts to control this plant from spreading. They may inadvertently introduce this plant from other areas.

Biological Control:
None.

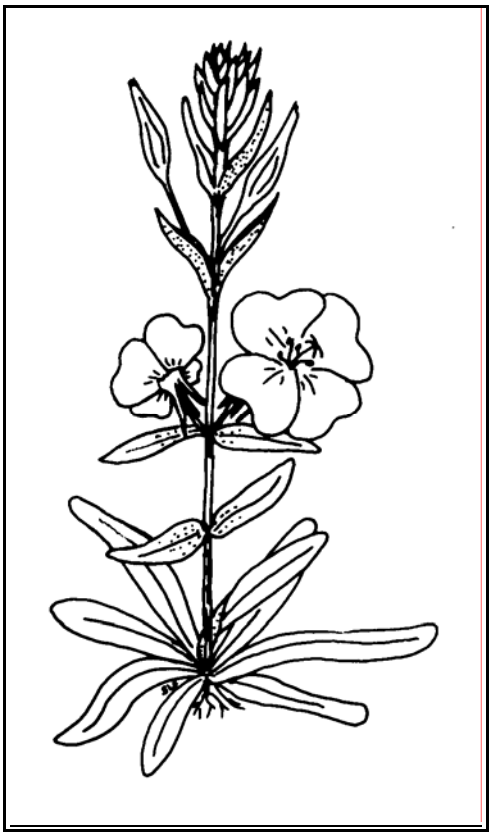
RECOMMENDATIONS:

All existing plants have been pulled out with weed wrenches along Freshwater Spit, the only known occurrence of this species in REDW. Removal should continue annually. The hybrid *L. arboreus* x *L. rivularis* hybrid is now prevalent along Freshwater Spit, and these individuals should also be removed annually to prevent further degradation of the gene pool. Seedlings should continue to sprout up from the seed bank for approximately 10 years following complete removal of the adults, making follow-up monitoring and maintenance a necessity for now. REDW's *Lupinus arboreus* management and monitoring program should also be coordinated with the California State Parks, as it is a species of mutual concern.

Monitoring:
Spring surveys of susceptible coastal habitats will be made annually, and newly discovered individuals will be removed at that time.

Oenothera glazioviana and O. glazioviana x O. wolfii

Cultivated Evening Primrose and Hybrid



THREATS:

Oenothera glazioviana is a cultivar that occurs on private lands adjacent to Redwood National Park. It is capable of cross-breeding and producing a viable hybrid with Wolf's Evening Primrose, *Oenothera wolfii*, a park sensitive species. *O. wolfii* is listed by CNPS as a threatened species. It is also a candidate for listing by the U.S. Fish and Wildlife Service, and is expected to be listed as a threatened species in the near future.

The *O. glazioviana x wolfii* hybrid occurs south and north of REDW. It also occurs alongside U.S. 101 on the south side of the Klamath River near the Coastal Drive exits. The hybrid appears to be more aggressive than either parent, becoming established along roadsides and in disturbed soils (Imper, 1987). At present neither the hybrid or *O. glazioviana* occur within the boundaries of the park.

NPS Management Policies (USDI, 1988) dictates that "The NPS will strive to protect the full range of genetic types (genotypes) native to plant...populations in the parks...". In addition, the management of exotic species that are "interfering with natural processes and the perpetuation of natural features or native species (especially those that are endangered, threatened, or otherwise unique)" is a high priority.

MANAGEMENT OPTIONS:

No Action:
O. glazioviana and its hybrid may expand into the park and hybridize with the native *O. wolfii*, swamping out its native characteristics. Hybridization with *O. wolfii* will also result in further habitat loss.

Mechanical Control:
Manual removal: Individuals or populations of *O. glazioviana* or the hybrid that are found in the park should be removed immediately. Invaded sites should be monitored after eradication to insure absence of future seedlings.

Chemical Control:
None.

Cultural Control:
Inform plant nurseries, landowners, and landscapers about the problem of planting and maintaining populations of *O. glazioviana* in the vicinity of *O. wolfii* populations.

RECOMMENDATIONS:

Annual monitoring of all populations of *O. wolfii* while simultaneously monitoring for *O. glazioviana* and/or the hybrid should continue. Special attention should be given to detecting evidence of hybridization in isolated pure stands of *O. wolfii*. Populations of hybrids discovered within REDW should be removed immediately.

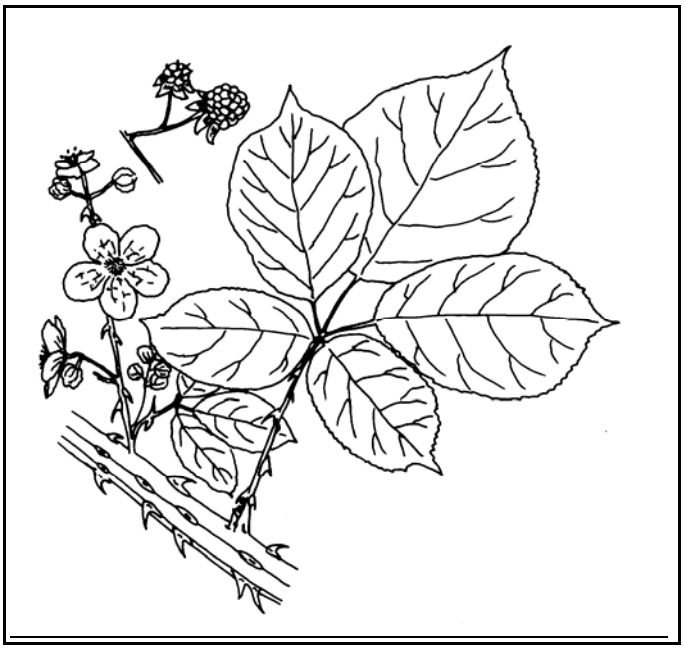
Cultural control should be implemented to avoid further encroachment of *O. glazioviana* and the hybrid into areas currently populated by pure stands of *O. wolfii*.

Monitoring:

REDW should establish contacts with CalTrans and the adjoining California State Parks and adjacent private landowners to cooperate in removal of populations which may jeopardize the genetic integrity of *O. wolfii* populations inside the park.

Rubus discolor

(Himalaya Berry)



THREATS:

Rubus discolor forms impenetrable patches in grasslands, alluvial terraces, and along fencelines throughout REDW, and can completely dominate areas if left alone. The stems are heavily armed with thorns, preventing natural biological or human activities from occurring. If the above-ground portions are removed, sprouts appear rapidly from reserves in the swollen base. These sprouts produce flowers within two years, making control difficult over the long term. New shoots can also form from roots near the ground surface, although they sprout less vigorously. *Rubus discolor* presents a threat to the aesthetic character and biological and human use of infested areas.

MANAGEMENT OPTIONS:

No Action:

Continued spread and establishment, in sharp contrast with the native flora and aesthetic character of REDW. Loss of the site for any other purpose.

Mechanical Control:

Hand Removal and/or Mowing: At the time of flowering, the above-ground portion of the *Rubus discolor* plant should be removed with hand tools and/or by mowing. The swollen base, and as many roots as possible, should then be dug out to prevent sprouting.

Prescribed Burning: *Rubus discolor* burns quite readily because of the excessive buildup of fuel around the base of each plant. Burning kills the above-ground portion, but the roots remain to sprout. Burning can be used to make the root system more accessible for hand-removal or herbicide treatments.

Chemical Control:

Herbicides have been used to successfully eradicate *R. discolor* in many locations. Treatments are generally applied to the root system after the plant has resprouted following burning or hand-removal. Alternating repeated burning and herbicide applications might prove effective in depleting the root system's capability of sprouting. The initial use of herbicide would be experimental, and applied only on small test areas.

Cultural Control:
None.

Biological Control:
None.

RECOMMENDATIONS:

Identify priority sites parkwide where *Rubus discolor* populations are expanding and/or where patches are altering the natural vegetation beyond recognition. Determine the best possible method on a site-specific basis. Prescribed burning in the Bald Hills is currently scheduled to occur on a five-year rotation, which will control the spread of this plant. Coastal prairies appear to be most susceptible to becoming completely covered, and should be added to the prescribed burning program. Isolated plants parkwide should be removed by hand. Herbicides will only be used as a last resort if other methods prove to be ineffective in controlling this species.

Monitoring:
All sites where *Rubus discolor* has been removed must be monitored for at least three years, and any new growth should be removed immediately.

Senecio jacobaea

(Tansy Ragwort)

THREATS:

Senecio jacobaea occupies coastal and upland prairie areas, occupies native species habitat, and is highly toxic to cattle and horses. It spreads easily from wind-blown seeds. Pressure was exerted upon REDW by private, city and county representatives to control *S. jacobaea* because of this species' threat to adjacent private lands.

MANAGEMENT OPTIONS:

No Action:

Populations may increase and spread beyond the influence of biological control agents and invade private lands if no control measures are taken.

Mechanical Control:

Hand removal of the entire plant and root system is very effective for controlling small isolated populations. Flower stalks should be bagged to prevent seed dispersal into uninfected areas.

Chemical Control:

None.

Cultural Control:

On active grazing lands, stock management can prevent the establishment of *S. jacobaea*.

Biological Control:

REDW has been successful in controlling *S. jacobaea* with biological control methods. Two biological control agents, the cinnabar moth (*Tyria jacobaeae*) and the tansy flea beetle (*Longitarsus jacobaea*) were introduced by U. S. Department of Agriculture agents on 115 hectares of coastal prairie in REDW. The flea beetle was found to be an effective control but must be monitored to ensure its continued effectiveness (Holden 1989).

RECOMMENDATIONS:

Surveys should be made in June each year to determine the presence of biocontrol agents for *S. jacobaea* in cooperation with the Del Norte County Farm Advisor. In mid to late summer, new plants and populations are most obvious and must be located and removed by hand.

Monitoring:

The primary control activity for *S. jacobaea* in REDW is to monitor the tansy flea beetle and

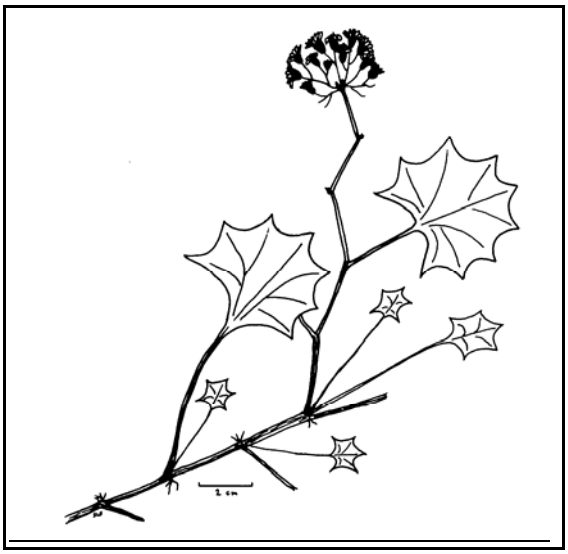
tansy ragwort populations throughout park. These activities include sampling flea beetle larvae in ragwort petioles in March. If flea beetle populations appear to be healthy and ragwort populations are declining (or are stabilized at a tolerable level), then no removal of the weed is warranted. If beetles are not present in isolated locations of ragwort, the plants should be manually removed.

Biological control efforts will lose effectiveness as the ragwort populations decrease over time, causing starvation of the beetle population. At this time, the remaining plants should be manually removed and the site should be monitored to assure complete population eradication. If this is not possible, the beetles should be reintroduced to prevent reestablishment of *S. jacobaea* populations on REDW lands.

Greater efforts must be made in educating park staff, environmental school counselors, and grounds keepers about the need to remove *S. jacobaea* plants. Plants collected at the Howland Hill School site were in obvious locations and may have been left as ornamentals.

Senecio mikanioides

(German-Ivy)



THREATS:

Senecio mikanioides, native to south Africa, is a perennial vine with large, shiny, waxy leaves. It produces showy yellow flowers, making it seem to be an attractive plant for landscaping around buildings. Unfortunately, it is invasive, fast growing, and difficult to eradicate due to its viny character and ability to root at every leaf node along the stem. This species is found along the trail leading to Nickel Beach, and at the Davison Ranch. In other areas it grows in brackish and freshwater wetland areas, forms dense ground mats in the open sun, and climbs on and smothers other vegetation in the shade and sun.

The adaptability of this species to many vegetation communities and the difficulty of complete removal makes german-ivy a species that will be extremely disruptive if allowed to become further established within Redwood National Park. *S. mikanioides* only spreads vegetatively on the north coast, so can be controlled by complete removal of existing plants.

MANAGEMENT OPTIONS:

No Action:

Populations may increase and spread beyond landscaped and old homestead sites if control measures are not taken.

Mechanical Control:

Mechanical or hand removal of the entire plant and root system is effective for controlling the spread of the park's small populations. However, the ability of this species to root at all nodes makes it imperative that all live material be removed from the soil. The root systems extend fairly deep into the soil, making this a difficult if not impossible task. In addition, all plant materials should be bagged before being disposed of to prevent establishment into uninfected areas.

Chemical Control:

Control work at San Simeon State Park has included treatments with various herbicides. It appears that permanent removal of german-ivy via herbicide application cannot be accomplished due to the tenacious tendency of the rooting nodes. However, glyphosate, oxyfluoren, and triclopyr have been successful for initial control.

Cultural Control:

Vegetation used in landscaping around Redwood's buildings should not include this species, and existing plants should be controlled to prevent spread.

Biological Control:
None.

RECOMMENDATIONS:
Preliminary control should be attempted by manual removal. The known locations of this species are fairly small, and labor time and costs should be minimal. Following manual removal, the sites should be monitored to determine the effectiveness of the treatment, and the necessity of further treatment, possibly to include herbicide applications.

Monitoring:
All known locations of this plant should be mapped and documented for future monitoring. All sites should be monitored after manual removal. Park staff (particularly buildings and grounds staff) should be made aware of this species so that other sites infested with *Senecio mikanioides* can be identified and treated.

TABLE II. SUMMARY OF CONTROL TECHNIQUES FOR HIGH PRIORITY SPECIES

CONTROL TECHNIQUE SPECIES	MECHANICAL CONTROL	CHEMICAL CONTROL	CULTURAL CONTROL	BIOLOGICAL CONTROL
Ammophila arenaria (European beachgrass)	- Manual removal (digging & pulling) - Heavy equipment (plowing)	- Sea water application to foliage and root system	None	None
Arrhenatherum elatius (Tall oatgrass)	- Prescribed fire every 3-5 years - Mowing, discing, and reseeding	- Herbicide treatments	None	- Prescribed grazing by livestock
Carpobrotus chilensis (Sea-fig)	- Hand pulling	- None	- Education of park visitors, staff, and outside agency personnel	None
Cortaderia jubata (Pampas grass)	- Mechanical removal with wire wrapped around the base of each plant - Mowing to prevent flowering stalks - Manual removal with hand tools	- Herbicide treatments	- Roadside maintenance to encourage canopy closure - Second growth thinning to promote better canopy closure	None
Cytisus scoparius (Scotch broom)	- Hand removal using weed wrenches, pulaskis, shovels, grip hoists - Draught animals pulling out plants - Heavy equipment removal with front-end loaders - Prescribed burning	- Herbicide treatments following prescribed burning or mechanical removal	- Vehicle cleanliness - Road maintenance to speed canopy closure along road corridors	- Twig mining moths (*Leucoptera spartifoliella*) treatments
Genista monspessulana (French broom)	- Hand removal using weed wrenches, pulaskis, shovels - Hand hoeing and weed-eating - Prescribed burning	- Herbicide treatments after prescribed burning or mechanical removal	- Vehicle cleanliness	- Vegetation succession to encourage shading
Hedera helix (English ivy)	- Cutting and hand removal of above-ground vines - Flaming leaves	- Herbicide application to kill vines and root systems	- Substitute native species of similar growth form for landscaping around park buildings	None
Hypericum perforatum	- Hand removal	None	- Vehicle cleanliness	- Introduction and maintenance

(Klamathweed)	- Prescribed burning to reduce long-term seed bank		- Road maintenance to speed closure of tree canopy	of klamath beetles (*Chrysolina quadrigemina*)
Lupinus arboreus (Yellow bush lupine)	- Hand removal with weed wrenches and pulaskis	None	- Education of park visitors, staff, and outside agency personnel	None
Oenothera glazioviana (Cultivated evening primrose)	- Manual removal	None	- Inform plant nurseries and adjacent landowners	None
Rubus discolor (Himalaya berry)	- Hand removal of root systems - Mowing - Prescribed burning	- Herbicide treatments to kill root systems	None	None
Senecio jacobaea (Tansy ragwort)	- Hand removal of small isolated populations	None	- Management of grazing stock	- Monitoring and maintenance of tansy flea beetles (*Longitarsus jacobaea*)
Senecio mikanioides (German-ivy)	- Mechanical or hand removal of entire plants	- Herbicide treatments to kill root systems of larger plants	- Avoid planting or maintaining this species as a landscape plant around park buildings adjacent to natural areas - Substitute native species of similar growth form for landscaping around park buildings	None

ENVIRONMENTAL COMPLIANCE

The draft Exotic Plant Management Plan and Environmental Assessment will be available for public review and comment. Any comments received will be addressed during preparation of the final plan. This document will be updated periodically to include new control techniques, new species priorities, and new control projects.

Individual exotic species management projects or portions of projects may be subject to internal park project clearance. This process allows review of all projects to ensure that the project would have no adverse effects on cultural resources, wetlands, floodplains, threatened, endangered or sensitive species or critical habitat, and would not have highly uncertain or potentially significant environmental effects or involve unique or unknown environmental risks.

A Park Project Clearance form is completed by the project initiator and circulated to Division Chiefs and staff specialists (Supervisory Botanist, Fish and Wildlife Ecologist, Environmental Specialist, Archeologist, Landscape Architect and Safety Officer). The latter review the project and determine if resources may be impacted that would necessitate an environmental assessment or impact statement. The Superintendent or Deputy Superintendent makes a final determination based on review of the project and resource specialists' comments. Any necessary mitigating measures or project modifications will occur prior to initiation of a project, insofar as possible.

Plans for large-scale, mechanical exotic plant control projects in locations where there may be sensitive wildlife will be planned and reviewed normally at least two years in advance of when the project is actually to be carried out. This advanced planning may be necessary in order to complete biological surveys for rare, threatened and endangered species. No other large scale approaches are anticipated.

ENVIRONMENTAL ASSESSMENT

PURPOSE AND NEED FOR ACTION

The presence and spread of exotic (non-native) plant species in Redwood National Park (REDW) is a significant concern to the park. It is the policy of the National Park Service (NPS) "...to maintain, rehabilitate, and perpetuate" the integrity of park resources (USDI, 1988). NPS policy is to manage, control, and/or eradicate exotic species that threaten native species to prevent resource degradation. This resource degradation includes elimination of native plant and wildlife species through competition, over-crowding, or interbreeding, changes in ecological function with vegetation cover changes from grasslands to shrublands, and changes in physical processes such as sand movement by the presence of exotic species. Exotic plant species in REDW threaten significant park resources through these processes, causing a gradual decline in the ecological function and aesthetic value of once-pristine areas of the park.

REDW proposes to undertake a program to manage, control, or eradicate exotic plant species that threaten the integrity of native plant populations and communities. This Environmental Assessment describes alternative methods to control exotic plant species and evaluates the impacts of an exotic plant management program.

AFFECTED ENVIRONMENT

Location and Project Area

Redwood National Park, a World Heritage Site, is located in northwestern California, between Crescent City in Del Norte County and Arcata in Humboldt County (Figure 2). The 110,000 acre park includes about 35 miles of Pacific Ocean coastline. Three California State Parks, Jedediah Smith, Del Norte Coast and Prairie Creek Redwoods lie within the established national park boundaries (Figure 3).

Natural Resources

Air Quality

Air quality within Redwood National Park is considered to be good to excellent. The park is a Class I airshed. There are many natural factors which reduce air quality (fog, clouds, rain, salt spray haze, natural forest inversion haze). Occasional debris-pile burning, wood-stove burning, prescribed burning, and vehicles on roads and highways are human-caused sources of pollution in the park. None create resource problems in the park at present levels.

Figure 2. Location of Redwood National and State Parks in northwestern California.

Figure 3. Location of State Parks within established National Park Boundaries.

Climate

The climate is characterized by rainy winters and rainless summers. Summer coastal fog is common. Prevailing winds are westerly, coming in directly from the Pacific Ocean. Snow falls infrequently at higher elevations. Average annual rainfall is 70 inches in Crescent City, 87 inches in Klamath, and 69 inches in Orick. Rainfall often exceeds 100 inches per year in inland portions of the park such as the Bald Hills in the Redwood Creek drainage. Temperatures in Crescent City vary from a mean daily maximum of 60.4° to a mean daily minimum of 44.8°F, and in Orick from 61.1°F mean maximum to 42.8°F mean minimum temperature.

Geology

Geologically, the park lies on the Franciscan Formation. In the Redwood Creek basin the west side consists of a quartz-mica schist, whereas the east side lies on unmetamorphosed sedimentary rocks including sandstones, siltstones, and minor amounts of conglomerates. In the rest of the park, there are also isolated exposures of volcanic greenstones and cherts, serpentine, and small remnants of uplifted marine and river sediments.

Topography

The topography is comprised of two distinctive physiographic environments - the coastline, and the mountains of the Coast Range. The coastline is rugged with stretches of steep, rocky cliffs broken by rolling slopes. The tidal zone is generally rocky and difficult to traverse, except for Gold Bluffs Beach, a seven-mile expanse of dunes and sandy beach. Inland from the coast lies the dominating physiography of the Coast Range. Major streams and ridge-lines trend northwest. The gently rounded summits of the mountains contrast with the steep side-slopes that have been deeply incised by streams. Elevations in the park range from sea level to 3,267 feet at an unnamed summit above Coyote Creek.

Soils

The soils in Redwood National Park are derived from the underlying Franciscan Formation. Residual soils are confined mainly to patches on sloping ridge crests, except for those developed on the Gold Bluffs formation. There are also alluvial soils in the park that developed on flood-plains, in alluvial valleys, and on stream terraces of major streams and rivers. Variations in soil types are controlled by the topography, kinds of rock types, ages of geomorphic surfaces, and influences of vegetation. Local variations may result from microclimatic differences influenced by slope aspect.

Water Resources and Hydrology

Redwood National Park has varied water resources that include groundwater (springs), freshwater (streams and ponds), salt water (Pacific Ocean), transitional areas (brackish lagoons), and seasonal wetlands. Portions of five significant watersheds pass through parts of Redwood National Park. They are, from north to south, the Smith River, Mill Creek, the Klamath River, Prairie Creek, and Redwood Creek. Surface water quality is strongly affected by previous land use practices and by storm events. Hydrology and physical stream systems have been altered by these uses, causing concentrations and/or the absence of sediments and woody debris in drainages, obliteration and diversion of small drainages with road building and logging practices, downstream landslides, higher peak winter discharge,

and lower peak summer discharge.

Vegetation

The park's varied vegetation types result from topographic relief and differences in soils, aspect, and climate. There are six major vegetation types in Redwood National Park:

Coniferous forests - Sitka spruce forests dominated the area immediately adjacent to the ocean. Most of these were logged prior to 1940, and most spruce forests in the park are second-growth stands. Old growth redwood forests consists of coast redwood trees with Douglas-fir, western hemlock, grand fir, and tan oak as associates. With increasing elevation and distance from the ocean, redwood becomes less abundant and these associated species increase in importance. Second-growth forests throughout the park are usually over-represented by Douglas-fir trees, especially if aerially seeded due to timber management by previous land owners. These stands vary in age throughout the park, ranging from selective cuts dating from the 1850s to clearcuts dating to 1978. Jeffrey pine woodlands are limited in distribution to the thin, nutrient-poor serpentine soils in the Little Bald Hills. The sparse overstory consists of Jeffrey pine, knobcone pine, and Douglas-fir, with an understory of native perennial bunchgrasses and forbs. Few exotic species occur within this community.

Oak woodlands - Oregon white oak dominates the woodlands, with scattered individuals of California black oak. California bay-laurel and big-leaf maple are found on rock outcrops and stream channels. Douglas-fir is a natural invader of both prairies and oak woodlands.

Prairies - Two areas of prairie exist in the park. The Bald Hills prairies consist of a mosaic of native and exotic perennial and annual grasses and forbs. Exotic species dominate the grassland cover, and only two native grass species are found in significant numbers. Prior to the introduction of livestock, the prairie vegetation was primarily native bunchgrasses interspersed with annual and perennial clovers. The Little Bald Hills prairies consist mostly of native perennial bunchgrasses (fescues), with very few exotic species (mainly herbs and forbs) scattered within the grassland areas.

Coastal strand and prairies - Vegetation along the coastline varies according to topography and exposure to ocean breezes. The beach strand consists of low-lying herbaceous vegetation growing on sand dunes and unstable sediments. This type is found from north to south along the entire park coastline. Coastal prairies occur on bluffs, and are a mosaic of native and exotic grassland species, with increasing dominance of exotic species as time elapses.

Northern Coastal Scrub - The scrub community is interspersed with the coastal prairies, and consists of shrub species such as coyote brush, poison-oak, salal, huckleberry, silk tassel, ocean spray, and California blackberry. This community acts as an interface between the coastal prairies and forests.

Riparian - Riparian areas vary from alder forests to spruce swamps, with many understory shrubs, forbs, and herbaceous species. Disturbed riparian zones often consist of high numbers of exotic species with significant cover.

Wetlands and Floodplains

These occur primarily near the coast and in broad valley bottoms within the park. The largest, most conspicuous natural wetlands are the lagoons and estuaries. There are also small ponds and water impoundments in the park. Major drainages in the park have associated floodplains. Hundred-year flood levels have been determined for developed areas. Some exotic species occur within these zones, either growing within the water or on the seasonally dry floodplains.

Wildlife and Fisheries

The wildlife of the park includes a broad spectrum of common species of the Pacific states. Large mammals include Roosevelt elk, black-tailed deer, coyote, American black bear, bobcat, and mountain lions. Other residents are various reptiles (snakes, lizards) and amphibians (frogs, newts, salamanders). Bird species are both resident and migratory. A total of 402 vertebrate species are likely to occur within the park boundaries. Provisional counts list 29 amphibian and reptile species, 279 bird species, and 58 mammal species. It is unknown how many invertebrate species occur in the park. There are approximately 39 species of marine, freshwater, and anadromous fish in the park.

Threatened and Endangered species

Plant Species - Rare, threatened and endangered plants are listed in Appendix G. The park currently has no state or federally listed threatened or endangered species. The National Park Service manages candidate species (species currently under review for federal listing as endangered or threatened) parallel to the management of federally listed species (USDI, 1991). The coastal strand, bluffs, and rock outcrops host the only candidate plant species of Redwood National Park: Wolf's evening primrose and pink sand verbena. In comparison, heavily forested areas contain no recognized sensitive plant species.

Animal Species - Rare, threatened and endangered animals are listed in Appendix H. Two federally listed threatened species, the northern spotted owl and the marbled murrelet, are known to reside in the park year round. Murrelets are dependent on old-growth forests, but spotted owls can occur in older second- growth forests. The snowy plover, a threatened coastal bird species, is known to occur along the coast north and south of the park, but has not been found nesting within the park to date. Several endangered bird species frequent the park during the summer months (i.e. peregrine falcons, bald eagles), but their breeding status is unknown.

Cultural Resources

Prehistoric and Traditional Cultural Properties

During the first significant contact between Europeans and Native Americans in northwestern California (around 1830 - 1850), three ethnographic groups occupied what is now Redwood National Park: the Yurok, the Tolowa, and the Chilula. Prehistoric, and ethnographic cultural resources associated with these groups and their ancestors include major villages, temporary and seasonal camps, trail sites, and ceremonial or power-seeking places. These cultural resources are of great importance, not only as part of Native American history but also as places which are still in use.

Historic Resources

Historic resources distributed throughout Redwood National Park represent the major stages of regional land use and social and economic history. Items of early sea trade are present in some of the coastal prehistoric/historic villages. Trails, roads, and stage stops associated with early transportation networks are found in the northern part of Redwood National Park and in the Redwood Creek basin. Mining settlements were established along the coast. Landscaping, structures and equipment associated with homesteading and early ranching are located within the park boundaries as are buildings and support facilities associated with the commercial industries of logging, fishing, and dairy ranching. Military structures are also present.

National Register of Historic Places

Along the coast, three ethnographic/prehistoric village sites, a portion of the Old Redwood Highway, and a World War II facility are all listed on the National Register. The greatest concentration of cultural resources is in the Bald Hills of the Redwood Creek basin. Twenty-six of the archeological sites are included in the Bald Hills Archeological District, listed on the National Register. Additional archeological sites are eligible. Also located in the Bald Hills are the Lyons Ranches which include the extant structures but also the prairies and oak woodlands which were grazed and farmed. These properties are currently being nominated to the National Register as a rural historic district.

Socioeconomic Conditions

Visitor Use and Experience

Primary visitor use areas are Freshwater Lagoon Spit, the Bald Hills Road and prairies, Enderts and Crescent City beaches, the Little Bald Hills, the Tall Trees Grove and Redwood Creek basin, and the Lady Bird Johnson Grove. Visitors gain access to park areas in vehicles, by hiking, bicycling, and on horseback. All of these areas have some exotic species as a component of the vegetation cover. Many visitors notice the presence of exotic species, particularly the more showy species such as Scotch broom, pampas grass, and foxglove. Park comment/complaint forms are occasionally received by vegetation management staff complaining about the presence of exotic species in areas such as the Tall Trees Grove, Bald Hills, and Freshwater Beach area.

Visual Quality and Aesthetics

Visual quality is good to excellent due to the many long distance unobstructed views of pristine and recovering forest areas throughout the park. The park has many opportunities to experience nature and to recreate, including old growth forests and the tallest redwood trees in the world, coastal beaches, and prairies and oak woodlands in the Bald and Little Bald Hills. There are many trails throughout the park provide ample opportunities for exercise in an outdoor environment. The old growth forests, streams and rocky coastlines and beaches provide opportunities for solitude and to hear natural sounds away from human influences. The park is dedicated to managing the natural area vegetation as it was prior to the influence of Europeans, and exotic plant species detract from the aesthetic qualities of native vegetation by indicating the presence of outside influences on the land.

Park Operations

The Maintenance Division has primary responsibility for keeping park roads, trail edges and landscaped areas free of overgrowing vegetation. These activities include some management of exotic species where present. The Vegetation Management branch in the Resources Management Division works on direct management, control, and inventory of exotic species throughout the park, and assists with coordination of maintenance activities which may affect exotic species. All park staff assist with exotic species management projects as these duties are assigned.

ALTERNATIVES

ALTERNATIVE 1 - NO ACTION

Under this alternative, no management of exotic plant species would occur. Exotic plants would not be removed by burning or mechanical removal. No herbicides would be used to control exotic species. Exotic plants would not be inventoried or monitored. Natural vegetation associations would continue to be degraded.

ALTERNATIVE 2 - MECHANICAL CONTROLS

Under this alternative, exotic plant species would be controlled by mechanical methods. Mechanical controls would include heavy equipment, power tools, hand tools, manual removal, draught animals, and prescribed fire. Personnel would receive training in the use of mechanical control methods and timing. All plans to use mechanical controls would be reviewed by vegetation and wildlife program managers, and projects would be timed to avoid any adverse impacts to threatened, endangered, or sensitive species.

Some exotic species, such as Scotch broom, deposit long-lived seeds into the soil and these seeds may be in mud from infested locations. Before departing an infested worksite, crews would be directed to clean their boots, tools, tires and machinery in order to prevent seed dispersal. Soil compaction would be minimized by restricting work to the season when the soils are dry, and work would be planned and carried out in a manner to minimize the number of passes over the ground. After work is completed, the soil conditions would be evaluated. If there is compaction, surface layers would be disced or ripped to restore permeability.

Prescribed fire would be used in areas where fire occurred naturally, such as in the Bald Hills prairies and oak woodlands. Prescribed fires would be applied at a frequency to simulate natural fire frequencies, and would be planned and implemented in accordance with the Redwood National Park Fire Management Plan (USDI, 1994).

ALTERNATIVE 3 - CULTURAL CONTROLS

Under this alternative exotic plant species would be controlled by attempting to change human activities and behaviors. The cultural control alternative would take into consideration the effects humans have on spreading and promoting the growth of exotic plants. Activities of visitors, park personnel, and outside agencies could minimize opportunities for colonization by exotics. These techniques include vehicle cleanliness to reduce the possibility of spreading long lived seeds of species, such as Scotch broom, in mud, debris and crops from infested locations, information dissemination in the form of signs, interpretive displays, brochures, and programs, and evaluation and management of exotic species in cultural landscapes. Increased inter-agency cooperation and cooperation with adjacent landowners would be promoted to assist in control of species crossing political boundaries, and to alert other landowners of potentially troublesome species encroaching on their lands.

ALTERNATIVE 4 - BIOLOGICAL CONTROLS

Under this alternative, exotic plant species would be controlled by biological means with pathogens or natural succession. These would include insect and fungal or bacterial pathogens which attack specific species and limit their growth or reproduction, such as the tansy flea beetle for tansy ragwort and the Klamath beetle for Klamath weed control. Introductions would be carefully controlled so as not to harm other native species or species of economic importance, and would only be introduced after several years of scientific evaluation. Canopy closure by native evergreens and/or hardwoods through natural succession would suppress or eliminate shade-intolerant exotic species. Natural succession would be encouraged by limiting canopy clearing during routine maintenance activities.

ALTERNATIVE 5 - CHEMICAL CONTROLS

Under this alternative, exotic plant species would be controlled either through the use of herbicides or by altering the chemical environment. Soil chemistry would be managed to restore particular conditions needed by native plant communities, or to selectively target exotics within a plant community. A constraint on managing soil chemistry is that the soil chemistry which can support native plants would be reestablished after elimination of the exotic species.

Herbicides would be used to control exotics in natural vegetation only if effective and other control techniques were ineffective. If herbicides were used, they would be applied in strict accordance with NPS Integrated Pest Management guidelines under the supervision of the park IPM coordinator and in compliance with applicable state regulations.

PREFERRED ALTERNATIVE

The preferred alternative for exotic plant species management would be a combination of Alternatives 2, 3, 4 and 5. The control techniques chosen would vary depending on the target species, its location, and the ecological changes it had caused. Some species would receive treatments from a single alternative (i.e. mechanical control), whereas others would receive treatments from two or more alternatives, such as mechanical removal with cultural control. These multi-treatment species include Scotch broom, pampas grass, English ivy, tansy ragwort, European beach grass, and Himalayan blackberry. The preferred treatment for each species could change as information becomes available about successful control methods from other agencies and individuals working in exotic species control. This alternative is consistent with U.S. Department of the Interior and National Park Service IPM policies.

ENVIRONMENTAL CONSEQUENCES

The environmental consequences of the No Action and Preferred Alternative are discussed in the following text. The impact matrix on page 67 shows the short- and long-term positive, negative, and neutral consequences of each alternative (1 through 5) and the preferred alternative (alternatives 2 through 5). Refer to the text for greater detail of specific control method impacts.

NO ACTION

The no action alternative would have long-term repercussions to the park ecosystem. Exotic plant species would be free to invade, establish, grow, and reproduce throughout the park. Native flora and fauna (including threatened, endangered, and candidate species) would be displaced due to loss of habitat and loss of genetic integrity. The appearance and ecological function of large areas would change as the vegetation types changed (i.e. grassland to shrubland, low coastal dunemat to tall mounding beach grass). There would be changes in nutrient availability as exotic plant species draw on the existing nutrient load of the ecosystem. Fire fuel loadings would change through changes in the fuels (grass to shrub), altering the fire regime. Tall dunes would form, obstructing ocean views and changing the natural wind-beach processes from constantly blowing winds. The natural soil chemistry would be altered by the addition of exotic plant tissues and accumulated salts. The competition between plants for limited resources such as nutrients, light, and pollinators would be altered, causing displacement of native species. These changes would then result in changes in the availability of natural food for wildlife.

PREFERRED ALTERNATIVE (Alternatives 2 through 5)

Natural Resources

Air Quality

Air quality would be temporarily reduced by smoke from prescribed burns. The timing of prescribed burns is controlled by the North Coast Unified Air Quality Management District to minimize adverse impacts to air quality. All prescribed burning would be in accordance with regulations and an approved park Fire Management Plan. Mechanized equipment use would result in a temporary slight decrease in air quality from diesel fumes, dust, etc. Decomposing herbicides fumes would slightly decrease air quality. All use of pesticides would be in accordance with EPA regulations and NPS policy to avoid adverse effects on non-target species from air-borne pesticides. There would be no significant adverse long-term impacts to air quality from any of the alternatives.

Topography and Soils

No significant adverse impacts to soils are anticipated. The temporary exposure of soils due to removal of plant cover would temporarily increase erosion potential. In small areas surrounded by vegetation, there would be no significant impact. In large areas, work would be timed to avoid rain and park staff would use sterile or non-seeding straw mulch or cloth

erosion barriers as a temporary substitute for plant cover. The removal of roots would reduce soil strength. In small areas surrounded by vegetation, there would be no significant impact. Most manual removal efforts only affect small areas, whereas heavy equipment removal can affect larger areas and have greater impact potential. The consequences of loss of root strength would be assessed on a case by case basis for large areas, steep slopes and areas near streams. If significant impacts are judged possible, the area would be broken into smaller units and treated incrementally.

Heavy equipment operations compact soil surface layers. The soil surface is most susceptible to compaction when wet and least susceptible when dry. With continued heavy equipment operation, soil compaction is progressive, in that the remaining pore space is decreased in each pass. Once vegetation has become re-established on the site, compaction gradually decreases over time to normal levels. Surface soil layers would be temporarily or permanently displaced during removal of exotic plants by heavy equipment. In some cases, the permanent relocation of soil would visibly alter the micro-topography. However, permanent displacement would only be allowed in areas needing recontouring. Small-scale recontouring would be used to restore natural contours or to recover topsoil displaced by previous land-use disturbances. Temporarily moving soil would have no significant impact. The restoration of missing topsoil and natural land contours would restore visual integrity, encourage the return of a natural pattern of vegetation, and reduce the potential for accelerated erosion. Long-term increased root strength might result from the elimination of exotic annual species and the re-establishment of native perennial grasses on the prairies, with possible reductions in earthflow movement and gullying. These would generally be interpreted as beneficial effects.

European beach grass traps sand, building steep dunes and restricting the natural movement of wind and sand across the beach. Upon removal of the beach grass, topographical changes would occur as winds gradually lower the dunes. A natural pattern of wind and sand movement would return. These conditions would favor either persistence or the return of native plant communities and increase sites available for snowy plover nesting to the coastal strand. All of these effects would generally be interpreted as beneficial ones. There would also be an increase in blowing sand, which could present maintenance and visitor problems in areas where removal occurred adjacent to roads and visitor use sites such as picnic areas and campgrounds. These could be considered negative impacts.

Water Resources

Temporary, limited increases in sediments and turbidity would result from destabilized and disturbed soils. Site-specific methods would be adopted to avoid soil disturbance in critical areas along streams, or straw mulch or other means of erosion control would be used if there were a significant slope and area of disturbance adjacent to a stream. Watershed rehabilitation staff would be consulted to review specific projects. Over the long term, the re-establishment of native grasses with their long fibrous root systems would increase soil stabilization, improving water quality through decreased turbidity. Herbicides, if used, would be chosen based upon minimum toxicity and leaching capacities if designated for wet or drainage areas.

Floodplains and Wetlands

Suspended sediments and turbidity increase temporarily when plants are removed from wet soils. Waterfowl can be disturbed and discouraged by human activities during nesting and migration. These would be considered negative impacts. To minimize increasing suspended sediments, in seasonal wetlands, exotic plants would be removed only during the dry season. In perennial wetlands, exotic plants would be removed by using boats when water levels were high and in motion. Work would be timed to avoid disturbance to nesting and migrating waterfowl. Over the long term, removal of exotics would favor the re-establishment of native wetland plants by reducing competition. Tall, dense stands of exotic wetland plants, such as reed canary grass, trap suspended sediment, gradually raising the ground level and diminishing wetland functions. Removal of these exotic plants helps to preserve functioning wetlands. The preservation of wetlands, wetland functions and native wetland species by removal of exotic plants would be considered positive impacts.

Vegetation

Exotic plant species removal would decrease the competition for habitat and limited resources such as space, light, and nutrients between the remaining native plants. Native species cover and vigor would increase as a direct result of this release from competitive stress. The expansion of exotic species populations would be prevented, and available habitat for native species would be maintained. Fewer exotic species would invade into and become established in the park because of increased inter-agency cooperation and cooperation with neighboring landowners. Native plant species would benefit from prescribed burning, while many exotic species would decline in numbers and ability to spread. Fire would be used to manipulate the vegetation to benefit the native species at the exclusion of exotics species so they would be unable to spread further into native plant communities, if not gradually suppressed and killed off over time. Otherwise, many vegetation communities susceptible to change (such as the prairies and coastal strand) would become dominated by exotic plant species that are currently found outside park boundaries but have not yet become established within the park (i.e. yellow star-thistle, gorse). Herbicides, if used, would be chosen for minimum toxicity and for species specific and/or systemic modes of action.

The genetic integrity of some native plant populations (i.e. Wolf's evening primrose, riverbank lupine) would be protected by the removal of closely related exotic species. Hybridization and cross-pollination can cause a decrease in seed production of the pure native species, and removal of the exotics would eliminate this problem.

Control and management of exotic plant species would help REDW meet the legislative and Park Service goals of preserving and protecting the vegetation and ecosystem processes that were present in the area prior to the influence of European humans.

Visual Quality and Aesthetics

The park "natural scene" would be enhanced for public enjoyment, learning and interpretation, especially in open ecosystems such as the prairies and coastal strand. Along the strand, species such as European beach grass suppress natives to such an extent that the abundance and diversity of native flowering plants is low and, consequently, the diversity of flower types, color and foliage is also low. Removal of the exotic species would enhance the

diversity and aesthetic qualities of these areas.

Exotic plant control would open and maintain views of the ocean and prairies, providing a contrast to the thick vegetation within second-growth forest stands and shrublands. European beach grass accumulates sand, causing the creation of dunes tall enough to obstruct a clear view of the beach and ocean, so the ocean would be more visible with the removal of this species. Removal of large stands of scotch broom would open vistas in the Bald Hills prairies. The aesthetic and visual qualities of native vegetation cover throughout the park would be guaranteed over time, so that future generations would be able to visit naturally functioning old-growth forests, prairies, beaches, and wetland areas.

Wildlife and Fisheries

Native wildlife habitat for breeding, nesting, and feeding would increase due to an increase in native vegetation cover and vigor. Fewer wildlife corridors would be affected by the impenetrable masses of vines and spiny branches of such species as Himalaya berry, English holly, and English ivy. Natural processes critical for creating and maintaining wildlife habitat (such as fire in the prairies and natural sand movement on the beaches) would be restored and maintained. Wildlife species would be temporarily displaced during heavy equipment use. Heavy equipment operations would be timed to minimize disruptions to wildlife and fish populations. Extreme caution during herbicide applications, and avoidance of wet areas, would eliminate the possibility of negative impacts to invertebrates and aquatic species.

Threatened and Endangered Species

Animal Species

There would be an increase in the availability of habitat for breeding, nesting, and feeding activities for snowy plovers and other shorebirds, due to an increase in unstabilized sand and low ground-hugging vegetation. Heavy equipment operations, human presence, and prescribed burning would be timed to avoid disturbance of T&E species during nesting and other sensitive activities.

Plant Species

There would be decreased plant competition for habitat and limited resources. The genetic integrity of candidate listed species (Wolf's evening primrose) would be maintained by limiting hybridization and cross-pollination with exotic species.

Cultural Resources

In general, the removal of exotic species would contribute to the restoration and maintenance of the historic and ethnographic cultural landscapes in the park, especially in the Bald Hills of the Redwood Creek basin. Control of exotic, non-invasive vegetation associated with these landscapes would not be considered unless other resource management problems arose from their presence. Invasive exotic species would be permanently removed, and if appropriate, replaced with native non-invasive species with similar appearance in order to retain landscaping functions. All treatments would be planned and implemented in accordance with NPS-28 (USDI, 1993).

Prehistoric and historic archeological resources could be adversely affected by heavy equipment use. Although prescribed burning would cause some degradation of cultural artifacts through oxidation and heating, it is assumed that low-intensity fires would not adversely effect archeological resources. Surface surveys would be conducted prior to prescribed burns to limit damage to exposed artifacts. Mechanical disturbance to cultural sites would be avoided through consultation with the park archeologist in conjunction with park project clearance procedures, and other control methods would be used instead wherever cultural artifacts were found. There are no anticipated adverse effects to cultural resources from the use of biological or cultural control methods. Where the use of chemical methods could affect soil chemistry on archeological sites, the park archeologist would be consulted.

Proposed actions would be implemented in compliance with Section 106 of the National Historic Preservation Act and the 1990 Programmatic Agreement among the NPS, the Advisory Council on Historic Preservation, and the National Conference of State Historic Preservation Offices. For all action alternatives involving ground disturbance, cultural resource inventories would be completed prior to ground disturbance. If the action would have no effects on archeological resources, a clearance would be obtained from the Western Archeological and Conservation Center. All efforts would be made to implement the proposed action without disturbing cultural properties. Should it not be possible to avoid a cultural resource through accommodation during the design phase, mitigative measures would be developed in consultation with the California State Historic Preservation Officer. If unrecorded archeological resources were uncovered during any removal efforts, work would cease and the archeologist would be contacted.

For all action alternatives, the park would consult with the appropriate Native American Heritage Advisory committees and the Yurok Tribe in order to determine whether or not traditional cultural properties are present within the area of project impacts. To the extent possible, recommendations of the consultants regarding the management of park lands in the vicinity of these properties would be followed.

Socioeconomic Conditions

Park Operations

Disruption of park operations would be minimized through careful planning of the use of park staff and park equipment for removal operations, monitoring, evaluation, and maintenance of these projects. Application of mechanical controls would pose risks unless personnel were trained properly. Staff time would also be used to increase employee awareness of the need to integrate exotic plant control operations with other research, resource management and maintenance operations in the park.

Visitor Use and Experience

Visitors would gain an increased knowledge of the mission of REDW and the National Park Service to protect and preserve the native vegetation and ecosystem processes through the development and dispersal of brochures, slide programs, and visitor center displays. The park's environmental education schools and school outreach programs would utilize slide shows and site visits to educate students about native flora and exotic

species management. Many visitors are aware of the concept of exotic plants and their potential harm to the environment. For these people, the presence of intrusive exotics detracts from the park experience and perception that the National Park Service is a steward of national treasures. Visits to the park would be enhanced by this increased awareness of the complexities of resources management issues, and the awareness that many attractive garden plants can escape and become harmful in the wild, especially in parks such as REDW, which have been established to preserve the natural, biological and scenic heritage.

Furthermore, visitors would be given more of an opportunity to explore the park as certain exotic species were removed, particularly those with thorns, spines, or toxic characteristics. Outdoor user groups such as horse groups would be able to enjoy the park without fear of their horses consuming toxic exotic weeds such as tansy ragwort.

TABLE III. EXOTIC PLANT MANAGEMENT PLAN IMPACT MATRIX

Alternatives: / Resource:	ONE No Action		TWO Mechanical		THREE Cultural		FOUR Biological		FIVE Chemical	
Impact Duration	Short	Long	Short	Long	Short	Long	Short	Long	Short	Long
Air Quality	0[1]	0	-	0	0	0	0	0	-	0
Topography and Soils	0	0	-	+	0	+	0	+	0	+
Water	0	0	-	0	0	0	0	0	-	0
Vegetation	--	--	+	++	+	++	+	++	-	++
Wildlife and Fisheries	--	--	0	+	0	+	0	+	0	+
Threatened, Endangered, and Sensitive Species	--	--	++	++	+	++	+	++	0	++
Cultural Resources	-	--	0	0	0	0	0	0	0	0
Socioeconomic	-	-	0	+	++	+	-	+	0	+
Aesthetics and Visual Quality	-	--	0	++	0	++	0	+	0	+

[1]Symbols indicate the following:
++ highly positive effect; + positive effect; 0 neutral effect; - negative effect; -- highly negative effect
See text of Environmental Assessment for specific factors interpreted as positive, neutral or negative effects.

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Appendix A.

EXOTIC PLANT SPECIES OF REDWOOD NATIONAL PARK

(High priority species for control are underlined)

Agrostis capillaris
Agrostis gigantea
Agrostis stolonifera
Aira caryophyllea
Aira praecox
Ammophila arenaria
Anagallis arvensis
Anethum graveolens
Anthemis cotula
Anthoxanthum aristatum
Anthoxanthum odoratum
Arrhenatherum elatius
Avena barbata
Avena fatua
Avena sativa
Bellis perennis
Brachypodium distachyon
Brassica nigra
Brassica rapa
Briza maxima
Briza minor
Bromus catharticus
Bromus diandrus
Bromus hordeaceus
Bromus inermis ssp *inermis*
Bromus stamineus
Bromus sterilis
Bromus vulgaris
Cakile maritima
Callitriche stagnalis
Cannabis sativa
Capsella bursa-pastoris
Carpobrotus chilensis
Centaurea melitensis
Centaurium erythraea
Cerastium arvense
Cerastium glomeratum
Chamomilla suaveolens
Chenopodium album
Chenopodium botrys
Cichorium intybus
Cirsium arvense
Cirsium vulgare
Conium maculatum
Convolvulus arvensis
Coronopus didymus
Cortaderia jubata
Cortaderia selloana
Cotoneaster franchetti
Cotoneaster pannosa
Cotula australis
Cotula coronopifolia
Crepis capillaris
Cupressus macrocarpa
Cynosurus cristatus
Cynosurus echinatus
Cytisus scoparius
Dactylis glomerata
Danthonia pilosa
Datura stramonium
Daucus carota
Digitalis purpurea
Dipsacus fullonum
Egeria densa
Elytrigia repens
Erechtites glomerata
Erechtites minima
Erodium botrys
Erodium cicutarium
Festuca arundinacea
Filago gallica
Foeniculum vulgare
Galium divaricatum
Galium parisiense var *leiocarpum*
Gastridium ventricosum
Genista monspessulana
Geranium carolinianum
Geranium dissectum
Geranium molle
Geranium pusillum
Gnaphalium collinum
Gnaphalium japonicum
Hedera helix
Holcus lanatus
Hordeum marinum ssp *gussoneanum*
Hordeum murinum ssp *leporinum*
Hordeum vulgare
Hypericum perforatum
Hypochoeris glabra
Hypochoeris radicata
Ilex aquifolium
Isatis tinctoria
Lapsana communis
Lactuca saligna
Lathyrus latifolius
Lathyrus sphaericus
Leontodon taraxacoides
Leucanthemum vulgare

Linum bienne
Lolium multiflorum
Lolium perenne
Lolium temulentum
Lotus corniculatus
Lotus uliginosus
Lupinus arboreus
Lythrum hyssopifolium
Madia sativa
Malus sylvestris
Medicago arabica
Melilotus alba
Melilotus indica
Melissa officinalis
Mentha pulegium
Myosotis discolor
Myosotis latifolia
Myosotis micrantha
Narcissus psuedonarcissus
Oenanthe pimpinelloides
Oenothera glazioviana
Parentucellia viscosa
Phalaris aquatica
Phalaris arundinacea
Phalaris paradoxa
Phleum pratense
Pinus radiata
Plantago coronopus
Plantago lanceolata
Plantago major
Poa annua
Poa compressa
Poa pratensis ssp *pratensis*
Poa trivialis
Polycarpon tetraphyllum
Polygonum cuspidatum
Polygonum polystachyum
Polypogon australis
Polypogon monspeliensis
Prunella vulgaris var *vulgaris*
Pyrus communis
Ranunculus muricatus
Ranunculus repens
Raphanus raphanistrum
Raphanus sativus
Robinia pseudo-acacia
Rubus discolor
Rubus laciniatus
Rumex acetosella
Rumex crispus
Rumex obtusifolius ssp *agrestis*
Saponaria officinalis
Scandix pecten-veneris
Senecio jacobaea
Senecio mikanioides
Senecio sylvaticus
Senecio vulgaris
Sherardia arvensis
Silene gallica
Silybum marianum
Sisymbrium altissimum
Sisymbrium officinale
Solidago canadensis ssp *elongata*
Sonchus arvensis
Sonchus asper ssp *asper*
Sonchus oleraceus
Spergula arvensis ssp *arvensis*
Spergularia rubra
Stellaria media
Taeniatherum caput-medusae
Taraxacum officinale
Torilis arvensis
Torilis nodosa
Trifolium arvense
Trifolium dubium
Trifolium pratense
Trifolium repens
Trifolium subterraneum
Triticum aestivum
Ulex europaea
Verbascum thapsus
Verbascum blattaria
Veronica arvensis
Vicia benghalensis
Vicia disperma
Vicia hirsuta
Vicia sativa ssp *nigra*
Vicia sativa ssp *sativa*
Vicia tetrasperma
Vicia villosa ssp *varia*
Vinca major
Vulpia bromoides
Vulpia myuros var *hirsuta*

APPENDIX B.

SCIENTIFIC AND COMMON NAMES OF REDWOOD N.P. EXOTICS

(High priority species for control are under lined)

Family	Scientific Name	Common Name
AIZOACEAE	*Carpobrotus chilensis*	Sea Fig
APIACEAE	*Anethum graveolens*	Dill
	Conium maculatum	Poison Hemlock
	Daucus carota	Wild Carrot
	Foeniculum vulgare	Sweet Fennel
	Oenanthe pimpinelloides	-
	Scandix pecten-veneris	Venus's Needle
	Torilis arvensis	Japanese Hedge Parsley
	Torilis nodosa	Hedge Parsley
APOCYNACEAE	*Vinca major*	Periwinkle
AQUIFOLIACEAE	*Ilex aquifolium*	English Holly
ARALIACEAE	*Hedera helix*	English Ivy
ASTERACEAE	*Anthemis cotula*	Stinkweed, Dog-fennel
	Bellis perennis	English Daisy
	Centaurea melitensis	Tocalote
	Chamomilla suaveolens	Pineappleweed
	Cichorium intybus	Chicory
	Cirsium arvense	Canada Thistle
	Cirsium vulgare	Bull Thistle
	Cotula australis	-
	Cotula coronopifolia	Brass Buttons
	Crepis capillaris	Hawksbeard
	Erechtites glomerata	Fireweed
	Erechtites minima	Fireweed
	Filago gallica	Herba Impia
	Gnaphalium collinum	Cudweed, Everlasting
	Gnaphalium japonicum	Cudweed, Everlasting
	Hypochoeris glabra	Smooth Cats Ear
	Hypochoeris radicata	Rough Cat's Ear
	Lapsana communis	Nipplewort
	Leontodon taraxacoides	Hairy Hawkbit
	Leucanthemum vulgare	Ox-Eye Daisy
	Madia sativa	Coast Tarweed
	Senecio jacobaea	Tansy Ragwort
	Senecio mikanioides	German Ivy

Family	Scientific Name	Common Name
	Senecio sylvaticus	Ragwort, Groundsel
	Senecio vulgaris	Ragwort, Groundsel
	Silybum marianum	Milk Thistle
	Solidago canadensis ssp *elongata*	Canada Goldenrod
	Sonchus arvensis	Perennial Sow Thistle
	Sonchus asper ssp *asper*	Prickly Sow Thistle
	Sonchus oleraceus	Common Sow Thistle
	Taraxacum officinale	Dandelion
BORAGINACEAE	*Myosotis discolor*	Forget-Me-Not
	Myosotis latifolia	Forget-Me-Not
	Myosotis micrantha	Forget-Me-Not
BRASSICACEAE	*Brassica nigra*	Black Mustard
	Brassica rapa	Field Mustard
	Cakile maritima	Sea Rocket
	Capsella bursa-pastoris	Shepherds Purse
	Coronopus didymus	Wartcress
	Isatis tinctoria	Dyer's Woad
	Raphanus raphanistrum	Jointed Charlock
	Raphanus sativus	Wild Radish
	Sisymbrium altissimum	Tumble Mustard
	Sisymbrium officinale	Hedge Mustard
CALLITRICHACEAE	*Callitriche stagnalis*	Water-Starwort
CANNABACEAE	*Cannabis sativa*	Marijuana, Pot
CARYOPHYLLACEAE	*Cerastium arvense*	Field Chickweed
	Cerastium glomeratum	Mouse-Ear Chickweed
	Saponaria officinalis	Soapwort
	Silene gallica	Common Catchfly
	Spergula arvensis ssp *arvensis*	Starwort
	Spergularia rubra	Sand Spurrey
	Stellaria media	Common Chickweed
CHENOPODIACEAE	*Chenopodium album*	Pigweed
	Chenopodium botrys	Jerusalem-Oak
CONVOLVULACEAE	*Convolvulus arvensis*	Bindweed
CUPRESSACEAE	*Cupressus macrocarpa*	Monterey Cypress
DIPSACACEAE	*Dipsacus fullonum*	Fuller's Teasel

Family	Scientific Name	Common Name
FABACEAE	*Cytisus scoparius*	Scotch Broom
	Genista monspessulana	French Broom
	Lathyrus latifolius	Perennial Sweet Pea
	Lathyrus sphaericus	Smooth Pod Pea
	Lotus corniculatus	Bird Foot Trefoil
	Lotus uliginosus	-
	Lupinus arboreus	Yellow Bush Lupine
	Medicago arabica	Spotted Burclover
	Melilotus alba	White Sweetclover
	Melilotus indica	Small Sweetclover
	Robinia pseudo-acacia	Black Locust
	Trifolium arvense	Clover
	Trifolium dubium	Shamrock
	Trifolium pratense	Red Clover
	Trifolium repens	White Clover
	Trifolium subterraneum	Subterranean Clover
	Ulex europaea	Gorse
	Vicia benghalensis	Purple Vetch
	Vicia disperma	Vetch
	Vicia hirsuta	-
	Vicia sativa ssp *nigra*	-
	Vicia sativa ssp *sativa*	Spring Vetch
	Vicia tetrasperma	-
	Vicia villosa ssp *varia*	Hairy Vetch
GENTIANACEAE	*Centaurium erythrea*	Centaury
GERANIACEAE	*Erodium botrys*	Longbeaked Filaree
	Erodium cicutarium	Red Stemmed Filaree
	Geranium carolinianum	-
	Geranium dissectum	Cut leaf Geranium
	Geranium molle	Cranesbill
	Geranium pusillum	Geranium
HYDROCHARITACEAE	*Egeria densa*	Brazilian Waterweed
HYPERICACEAE	*Hypericum perforatum*	Klamath Weed
LAMIACEAE	*Melissa officinalis*	Bee Balm
	Mentha pulegium	Pennyroyal
	Prunella vulgaris var *vulgaris*	Selfheal
LILIACEAE	*Narcissus psuedonarcissus*	Daffodil

Family	Scientific Name	Common Name
LINACEAE	*Linum bienne*	Flax
LYTHRACEAE	*Lythrum hyssopifolium*	Loosestrife
ONAGRACEAE	*Oenothera glazioviana*	Cultivated Evening Primrose
PINACEAE	*Pinus radiata*	Monterey Pine
PLANTAGINACEAE	*Plantago coronopus*	-
	Plantago lanceolata	English Plantain, Ribgrass
	Plantago major	Common Plantain
POACEAE	*Agrostis capillaris*	Colonial Bentgrass
	Agrostis gigantea	Redtop, Bentgrass
	Agrostis stolonifera	Creeping Bentgrass
	Aira caryophyllea	Silver European Hairgrass
	Aira praecox	Hairgrass
	Ammophila arenaria	European Beachgrass
	Anthoxanthum aristatum	Vernal Grass
	Anthoxanthum odoratum	Sweet Vernal Grass
	Arrhenatherum elatius	Tall Oat Grass
	Avena barbata	Slender Wild Oat
	Avena fatua	Wild Oat
	Avena sativa	Cultivated Oat
	Brachypodium distachyon	-
	Briza maxima	Quaking Grass
	Briza minor	Small Quaking Grass
	Bromus catharticus	Rescue grass
	Bromus diandrus	Ripgut Grass
	Bromus hordeaceus	Soft Chess
	Bromus inermis ssp *inermis*	Brome
	Bromus stamineus	Thread Brome
	Bromus sterilis	Poverty Brome
	Bromus vulgaris	Narrow-flowered Brome
	Cortaderia jubata	Pampas Grass, Jubata Grass
	Cortaderia selloana	Pampas Grass
	Cynosurus cristatus	Crested Dogtail
	Cynosurus echinatus	Hedgehog Dogtail
	Dactylis glomerata	Orchard Grass
	Danthonia pilosa	Australian Oatgrass
	Elytrigia repens	Quackgrass
	Festuca arundinacea	Reed Fescue, Tall Fescue

Family	Scientific Name	Common Name
	Gastridium ventricosum	Nit Grass
	Holcus lanatus	Common Velvet Grass
	Hordeum murinum ssp *gussoneanum*	Mediterranean Barley
	Hordeum murinum ssp *leporinum*	Barley
	Hordeum vulgare	Barley
	Lolium multiflorum	Italian Ryegrass
	Lolium perenne	Perennial Ryegrass
	Lolium temulentum	Darnel
	Phalaris aquatica	Canary Grass
	Phalaris arundinacea	Reed Canary Grass
	Phalaris paradoxa	Canary Grass
	Phleum pratense	Cultivated Timothy
	Poa annua	Annual Bluegrass
	Poa compressa	Canadian Bluegrass
	Poa pratensis ssp *pratensis*	Kentucky Bluegrass
	Poa trivialis	Rough Bluegrass
	Polypogon australis	Chilean Beard Grass
	Polypogon monspeliensis	Annual Beard Grass
	Taeniatherum caput-medusae	Medusa Head
	Triticum aestivum	Cultivated Sterile Wheat
	Vulpia bromoides	Six Weeks Fescue
	Vulpia myuros var *hirsuta*	Rattail Fescue
POLYGONACEAE	*Polygonum cuspidatum*	Japanese Knotweed
	Polygonum polystachyum	Himalayan Knotweed
	Rumex acetosella	Sheep Sorrel
	Rumex crispus	Curly Dock
	Rumex obtusifolius ssp *agrestis*	Bitterdock
PRIMULACEAE	*Anagallis arvensis*	Scarlet Pipernel
RANUNCULACEAE	*Ranunculus muricatus*	Buttercup
	Ranunculus repens	Creeping Buttercup
ROSACEAE	*Cotoneaster franchetti*	Cotoneaster
	Cotoneaster pannosa	Cotoneaster
	Malus sylvestris	Common Apple
	Pyrus communis	Pear
	Rubus discolor	Himalayan Blackberry
	Rubus laciniatus	Cut-Leaved Blackberry
RUBIACEAE	*Galium divaricatum*	Lamarck's Bedstraw
	Galium parisiense var *leiocarpa*	Wall Bedstraw
	Sherardia arvensis	Field Madder

Family	Scientific Name	Common Name
SCROPHULARIACEAE	*Digitalis purpurea*	Foxglove
	Parentucellia viscosa	Yellow Parentucellia
	Verbascum blattaria	Moth Mullein
	Verbascum thapsus	Woolly Mullein
	Veronica arvensis	Corn Speedwell
SOLANACEAE	*Datura stramonium*	Jimpson Weed

Appendix C.

EXOTIC SPECIES THREAT CHARACTERISTICS

1)Displaces Rare, Endangered, or Sensitive species. This refers to plants and animals listed as rare or threatened by the state or the federal government. In addition, species identified as candidates for listing by the California Native Plant Society are considered sensitive in REDW, and are managed as listed species.

2)Cross-pollinates with native species. NPS policy requires that the genetic integrity of native species be maintained.

3)Exists with other exotic plants of similar growth-form producing broader control of biological/ ecological processes. Control efforts can be implemented concurrently with those on other exotic plants.

4)Shade tolerant, and successfully reproduces in the shade. These species have the potential to move into old growth areas, which have been relatively unimpacted by exotic species establishment up to now.

5)Plant establishment and spread is encouraged by soil/vegetation disturbance. Disturbance stimulates germination of seeds that have been dispersed into the area, or from seeds in the soil seed bank.

6)Clumping growth habit and rapid area coverage, causing eventual domination of the site and alteration of the microenvironment.

7)Large areas of habitat utilized by a particular exotic species exist within the park, which increases the potential for these species to displace natives.

8)Biological control not available, or of little value, and other more costly controls must be used.

9)Evergreen. Alters the microclimate throughout the year.

10)Perennial. A continuous threat due to ability to continuously produce and disseminate seeds.

11)Significant physical hazards, such as thorns, spines, and poisonous attributes, that make removal difficult.

12)Roadsides are the preferred habitat for establishment and dispersal. Roadsides provide a corridor for dispersal and potential line of advance into native plant communities. Plants may be dispersed in cargo or soil by passing vehicles.

13)Seeds are adapted for long-range dispersal (e.g. by wind via pappus or feathery plume; or wildlife via ingestion of attractive, edible fruits, or passive transport via sticky surfaces, awns, barbs, burs or bristles).

14)High seed longevity (> 10 years). This is a potentially long-term problem due to production of seeds which remain viable in the soil seed bank for long periods, threatening reestablishment despite complete removal of the existing plants.

15)Seed germination stimulated by heat (exposure of the soil to sunlight through removal of the mature exotic plants) or heat scarification (prescribed burning).

16)Sprouts from stumps, adventitious roots, and/or rhizome fragments. The entire plant should be destroyed with the first control effort, because sprouting changes the form or structure of the exotic plant making additional attempts to remove the plant more difficult.

17)Plant produces tap roots. The older the plant the greater difficulty in removal, and the greater the possibility of leaving some section of the tap root behind which may resprout after the adult is removed.

18)Listed as a State or Federal pest plant.

19)Causes major scenic or aesthetic intrusion because it contrasts in growth form and/or color with surrounding native vegetation.

20)Extensively modifies geophysical processes, such as sand deposition on beaches.

21)Highly visible, and difficult and costly to remove, because height exceeds 1 meter.

22)Likely to form populations in isolated locations with difficult access.

23)Attractive as food to native wildlife. May foster adverse wildlife-human interactions if located in or near developments surrounded by natural areas.

APPENDIX D.

EXOTIC PLANT CONTROL PRIORITY

(** Threat Status: D = Disruptive, PD = Potentially Disruptive)

01-Displaces rare, endangered, sensitive species.

02-Cross pollinates with native species.

03-With other invasive plants of same growth-form.

04-Shade tolerant.

05-Encouraged by soil disturbance.

06-Clumping distribution.

07-Large areas of available habitat, displaces natives.

Ammophila arenaria	+ + + ++ + + + + + + 11	D
Arrhenatherum elatius	+ + ++ + + + + 8	D
Avena barbata	+ + ++ + + 6	
Avena fatua	+ + ++ + + 6	
Avena sativa	+ + ++ + + 6	
Carpobrotus chilensis	+ + + ++ ++ + + ++ 11	D
Cirsium arvense	+ + + + ++ + + + + 10	PD
Cirsium vulgare	+ + ++ ++ + ++ + + 11	PD
Conium maculatum	+ + ++ ++ + ++ + 10	
Cortaderia jubata	++ ++ ++ + + + + + + 12	D
Cotoneaster franchetti	+ + ++ + + + + 8	PD
Cotoneaster pannosa	+ + ++ + + + + 8	PD
Cupressus macrocarpa	+ ++ ++ + + + 8	PD
Cynosurus echinatus	+ + ++ + + 6	
Cytisus scoparius	++ ++ ++ + ++ + + + + 14	D
Danthonia pilosa	+ ++ ++ + + + 8	
Digitalis purpurea	+ + ++ + ++ ++ + + + + 13	PD
Genista monspessulana		
Hedera helix	+ + ++ ++ ++ + + ++ + 13	D
Holcus lanatus	+ + + ++ + + + 8	
Hypericum perforatum	+ + + + ++ + ++ + + + 12	D
Ilex aquifolium	+ ++ ++ + + + + + 10	PD
Leucanthemum vulgare	+ + + + + + 6	
Lolium perenne	+ + ++ + + 6	
Lupinus arboreus	+ + + ++ + + ++ + + + + 13	D
Malus sylvestris	+ + + + + + + + 9	
Mesembryanthemum nodiflorum	+ + ++ + + ++ 8	

Oenothera glazioviana	+ + + ++ + + 7	D
Phalaris aquatica	+ ++ ++ + + + 8	PD
Phalaris paradoxa	+ ++ ++ + + + 7	
Phleum pratense	+ + ++ + + 6	
Pinus radiata	+ ++ ++ + + + + + 10	PD
Robinia pseudo-acacia	+ ++ ++ + ++ +++ + + + 14	PD
Rubus discolor	+ ++ ++ ++ + + + + + + 13	D
Rubus laciniatus	+ ++ ++ ++ + + + + + 12	
Senecio jacobaea	++ + + ++ + ++ + + + 12	D
Senecio mikanioides	+ + ++ ++ ++ + + 10	D
Silybum marianum	+ + ++ ++ + ++ + + 11	
Taeniatherum caput-medusae	+ + ++ + + 6	

Appendix E.

HIGH PRIORITY SPECIES AND SIGNIFICANT CHARACTERISTICS

Priority #1 -Exotic plants that threaten rare, endangered, or sensitive species.

Ammophila arenaria (European Beachgrass) - Shoreline habitats.
(01) Displaces park sensitive plants *Abronia umbellata* ssp. *breviflora* (pink sand verbena) and *Oenothera wolfii* (Wolf's evening primrose). Eliminates areas of open sand which could be used as nesting sites by the snowy plover, a bird proposed for listing as an endangered species.
(03) Grows with other invasive plants of the same growth form.
(06) Clumping distribution.
(07) Large area of available habitat and displace native species in these areas.
(08) Biological control is not available.
(10) Perennial.
(13) Seed morphology is adapted for dispersal.
(16) Sprouts and spreads from rhizome fragments.
(18) Listed as a State or Federal pest plant.
(20) Alters physical processes in foredunes, capturing sand, steepening slope, burying native dunemat community and blocking movement of sand to beach interior.
(22) Becomes established along isolated coastlines with difficult access for control activities.

Carpobrotus chilensis (Sea Fig) - Shoreline habitats.
(01) Displaces park sensitive species *Abronia umbellata* ssp. *breviflora* (pink sand verbena) and *Oenothera wolfii* (Wolf's evening primrose).
(03) Grows with other invasive plants of the same growth form.
(06) Clumping distribution.
(07) Large area of available habitat and displace native species in these areas.
(08) Biological control is not available.
(09) Evergreen.
(10) Perennial.
(13) Seed morphology is adapted for dispersal.
(16) Sprouts and spreads from rhizome fragments.
(19) Contrasts with the color of surrounding coastal vegetation.
(20) Alters physical processes in foredunes, capturing sand, steepening slope, burying native dunemat community and blocking movement of sand to beach interior.

Lupinus arboreus (Yellow Lupine) - Shoreline habitats.
(01) Displaces park sensitive species *Abronia umbellata* ssp. *breviflora* (pink sand verbena) and *Oenothera wolfii* (Wolf's evening primrose).
(02) Cross pollinates with native species (*Lupinus latifolius*).
(06) Clumping distribution.
(07) Large area of available habitat and displace native species in these areas.
(08) Biological control is not available.
(10) Perennial.

(12) Establishes and spreads readily along roadsides in coastal areas, and seed is spread by humans travelling from infested to uninfested areas along the coast.
(14) Seed longevity is high, adding to control problems from seed bank sprouting.
(15) Seeds are encouraged to sprout by heat scarification from exposure to sunlight.
(16) Sprouts from roots and stumps.
(19) Contrasts with the color of surrounding coastal vegetation.
(20) Height can be greater than 1 meter.
(22) Becomes established along isolated coastlines with difficult access for control activities.

Oenothera glazioviana (Evening Primrose hybrid) - Coastal areas.
(01) Displaces park sensitive species *Abronia umbellata* ssp. *breviflora* (pink sand verbena) and *Oenothera wolfii* (Wolf's evening primrose).
(02) Cross pollinates with native species (*Lupinus latifolius*).
(05) Encouraged by soil disturbance.
(07) Large area of available habitat and displace native species in these areas.
(08) Biological control is not available.
(12) Establishes and spreads readily along roadsides in coastal areas, and seed is spread by humans travelling from infested to uninfested areas along the coast.
(17) Tap roots.

Priority #2 -Exotic plants that pose other high priority threats, and exhibit the greatest number of characteristics that threaten specific park resources. These species will be managed as opportunities arise and personnel become available.

Arrhenatherum elatius (Tall Oat Grass) - Grasslands, prairies.
(03) Grows with other invasive plants of the same growth form.
(06) Clumping distribution.
(07) Large area of available habitat and displace native species in these areas.
(08) Biological control is not available.
(10) Perennial.
(13) Seed morphology is adapted for dispersal.
(16) Sprouts from roots and stumps.
(21) Height greater than 1 meter, making removal more difficult.

Cortaderia jubata (Pampas Grass) - Roadsides, alluvial deposits.
(05) Plant establishment and spread is encouraged by soil disturbance.
(06) Clumping distribution.
(07) Large area of available habitat and displace native species in these areas.
(08) Biological control is not available.
(09) Evergreen.
(10) Perennial.
(12) Roadsides are the preferred habitat for establishment and dispersal.
(13) Seed adapted for long-range dispersal by wind.
(16) Sprouts from roots and stumps.

(19) Contrasts with growth form and color of surrounding vegetation.
(21) Height greater than 1 meter, making removal more difficult.
(22) Becomes established in isolated areas where access for control activities is difficult.

Cytisus scoparius (Scotch Broom) - Bald Hills Prairies, roadsides.
(05) Plant establishment and spread is encouraged by soil disturbance.
(06) Clumping distribution.
(07) Large area of available habitat and displace native species in these areas.
(08) Biological control is not available.
(09) Evergreen.
(10) Perennial.
(12) Roadsides are the preferred habitat for establishment and dispersal.
(14) Seed longevity is high, adding to control problems from seed bank sprouting.
(15) Seeds are encouraged to sprout by heat scarification.
(16) Sprouts from roots and stumps.
(18) Listed as a State or Federal pest plant.
(19) Contrasts with the color of surrounding vegetation.
(21) Height greater than 1 meter, making removal more difficult.
(22) Becomes established in isolated areas where access for control activities is difficult.

Genista monspessulana (French Broom) - Smith River corridor, disturbed sites.
(03) Grows with other invasive plants of the same growth form.
(04) Shade tolerant in open forest understory.
(05) Plant establishment and spread is encouraged by soil disturbance.
(07) Large area of available habitat and displace native species in these areas.
(08) Biological control is not available.
(09) Evergreen.
(10) Perennial.
(11) Physical hazard: poisonous.
(12) Roadsides are the preferred habitat for establishment and dispersal.
(14) Seed longevity is high, adding to control problems from seed bank sprouting.
(15) Seeds are encouraged to sprout by heat scarification.
(16) Sprouts from roots and stumps.
(18) Listed as a State or Federal pest plant.
(21) Height greater than 1 meter, making removal more difficult.

Hedera helix (English Ivy) - Forested sites, old homesteads.
(03) Grows with other invasive plants of the same growth form.
(04) Shade tolerant.
(05) Plant establishment and spread is encouraged by soil disturbance.
(06) Clumping distribution.
(07) Large area of available habitat and displace native species in these areas.
(08) Biological control is not available.
(09) Evergreen.
(10) Perennial.

(11) Physical hazard: poisonous.
(13) Seed adapted for long-range dispersal by birds.
(16) Sprouts from roots and stumps.
(17) Tap roots.
(19) Contrasts with the growth form of surrounding vegetation.

Hypericum perforatum (Klamath Weed) - Prairies, roadsides and disturbed areas.
(03) Grows with other invasive plants of the same growth form.
(05) Plant establishment and spread is encouraged by soil disturbance.
(07) Large area of available habitat and displace native species in these areas.
(10) Perennial.
(11) Physical hazard: poisonous.
(12) Roadsides are the preferred habitat for establishment and dispersal.
(13) Seed adapted for long-range dispersal by birds.
(16) Sprouts from roots and stumps.
(17) Tap roots.
(18) Listed as a State or Federal pest plant.
(19) Contrasts with the color of surrounding coastal vegetation.
(22) Becomes established in isolated areas where access for control activities is difficult.

Rubus discolor (Himalaya Berry) - Grasslands, fencelines, alluvial terraces.
(04) Shade tolerant.
(05) Plant establishment and spread is encouraged by soil disturbance.
(06) Clumping distribution.
(07) Large area of available habitat and displace native species in these areas.
(08) Biological control is not available.
(09) Evergreen.
(10) Perennial.
(11) Physical hazard: thorns and spines.
(13) Seed adapted for long-range dispersal by wildlife, birds, and creeks.
(16) Sprouts from roots and stumps.
(19) Contrasts with the growth form of surrounding vegetation.
(21) Height greater than 1 meter, making removal more difficult.
(23) Fruit is a food, attracting wildlife which may create adverse wildlife-human interactions.

Senecio jacobaea (Tansy Ragwort) - Prairies, roadsides.
(05) Plant establishment and spread is encouraged by soil disturbance.
(06) Clumping distribution.
(07) Large area of available habitat and displace native species in these areas.
(10) Perennial.
(11) Physical hazard: poisonous.
(12) Roadsides are the preferred habitat for establishment and dispersal.
(13) Seed adapted for long-range dispersal by birds.
(16) Sprouts from roots and stumps.
(17) Tap roots.

(18) State listed as a pest plant.
(19) Contrasts with the growth form of surrounding vegetation.
(21) Height greater than 1 meter, making removal more difficult.

Senecio mikanioides (German-Ivy) - Old homestead sites.
(03) Grows with other invasive plants of the same growth form.
(04) Shade tolerant.
(05) Plant establishment and spread is encouraged by soil disturbance.
(06) Clumping distribution.
(07) Large area of available habitat and displace native species in these areas.
(09) Evergreen.
(08) Biological control is not available.
(10) Perennial.
(16) Sprouts from roots and stumps.
(19) Contrasts with the growth form of surrounding vegetation.

This selection will be reviewed and updated as scientific knowledge is acquired which redirects priorities and control efforts (e.g., the timing of control efforts, control techniques, knowledge of the ecology/biology of species), or if need for the control of a species develops.

APPENDIX F.

EXOTIC PLANT WATCH LIST

Other exotic plant species known to occur in the vicinity of Redwood National Park **

Family	Scientific Name	Common Name
ASTERACEAE	*Centaurea solstitialis*	Star Thistle
ERICACEAE	*Erica lusitanica*	Spanish Heath
FABACEAE	*Ulex europaeus*	Gorse

** This list will expanded as other exotic species are identified in the vicinity of the park.

Appendix G.

RARE, THREATENED OR ENDANGERED VASCULAR PLANTS IN OR NEAR REDWOOD NATIONAL PARK

	Status			
Taxa	USFWS[1]	Calif[2]	CNPS[3]	Habitat
Abronia umbellata Lam. ssp. *breviflora* (Standl.) Munz Pink sand verbena	C2	-	1B	Coastal strand. Occurs on several beaches in the park.
Arctostaphylos nortensis Wells Del Norte manzanita	C2	-	4	Occurs near the Little Bald Hills in chaparral and lower coniferous forests.
Bensionella oregana (Abrams & Bucig) Morton. Bensionella	C2	CR	1B	Heads of streams, edges of wet meadows. May be restricted to fog belt 2,000-5,000 feet. This species is not known in the park, but should not be eliminated from consideration.
Calamagrostis crassiglumis Thurb. Thurber's reed grass	C2	-	2	Swampy places, freshwater marshes, coastal scrub; Marin and Mendocino County to Del Norte Co., Alaska. Status in park unknown.
Calamagrostis foliosa Kearn. Leafy reed grass	C3c	CR	4	Rocky places along the coast. North coastal scrub; Sonoma to Humboldt Co. Has been collected south of park.
Cypripedium fasiculatum Wats. Clustered Lady's-slipper	C2	-	4	Occurs near the park in Del Norte County.
Erigeron cervinus Greene Siskiyou Daisy	-	-	4	Formally *E. delicatus*. Rocky cliffs above rivers and streams in old-growth redwood and Douglas-fir forests. Known in the park. Protected under CEQA.

Eriogonum nudum Benth. var. *paralinum* Reveal. Del Norte Buckwheat	-	-	2	Not known from within the park but does occur in coastal prairies and coastal bluffs. Protected under CEQA.
Eriogonum pendulum Wats. Waldo eriogonum	C3c	-	2	Dry serpentine slopes or ridgetops, along streams or in disturbed areas, evergreen forests less than 3,100 feet. Collected north of the park.
Lathyrus palustris L. Marsh pea	-	-	2	May occur in the northern sections of the park. Wet areas, lower coniferous forest, and bogs or fens. Protected under CEQA.
Lillium occidentale Purdy Western lily	FE	CE	1B	Former range included park lands. Collected north and south of the park in northern coastal scrub, coastal prairie.
Lillium vollmeri Eastw. Vollmer lily	C3c	-	4	Wet areas, serpentine. North coastal coniferous forests.
Listera cordata (L.)R.Br. Heart-leaved Twayblade	-	-	4	Potentially endangered by logging. Occurs in the park, near the town of Orick. Protected under CEQA.
Oenothera wolfii Raven, Dietrich & Stubbe Wolf's evening primrose	C1	-	1B	Coastal bluffs, gravel road banks near the coast. Known in the park.
Phacelia argentea Nels & Macbr. Sand dune phacelia	C2	-	1B	Coastal strand, Del Norte county to SW Oregon. Historically collected within the present park boundaries.
Piperia candida Morgan & Ackerman White-flowered Rein Orchid	-	-	4	Perennial herb that may occur near the Bald Hills. No collections have been made within the park. Sometimes occurs

				on serpentine soils. Protected under CEQA.
Saxifraga nutallii Small Nuttall's Saxifrage	-	-	2	Only one occurrence in California along the lower portions of the Smith River. Protected under CEQA.
Sidalcea malacroides (H. & A.) Gray Maple-leaved Checkerbloom	-	-	1B	Known to occur historically within the park. Coastal prairies. Protected under CEQA.
Sidalcea malvaeflora (DC.) Benth. ssp. *patula* C.L. Hitchc. Siskiyou Checkerbloom	C2	-	1B	Only known from ten occurrences in California, a few of the locations very near the park.
Veratrum insolitum Jeps. Siskiyou False-hellebore	C1	CC	4	Occurs in forests east of the park boundary. Has not been collected in the park.
Viola primulifolia L. ssp. *occidentalis* (Gray) L.E. Mckinney & R.J. Little Western bog violet	C2	-	1B	Wet areas, on and off serpentine, in mixed evergreen forests. Collected north of the park.

[1] Federal status of species in 50 CFR Part 17.12, August, 1993. USFWS. Endangered and Threatened Wildlife and Plants; Review of Plant Taxa for Listing as Endangered or Threatened Species; Notice of Review.

PFE = Proposed for federal listing as endangered
FE = Federally listed, endangered
FT = Federally listed, threatened
C1 = Candidate for federal listing, sufficient data exist to move forward with proposed listing
C2 = Candidate for federal listing, need more information
C3c = Taxa no longer being considered for listing, more abundant or widespread than was previously believed and or those that are not subject to any identifiable threat.

[2] Species designated as endangered, threatened, or rare by the State of California. 1994 Department of Fish and Game, Endangered Plant Program, Sacramento, California.

CE = Endangered
CT = Threatened
CR = Rare
CC = Candidate for State Listing

[3] Species listed as rare or endangered by the California Native Plant society: Skinner, M.W. and B.M. Pavlik. 1994. Inventory of Rare and Endangered Vascular Plants of California. February 1994 Special Publication No. 1. Fifth Edition. CNPS. Berkeley. CA.

1B = Plants rare and endangered in California or elsewhere.
2 = Plants rare and endangered in California, but more common elsewhere.
3 = Plants for which more information is needed.
4 = Plants of limited distribution

Appendix H.

RARE, THREATENED OR ENDANGERED ANIMALS IN OR NEAR REDWOOD NATIONAL PARK

	Status		
Taxa	**USFWS[1]**	**Calif[2]**	**Habitat**
BIRDS			
Gavia immer Common Loon	-	CSC	Coniferous lakes, open lakes, bays, sea.
Pelecanus occidentalis californicus California Brown Pelican	FE	SE	Coast and ocean.
Phalacrocorax auritus Double-crested Cormorant (rookery sites)	-	CSC	Coast, bays, lakes, rivers.
Branta canadensis leucopareia Aleutian Canada Goose (wintering)	FT	-	Stage and rest at Lake Earl/Tolawa during migration.
Bucephala islandica Barrow's Goldeneye	-	CSC	Wooded lakes, beaver ponds. In winter, coastal waters.
Pandion haliaetus Osprey	-	CSC	Rivers, lakes, coasts. Known to breed in park.
Elanus caeruleus Black-shouldered Kite	-	SFP	Open foothills, grasslands, river valleys, marshes. Known to breed in park.
Haliaeetus leucocephalus Bald Eagle	FE	SE,SFP	Coast, lagoons, rivers and associated mature/old-growth forests.

Circus cyaneus Northern Harrier	-	CSC	Marshes, fields, prairies.
Accipiter cooperii Cooper's Hawk	-	CSC	Broken woodlands, canyons, river groves.
Accipiter striatus Sharp-shinned Hawk	-	CSC	Forests, thickets.
Buteo regalis Ferruginous Hawk	C2	CSC	Arid plains, open rangelands.
Aquila chrysaetos Golden Eagle	-	CSC,SFP	Open mountains, canyons, foothills, plains.
Falco columbarius Merlin	-	CSC	Open areas, coniferous forests.
Falco peregrinus anatum American Peregrine Falcon	FE	SE,SFP	Coastline.
Bonasa umbellus Ruffed Grouse	-	CSC	Mixed or deciduous woodlands.
Charadrius alexandrinus nivosus Western Snowy Plover (breeding)	FT	CSC	Beaches, coastal dunes. Several records from Lake Tolawa and Stone Lagoon.
Larus californicus California Gull	-	CSC	Coast, beaches, lakes, rivers.
Brachyramphus marmoratus	FT	SE	Feeds offshore, nests in old-growth forests.

Marbled Murrelet			
Cerorhinca monocerata Rhinoceros Auklet	-	CSC	Ocean.
Strix occidentalis caurina Northern Spotted Owl	FT	CSC	Occurs in old-growth and mature 2nd growth forests.
Strix nebulosa Great Gray Owl	FSS	SE	Dense forests and adjacent meadows. Three records in park. Transient.
Asio flammeus Short-eared Owl (breeding)	-	CSC	Prairies, marshes, dunes, irrigated lands.
Athene cunicularia Burrowing Owl (burrowing sites)	-	CSC	Prairies, seashore dunes.
Progne subis Purple Martin	-	CSC	Open or logged forests, towns, farms.
Parus atricapillus Black-capped Chickadee	-	CSC	Mixed & deciduous woods, willow thickets.
Icteria virens Yellow-breasted Chat (breeding)	-	CSC	Stream tangles, briars, willow thickets, moist canyons.
MAMMALS			
Antrozus pallidus Pallid Bat	-	CSC	Caves, mine tunnels, crevices in rocks, old buildings and hollow trees.

Plecotus townsendii townsendii Townsend's Western Big-eared Bat	C2	CSC	Caves, mine tunnels, old buildings and hollow trees.
Arborimus longicaudus Red Tree Vole	-	CSC	Spruce, hemlock, fir forests.
Arborimus albipes White-footed Vole	C2	CSC	Dense forest near small streams.
Martes pennanti pacifica Pacific Fisher	C2	CSC	Mixed hardwood forests, cutover wilderness areas.
Gulo gulo Wolverine	C2	ST	High mountains. Several unverified sightings in the area.
Eumotopias jubatus Stellar Sea Lion	FT	-	Marine and coastal.
Physeter catodon Sperm Whale	FE	-	Ocean, migratory.
Balaena glacialis Right Whale	FE	-	Ocean, migratory.
Eschrichtius robustus Gray Whale	FE	-	Ocean, migratory.
Balaenoptera physalus Finback Whale	FE	-	Ocean, migratory.
Megaptera novaengliae Humpback Whale	FE	-	Ocean, migratory.

HERPETOFAUNA			
Clemmys marmota Western Pond Turtle	C2	CSC	Heavily vegetated aquatic habitats and nearby forests, grasslands. Dead juvenile found in Redwood Creek estuary.
Rhyacotriton olympicus Olympic Salamander	-	CSC	Well shaded springs, streams and seeps in coastal forests.
Plethodon elongatus Del Norte Salamander	C2	CSC	Rock rubble of riverbeds, roadfills, moss-covered talus.
Ascaphus truei Tailed Frog	-	CSC	Cold, clear, rocky streams in humid forests.
Rana aurora draytonii Red-legged Frog	C2	CSC	Humid forests, woodlands, grasslands, streamsides.
Rana boylii Foothill Yellow-legged Frog	-	CSC	Woodland, chapparal or forest streams.
FISH			
Eucyclogobius newberryi Tidewater Goby	C2	CSC	Estuarine. Recorded in Redwood Creek estuary in 1981.
Onchyrhynchus clarki clarki Coast Cutthroat Trout	-	CSC	Streams, rivers, and ocean.
Onchyrhynchus kisutch Coho Salmon	-	CSC	Streams, rivers, and ocean.
Onchyrhynchus tshawytscha Chinook Salmon (spring run)	-	CSC	Streams, rivers, and ocean.

Onchyrhynchus mykiss gairdneri Summer Steelhead Trout	FSS,C2	-	Streams, rivers. Known in Redwood Creek.
MOLLUSCS			
Monadenia fidelis pronotis Rocky Coat Sideband Snail	C2	-	Rocky coastal shorelines.

[1]Federal status of species in CFR 17.11 and 17.12, August 19, 1992, USFWS. Endangered and Threatened Wildlife and Plants.

FE Endangered
FT Threatened
FSS Sensitive Species
C2 Category 2 candidate for federal listing
FPL Proposed for federal listing as threatened

[2]California Department of Fish and Game Natural Diversity Database, Special Animals, August 1991, and CDFG State and Federal Endangered and Threatened Animals of California, revised October 1992.

SE Endangered
ST Threatened
CSC Species of Special Concern
SFP Fully Protected Species