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BALD HILLS VEGETATION MANAGEMENT PLAN

REDWOOD NATIONAL PARK

FEBRUARY 1992

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BALD HILLS VEGETATION MANAGEMENT PLAN

REDWOOD NATIONAL PARK

CONTENTS

ILLUSTRATIONS

FIGURES

TABLES

I. INTRODUCTION

Approximately 1700 acres (688 hectares) of prairie and 660 acres (260 hectares) of Oregon white oak woodland occur along the ridgetop and southwest facing slopes of the Bald Hills in Redwood National Park (Figure 1). Above the redwood forest, the Bald Hills afford views of the Redwood Creek basin, Pacific Ocean, Trinity and Siskiyou mountains. The oak woodlands and adjacent prairies are easily accessible, rich in both natural and cultural resources and provide substantial wildlife habitat. They also support the greatest plant species diversity of any area in the park.

Since the arrival of white settlers in the 1850's, livestock grazing, cultivation, introduction of exotic plants and fire suppression reduced many of the once dominant native species. The prairies are now dominated by non-native grass and forb species.

Fire suppression also removed an important element necessary for the perpetuation of oak woodlands and prairies. Over thousands of years, periodic lightning and Native American-caused fires kept the natural invasion of Douglas-fir in check, preventing complete encroachment and replacement. Fire suppression accelerated the invasion of Douglas-fir into the oak woodlands and prairies. Bare soil resulting from road building also provided new areas for Douglas-fir invasion.

Within park boundaries, over one-fourth of the area that was prairie and oak woodland in 1850, is now coniferous forest. The widespread invasion of Douglas-fir is recognized elsewhere (Barnhart et al. 1987; Gizinski 1985; Griffin and Muick 1990; Kertis 1986a,b; Keter 1986,1987; Thilenius 1968; Tunnison 1973), and the loss of California's oak woodlands is of statewide concern (Agee 1987; Anderson and Pasquinelli 1984; Oxford 1987; Plumb 1980; Plumb and Pillsbury 1987).

The Park's goal for the Bald Hills is to maintain the diversity of plants and animals that prevailed when the area was first visited by European man. This plan proposes a mix of management strategies to restore, mimic and perpetuate natural processes that will maintain vigorous prairies and oak woodlands. A combination of resource protection, restoring fire through prescribed burning, manually removing Douglas-fir and reseeding and replanting with native species will be implemented.

These management strategies are guided by National Park Service Management Policies that call for the management of natural resources to maintain and perpetuate their inherent integrity (USDI 1988). Management objectives for Redwood

National Park include to restore and/or maintain the natural ecosystems of the park (USDI 1987). This plan is an addendum to Redwood National Park's Resources Management Plan (USDI 1990b). Redwood National Park's Fire Management Plan (USDI 1985) and Technical Report No. 21: Vegetation Ecology of the Bald Hills Oak Woodlands of Redwood National Park (Sugihara and Reed 1987a) serve as companions to this Bald Hills Vegetation Management Plan.

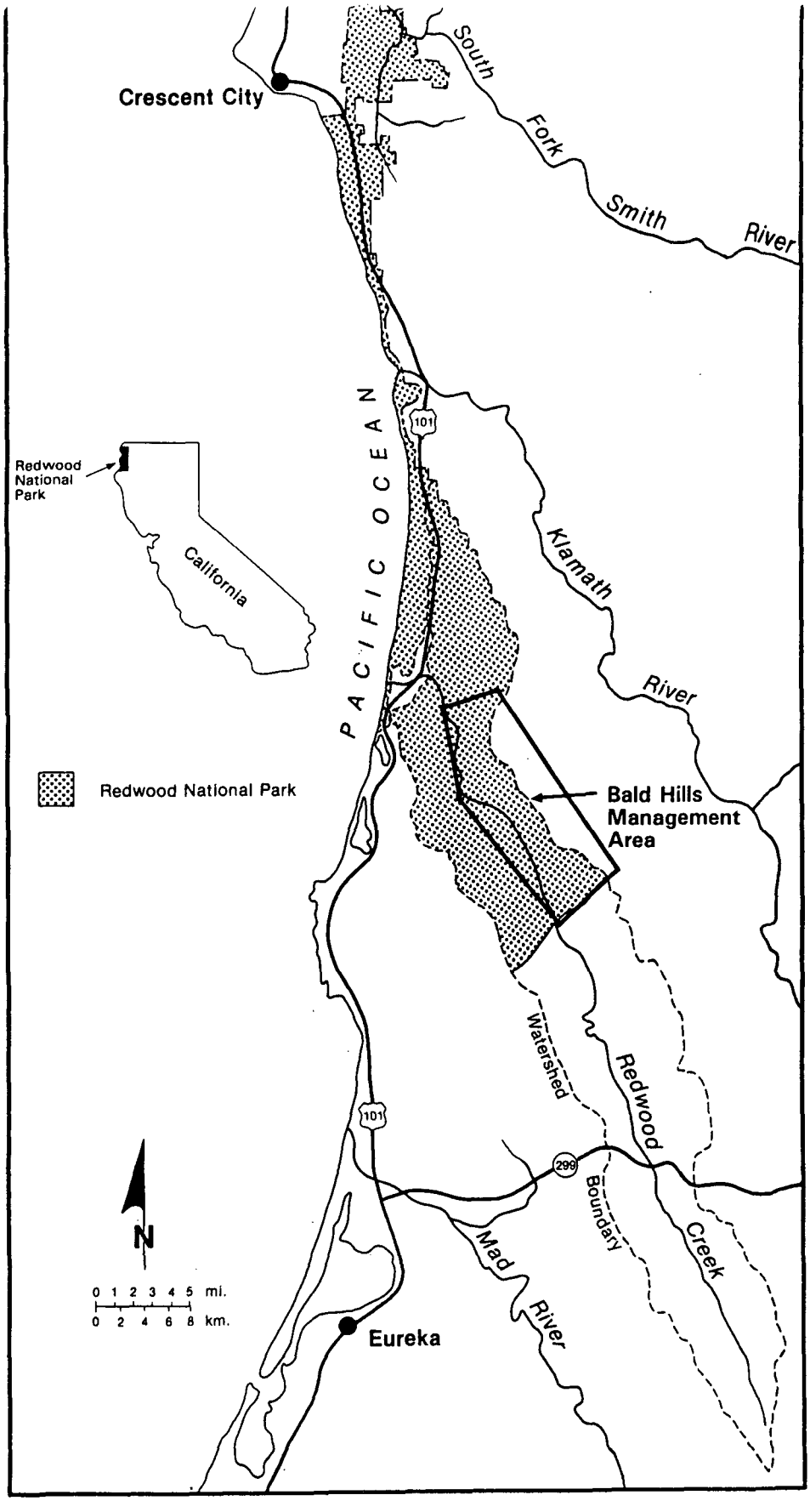

Figure 1. Location of Redwood National Park and the Bald Hills Management Area.

II. AREA DESCRIPTION

The Bald Hills of Redwood National Park occur as discontinuous grasslands and oak woodlands alternating with coniferous forest along the ridge crest dividing the Klamath River and Redwood Creek drainages. Finger-like extensions follow the subbasin divides into southwest facing valleys below (Figure 2). Within the boundaries of the park, the prairies and oak woodlands begin five miles (eight kilometers) from the Pacific Ocean and extend inland in a southeast direction for another seven miles (eleven kilometers) at elevations from 250 to 3100 feet (76 to 945 meters). Near the coast, the oaks form narrow strips between the prairies and redwood/Douglas-fir forest. Moving inland, the oaks begin to extend up stream channels into the prairies, becoming continuous woodlands near Schoolhouse Peak. The oak woodland/prairie mosaic is locally known as the **Bald Hills** (capitalized) and represents the northern extent of a regional vegetation type also known as **bald hills** (lower case)(Griffin 1977).

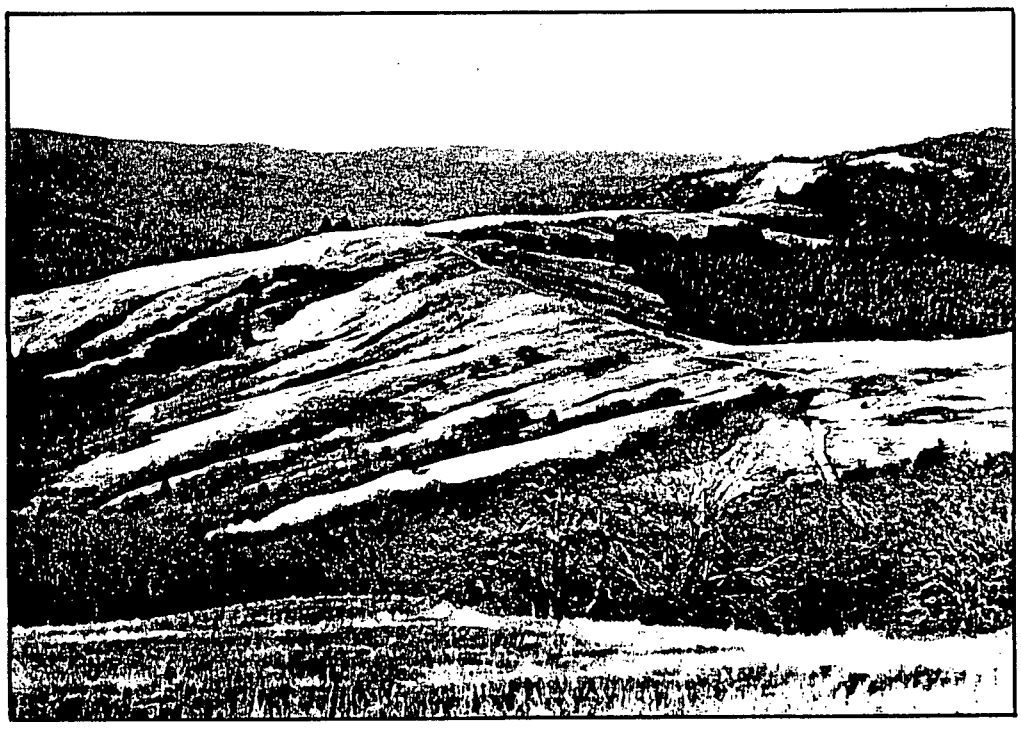

Figure 2. Bald Hills Vegetation. This view down the ridge from near Schoolhouse Peak looking towards the ocean shows bald hills prairies along the ridge, oak woodlands extending downslope and conifer forest below prairies and oaks.

Geology and Soils. The Bald Hills area is underlain by sheared sandstones and mudstones of the Franciscan assemblage (Harden et al. 1978). The area contains many large, slow-moving landslides or earthflows, many of which are found within prairies (Walter 1985). Deep-seated landsliding is an important geomorphic process responsible for shaping landforms and ground disturbance due to earthflow movement may partly explain the presence of the prairies and the absence of mature forest.

Hillslopes on prairies are generally hummocky and irregular. Average hillslope gradient is 34 percent. The dominant erosion processes operating on prairies are mass movement and gullying. Because of the thick vegetative cover, sheetwash and rainsplash erosion are negligible, except in local areas of exposed soils.

Soils of the Bald Hills were originally mapped in 1958-59 by the California Soil-Vegetation Survey. Subsequently, the original soil series were reclassified to meet new National Cooperative Soil Survey standards. With the series now redefined and narrowed, few of the old names are currently appropriate in Redwood National Park. All park soils are in the process of resurvey and reclassification. There are two major soil groups in the Bald Hills:

Xeralfs Most of these were formerly called Kneeland soils. Xeralfs are the most common group of soils in the prairies and oak woodlands and are characterized by a distinct increase in clay content with depth. In a typical profile, there is a thick, very dark brown clay loam A horizon overlying gray, mottled gravelly clay B and C horizons. The soils have impaired drainage and are most often found on slopes with lumpy and irregular or amphitheater-shaped relief. The underlying bedrock tends to be shale or is highly sheared. The impaired drainage of the soils is one likely cause for the resistance of these soils to colonization by Douglas-fir (Gordon 1980).

Umbrepts Most of these were formerly called Wilder soils. Umbrepts are the second most common group of soils in the prairies and oak woodlands and are distinguished from the Xeralfs by the lack of a clay increase with depth. In a typical profile, there is a thick, very dark brown loam A horizon overlying a yellowish brown gravelly loam C horizon. The soils are well drained throughout. They are confined mostly to upper slopes and ridges. The topography is generally smooth and rolling, and the underlying bedrock tends to be siltstone or fine-grained sandstone. These soils are highly vulnerable to surface erosion without a grass or mulch cover. Douglas-fir have been actively invading the Umbrepts.

Comparisons with adjacent forest soils show major differences associated with vegetation, relief and drainage. Soils under prairies and oak woodlands are typically dark in color to a depth of about two feet (60 centimeters). In contrast, soils under old-growth conifer forests are dark to only about three inches (7.5 centimeters). Soils under prairies, oak woodlands and forest also differ chemically from one another (Popenoe 1987). Typically, prairie soils have more nitrogen and organic matter than either the oak woodland or forest soils and the forest and oak woodland soils have a higher concentration of calcium and potassium in the surface horizons than do the prairie soils. The color and chemical differences indicate that these soils formed under different vegetation types since soil formation requires many centuries. The vegetation patterns must have been stable for a long time to allow the observed soil differences to develop.

Prairies. The Bald Hills grasslands, locally called prairies, are presently a mosaic of native and non-native perennial and annual grasses and forbs. Of the 284 plant species known to occur in the prairies (Appendix A), 67 percent are native and 33 percent are introduced or non-native. A handful of species, primarily non-natives, dominate the grasslands. The most common introduced species are tall oatgrass (Arrhenatherum elatius), sweet vernal grass (Anthoxanthum odoratum and A. aristatum) velvet grass (Holcus lanatus), dogtail (Cynosurus echinatus), soft chess (Bromus hordeaceous), six weeks fescue (Vulpia bromoides), plantain (Plantago lanceolata) and sheep sorrel (Rumex acetosella). Only two natives are found in significant numbers, California oatgrass (Danthonia californica) and foothill sedge, (Carex tumulicola).

Little is known about the species composition of the prairies prior to European settlement, but many believe that California's coastal grasslands were dominated by native perennial bunchgrasses (Amme and Pitschel 1989; Burcham 1981; Heady et al. 1977; Keter 1989). The most comprehensive overview of early northwestern California grasslands comes from Davy (1902). Davy interviewed early settlers and examined voucher specimens from an 1860's agrostology study, and concluded that prior to the introduction of livestock, the vegetation was primarily native bunchgrasses including species of Danthonia, Stipa, Melica, Poa, and Festuca, with annual and perennial clovers. By 1902, Danthonia californica (California oatgrass) was already uncommon, but Davy felt that it might have been the predominant grass species in northwestern California grasslands prior to European settlement.

Selective livestock grazing on native perennial grasses during summer periods (when non-natives have gone to seed), deliberate species introductions and heavy grazing pressure are cited as the primary reasons for the rapid replacement of native species with non-natives state-wide (Keter 1989). Today, Danthonia californica is the primary native grass in Bald Hills prairies, but distribution is patchy and comprises no more than 50 percent of the cover in any area. Greater detail about the species composition of the prairies can be found in Appendix B, Grenier, K.H. (1989), Hektner et al. (1983), Martin and Hektner (1988) and Saenz and Sawyer (1986).

Oak Woodland. Oregon white oak (Quercus garryana) dominates the oak woodlands with scattered individuals of California black oak (Q. kelloggii). California bay (Umbellularia californica) and big-leaf maple (Acer macrophyllum) are found near rock outcrops and stream channels. Douglas-fir (Psuedotsuga menziesii), is found throughout, ranging in size from seedlings to overstory trees.

Three general stand types are found (Table 1): 1) open stands composed of all size classes dominated by a few, large, widely scattered individuals; 2) closed-canopy stands of numerous, uniformly medium-sized, clustered or multiple-stemmed trees; and 3) dense closed-canopy stands with uniformly small, single-stemmed individuals (Sugihara et al. 1983; Sugihara and Reed 1987a). Understories of the all-sized and closed-canopy, multiple-stemmed stands are characterized by high herbaceous cover dominated by grasses with a few, tall shrubs scattered throughout. Low shrubs dominate the understory of the dense, single-stem stands.

TABLE 1. CHARACTERISTICS OF OAK STAND TYPES.

Stand Type	Average Percent Cover by Layer			Stems/Ac (ha)	Age Range in years	Typical DBH in inches (cm)	Percent of Woodlands
	Canopy	Shrub	Herb				
All-sized	76	1	85	24 - 215 (60 - 530)	1 to >350	0.02 to >39.4 (<0.5 to >100)	15
Clustered	86	2	80	299 - 1,032 (740 - 2,550)	80 - 120	3.9 - 11.8 (10 - 30)	70
Small Dense	90	46	58	1,821 - 4,856 (4,500 - 12,000)	25 - 50	<4.7 (<12)	15

Seven distinct community types have been described (Sugihara et al. 1987; Sugihara and Reed 1987a): 1) shrub-dominated understory, associated with the dense stands of small-diametered oaks; 2) a wet or mesic perennial forb and grass-dominated type found on lower, concave slopes associated with stands of clustered or multiple stemmed oaks and; 3) a dry or xeric grass-dominated type found on upper, convex, south facing slopes associated with all-sized stands. Four of the seven types occupy specific habitats: 4) rock outcrops occupied by moderately dense shrubs and scattered forbs and grasses; 5) stream channels dominated by dense shrubs and sparse perennial forbs; 6) seasonally moist areas on otherwise dry slopes dominated by perennial forbs; and 7) grass-dominated openings or glades, located between the stands.

Overall, 75 percent or 231 of the oak woodland species present are natives (Appendix C). Annual forbs and grasses in the glades and xeric, grass-dominated understory account for most of the non-native species.

Herbaceous and/or shrub cover is high throughout the oak woodlands with no area having less than at least 55 percent mean cover.

Wildlife. A complete inventory of wildlife species in the Bald Hills area has not been done. Black-tailed deer (Odocoileus hemionus), Roosevelt elk (Cervus elaphus roosevelti), coyote (Canis latrans), black bear (Ursus americanus), bobcats (Lynx rufus), garter snakes(Thamnophis sirtalis), Western fence lizards (Sceloporus occidentalis), ravens (Corvus corax), red-tailed hawks (Buteo jamaicensis), northern harriers (Circus cyanus), and common flickers (Colaptes auratus) are commonly seen. See Appendix D for a list of mammal, reptile, amphibian and bird species observed to date. Historic reports exist of bald and golden eagle (Haliaeetus leucocephalus and Aquila chrysaetos) nesting sites in the area. It is likely numbers of these birds have been significantly reduced from historic levels as they are now only occasionally seen migrating through the area. Developments and nearby logging activities may preclude the return of breeding populations. The grizzly bear (Ursus horribilis) and California condor (Gymnogyps californianus) historically occurred in the area, but have been totally eliminated.

The Bald Hills prairies in Redwood National Park 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 dramatically expanded its use of the prairies, most notably Elk Camp Prairie. J.J. Grenier (1989) estimates about 100 elk presently live in the

Bald Hills. Grenier et al.'s (1990) study of elk movement patterns and habitat use in the area showed elk use the prairies extensively and in greater proportion than expected based on its availability. These prairies are used the most in the spring and fall. Adjacent second-growth forests are used significantly less. Use of young (10-20 year old) second-growth forests is greatest during the rutting season (September - October). It is anticipated that as second-growth forests mature and the ground forage decreases, elk will use these forests even less, increasing the already high use of the prairies.

Threatened or Endangered Species. The northern spotted owl, (Strix occidentalis caurina) federally listed as threatened is found in the nearby conifer forests, but no studies have been conducted to determine its status in the oak woodlands. Bald eagles are occasionally observed in winter, but no nesting pairs are known to inhabit the park. The marbled murrelet (Brachyramphus marmoratus) may also occur in nearby old-growth redwood and Douglas-fir forests. No threatened or endangered plants are known to occur in the Bald Hills area.

Cultural Resources. Although not well known, Redwood National Park is rich in both coastal and inland cultural resources. Of the inland cultural resources, most are located on the east side of the Redwood Creek basin, in the vicinity of the prairies and oak woodlands, along ridgecrests and mid-slope benches, near springs or creeks. These cultural resources are of three types: prehistoric sites, historic structures and sites, and contemporary Native American sites. The prehistoric cultural resources consist of villages, seasonal camps, trails and ceremonial places representing use over the past 4,500 years by the Chilula Indians and the people before. The Bald Hills Archeological District, which is listed on the National Register of Historic Places and is significant both for its archeological research potential and its importance to local Native Americans, includes twenty-six of these cultural resources.

The historic cultural resources of the Bald Hills reflect the homesteading and ranching which began in association with gold mining to the east during the 1850's. Some of these resources are included in the Lyons Ranch Historic District which is eligible for listing on the National Register of Historic Places. This fifty-five acre district encompasses three separate sites including the Jonathan Lyons home ranch and two additional barns. The Lyons Family Ranches are significant in "American history, architecture and archeology and possess integrity of location, design,

setting, materials, workmanship and association" (Greene 1986).

A number of contemporary Native American cultural resources are located in the Bald Hills environs. These places are important to local Yurok and Redwood Creek Indians who retain strong ties to the area. They include gathering sites, villages where people's ancestors lived, travel routes and spiritual sites. Some of these places are used today and some are not but may be in the future.

The distribution and large number of cultural resources in the Bald Hills, which reflect a long period of intensive human use, can probably be directly attributed to environmental factors. Topography and water were certainly variables determining where people settled, but even more important are the prairies bordered by oak woodlands. It is the prairies and oak woodlands which attracted humans to the Bald Hills as evidenced by the high concentration of cultural resources in the ecotone between these two plant communities.

The cultural landscape during the period of Native American occupation could be characterized as a prehistoric or ethnographic landscape, while the landscape during the years of historic ranching would be referred to as a rural, or vernacular, historic landscape. The appearance of the vegetation of these two landscapes, was in all likelihood, similar to what is observed today. However, the oak woodlands and prairies would have been larger, and the understory would have been more open due to burning by the Native Americans and early settlers.

Visitor Use. Visitor use in the Bald Hills is primarily along Humboldt County's Bald Hills Road. No formal Redwood National Park developments currently exist south of the intersection with the Bald Hills Access Road (C-Line). Redwood National Park has prepared a Backcountry Trails Plan for the Redwood Creek portion of the park, including the Bald Hills Area (USDI 1984). An East Side Trail, proposed to be the major trail through this portion of the park, will follow a route mid-slope, principally through old-growth vegetation from Lady Bird Johnson grove to the mouth of Copper Creek. Trailheads along the Bald Hills Road at Whiskey-40, top of the C-Line Road, Dolason Prairie and Copper Creek would serve lateral trails connecting down to the East Side Trail and Redwood Creek below. A picnic area and an all-person accessible nature trail are also proposed for the Dolason Prairie trailhead.

It is expected that Redwood National Park will prepare a Development Concept Plan for the Bald Hills area in the next

two years. That planning process will be used to define types and level of visitor use, location and size of developments necessary to support those uses and broad interpretive themes that would be conveyed to visitors. Vegetation management activities will be one element in the planning process.

III. BACKGROUND INFORMATION

Historical perspective. Native Americans occupied the Bald Hills of Redwood National Park for at least 6,000 years before their decimation and eventual removal in 1864 (Benson 1983; Bickel 1979; Hayes 1985). Archaeological evidence indicates that many locations in the Bald Hills were utilized as villages, seasonal camps, trails or ceremonial sites. Although first-hand descriptions are rare, historical accounts indicate that Native Americans throughout the region frequently set fire to the prairies and oak woodlands (Heizer 1972; Keter 1987; King and Bickel 1980; Veirs 1987).

Lucy Thompson (1916) a Yurok Indian living at Weitchpec on the Klamath River 10 miles (16 kilometers) from the park, wrote that "when the Indians first reached the Klamath there were large prairies and vast tracts of grassy land which have since grown up in timber and underbrush. Many of the prairies were set on fire and burnt off every year during the dry season, which kept the timber from growing up very fast." The Native Americans burned the prairies and oak woodlands to keep them open for game, stimulate the growth of plants used in basketry, attract wildlife and to make food gathering easier.

Periodic burning continued with early European settlement but was eventually discontinued and replaced by a policy of wildfire suppression (Stover 1983).

With the discovery of gold in the Trinity, Klamath and Salmon River areas in the 1850's, the Bald Hills became an important trade route between the coast and the mines. Proximity to a ready market in the gold mines led to homesteading and the development of an active livestock industry. Between 1850 and 1870, ten ranches, each from 10 to 50 acres (4 to 20 hectares) were established (Shoup 1983). Conflicts between the settlers and Native Americans resulted in the Native Americans being killed or relocated by 1864.

The first homesteaders concentrated on raising mules, horses and cattle for the pack trains and gold miners. Several also grew potatoes, oats, corn, wheat and hay. Around 1865, the regional wool industry began to flourish and the ranchers switched to raising sheep. Sheep ranching predominated until it became unprofitable in the 1940's and the ranchers again turned to raising cattle (Greene 1980). Some local ranchers believe the problems with sheep ranching stemmed from an increase in the coyote population. As adjacent forests were logged, the deer population increased

in response to increased forage and subsequently, the coyote population expanded. The coyotes did not restrict their diet to deer and heavy predation on lambs occurred. Other ranchers feel the declining wool and mutton market prompted the change. Still others maintain the higher cost of fencing to keep sheep out of logged areas, as compared to cattle, caused the change. The actual reason may be a combination of all of these factors (King and Bickel 1980).

Except for a small area near Schoolhouse Peak, which last held sheep in 1962-63, none of the prairies now in the park has been grazed by sheep since 1949 (Lane 1983). Cattle grazing continued until the Bald Hills area was added to Redwood National Park in 1978. It too was phased out by 1982, although occasional trespass continues.

Upstream of the park, extensive white oak woodlands were cut and cleared, but the extent of large-scale oak harvesting in the park is unknown (Stover 1987). Some oaks were thought to have been cut during homesteading. Elsewhere, Oregon white oak wood was utilized for fence posts, furniture and fuel (Silen 1958). Adjacent redwood and Douglas-fir forests were logged between the 1940's and 1978. During this period roads and skid trails were built through the prairies and woodlands to gain logging access.

Wildlife was historically abundant in northwestern California, including the Bald Hills, and provided an important food source to native peoples. Historic accounts of wildlife and their numbers are recorded in the journals of early trappers and explorers. The first Europeans to reach what is now the park, were part of the Jedediah Smith party (Sullivan 1934) in the spring of 1828. Both Smith and his clerk Rogers kept journals giving descriptions of their daily route of travel which permit accurate location of their camps (Pearsall et al. 1943). Smith crossed the Klamath near Hoopa on May 9 and eventually "...encamped in what we called Ganns Prairie on May 19th, remaining there for four days." On the 19th he reported six elk killed, "..two in tolerable order (fat enough to be palatable and nutritious)". On the 20th, Rogers saw elk on his reconnaissance to the coast. Other animals they recorded were black-tailed deer, black bear, grizzly bear, raccoons, "large and small wolves", foxes, "wild cats", squirrels, large and small "buzards", crows, ducks, ravens, several kinds of hawks, and eagles. The large "buzard" referred to here is probably the California condor, and the small, the turkey vulture. The large and small wolves may be coyote and grey fox as there is no evidence that timber wolves occurred in northwestern California.

Probably the most conspicuous animal species of the Bald Hills was the elk. Miners and settlers arrived in earnest in 1850 and readily took the available elk. In 1850-1852, "Elk then roamed over the Bald Hills in bands of hundreds, perhaps thousands" (Wistar 1937). While Wistar may exaggerate numbers, he clearly describes the ease with which a person armed with a rifle could take an elk. "Elk hunting, whether mounted or by still hunting on foot, was then in its best condition, and supplied unsurpassed sport. Thousands roamed over the Bald Hills, and could be found in almost any of the great ravines, from which when started below, they would rush out above in large bands with a sounding tread like the rush of a cavalry regiment."

During the gold rush of 1848-1855, Roosevelt elk were hunted heavily to supply food for mining camps (USDI 1983). When the rush was over, settlement began and a great deal of elk habitat was converted to crop land. Elk were then killed to protect against crop depredations. In addition to hunting for food and habitat conversion, hide hunters also began taking elk. The result was the almost total extirpation of Roosevelt elk from northern California. The only elk that persisted through this period were those occupying coastal lowlands in the northern part of coastal California where dense forests and brush fields provided protective cover. In this local area, notably coastal Humboldt County north of Eureka to about Klamath, elk were again locally abundant by 1964.

Following extensive clearcutting of redwood forests within the Redwood Creek region near Orick and Big Lagoon, elk numbers increased over the recent decades (Stevens 1965; Lemos and Hines 1974). The same response in animal numbers probably accompanied other wildlife species such as black-tailed deer, black bear and a host of small mammals, but this is poorly documented.

Research to date. Since the acquisition of the Bald Hills area in 1978, a number of vegetation, soils, wildlife, geologic and archeological studies or inventories have been completed or initiated:

Vegetation - Baseline vegetation data has been collected through a series of permanent monitoring plots and two masters thesis projects. The quantitative descriptions and vascular plant species lists found in Section II and Appendices A, B, C and E are drawn from Grenier, K.H. 1989, Hektner et al. 1983, Martin and Hektner 1988, Reed 1987, Reed and Sugihara 1987, Saenz 1983, Saenz and Sawyer 1986, Sugihara et al. 1983, Sugihara and Reed 1987a and b, Sugihara et al. 1987, and Veirs 1981. The Appendix E maps were generated from Reed, Sugihara and J.J. Grenier's

unpublished vegetation maps which are entered on Redwood National Park's Geographic Information System.

Redwood National Park initiated experimental prescribed burning in 1980. To date, 15 prescribed burns totalling 356 acres of Bald Hills prairies and oak woodlands have been conducted. Results of those burns are reported in Hektner et al. 1983, Martin and Hektner 1988, Sugihara et al. 1983 and Sugihara and Reed 1987b. Additional unpublished data is on file at Redwood National Park's South Operations Office.

Prairie results to date indicate that annual grass and forb diversity increased for one or two seasons after a prescribed burn then declined to pre-burn levels. Perennial grasses and forbs were essentially unaffected by the burns with the exception of tall oatgrass, Arrhenatherum elatius, which was inhibited by fire.

Within the oak woodland, all shrub species, even when top-killed, sprouted following the burns. Douglas-fir under 10 feet (three meters) tall were killed when at least 70 percent of the foliage was scorched. All sampled oaks under 10 feet were top-killed but sprouted whereas oaks taller than 10 feet suffered little damage and produced few sprouts. Unburned oak plots had 35 percent background level of sprouting, mainly in small size classes but burned plots experienced 58 percent sprouting. The amount of sprouting varied with fire intensity, diameter at breast height (DBH) and whether the tree was alive or dead at the time of the burn or was killed during the fire. Little sprouting was noted after a low intensity prescribed burn but considerable sprouting occurred following two higher intensity fires. Preliminary results following one of the high intensity prescribed burns show sprouting occurred in 50 percent of the surviving trees, 70 percent of the dead trees and 82 percent of the top-killed trees. Oaks under 9.5 inches (24 centimeters) diameter at breast height (DBH) were sometimes top-killed but sprouted vigorously. Oaks over 9.5 inches DBH were rarely affected although some trees as large as 15 inches (38 centimeters) were occasionally top-killed, then resprouted. Prescribed burning-induced mortality accelerated patterns of self-thinning seen in unburned stands by increasing the mortality by 19 percent mainly in the small size classes. The net effect of fire on stand structure appears to be reduction in small size classes and the formation of a new size class by fire induced sprouting. Preliminary results of a small study show that 47 percent of the oak seedlings also sprouted following a low intensity prescribed burn.

A stand of young dense Douglas-fir that did not carry fire during one oak woodland prescribed burn was subsequently

cut. Understory vegetation cover increased from one percent to 61 percent in five years following the removal of the fir.

An area of oak woodland where Douglas-fir was co-dominant was treated by girdling to prevent immediate conversion to conifer forest. Herbaceous understory cover increased from zero to 35 percent in four years. A "stress crop" of cones produced by the dying fir has subsequently resulted in a flush of new Douglas-fir seedlings in the understory.

Cattle grazing was phased out by 1982. Prairie monitoring shows that plant species diversity dropped dramatically with the primary reduction being in the annual grasses and forbs. Natives increased slightly in importance, primarily due to the increase of California oatgrass, Danthonia californica.

A master's thesis project is underway which will evaluate the effects of spring and fall prescribed burns on tall oatgrass, Arrhenatherum elatius and California oatgrass Danthonia californica (Arguello 1990). Preliminary results from a June prescribed burn suggest that spring burning may be more detrimental to Danthonia california than to Arrhenatherum elatius (Arguello 1991).

A second master's thesis project in progress is documenting the annual and individual differences between oak trees in pollen production, flower initiation and acorn development. Seedling establishment is also being followed to project changes in stand dynamics and structure that may influence potential post-grazing management (Reed 1990).

Soils - Extensive soil description and mapping is underway in the prairies and oak woodlands in cooperation with the Soil Conservation Service. To date 43 soil profiles have been described and chemically characterized, and the map units digitized onto Redwood National Park's Geographic Information System (Gordon 1980; Popenoe 1987 and unpublished maps and data). Prairie soils diversity is much greater than in the adjacent conifer forests. Sturhan (in preparation) documented soil moisture and temperature regimes in the oak woodlands. Popenoe and Lewis (unpublished data) measured soil temperature gradients with elevation and soil temperature across prairies in relation to position of surrounding forest canopy. More Douglas-fir encroachment was noted where the soils were shaded in the winter and spring.

Wildlife - Grenier (USDI 1990c) conducted an elk habitat use and home range study in the Bald Hills. Plant species composition and structure, weather variables, and elk locations were determined for four vegetation types

throughout the year. A preliminary analysis of elk food habits in the area was completed (unpublished data). These results will be adjusted for the digestibility of food items.

Steinberg (1989, 1990) studied home range and food habits of coyotes in the Bald Hills. An index for monitoring coyote abundance in the Redwood Creek basin is also being developed. Davenport (1982) conducted an inventory of birds in the Bald Hills oak woodlands. Clover et al.(1989) found evidence that Bubonic Plague is present in eleven species of mammals in the Bald Hills.

Geology - Extensive geomorphic mapping for erosion control and watershed restoration work has been completed for most of the Bald Hills area (unpublished maps and reports on file at Redwood National Park, Orick, CA). Additional baseline data include geologic and erosional landform maps of the Redwood Creek drainage (Harden et al. 1981; Nolan et al. 1976) and several studies on earthflow mass movement, erosion and gullies (Harden et al. 1978; Nolan et al. in press; Walter 1985).

Iverson (1984) gave a detailed account of movement of an active earthflow near the mouth of Minor Creek, a prairie 15.5 miles (25 km) upstream of Redwood National Park's boundary. Hagans and Weaver (1987) quantified causes and magnitude of gully erosion.

Cultural Resources - A number of archaeological surveys and excavations, historic studies, artifact analyses, Native American consultations and a research design have been completed. Descriptions of these projects and their results, which provide a detailed data base of information about the Park prehistoric, historic and contemporary Native American cultural resources, are included in Eidsness (1988).

A comparison of the distribution of prehistoric cultural resources in the Bald Hills, with the areas invaded by Douglas-fir since 1850, confirms that, for the most part, these cultural resources are located at prairie and oak woodland margins. The 'forests' which some of the prehistoric cultural resources now appear to be situated in, were in fact not forests when Native Americans used the area.

IV. SUMMARY OF THE PROBLEM

Three vegetation management problems are notable in the Bald Hills: (1) encroachment of Douglas-fir, (2) replacement of native herbaceous species with non-native species and (3) declining wildlife habitat.

Douglas-fir encroachment. Currently, the park's oak woodlands and prairies are three-fourths the size that they were in 1850. Douglas-fir is a rapid invader into these areas and if left undisturbed quickly overtops and out competes shade-intolerant oaks (Reed and Sugihara 1987). Over 830 acres (336 hectares) of prairies and oak woodlands have converted to Douglas-fir dominated forest during the last 130-140 years (Figure 3). See Sugihara and Reed (1987a) for methods used to determine extent of encroachment. More than half the remaining oak woodlands already have sufficient Douglas-fir in the understory to convert those areas during the next few decades.

Today's prairies and oak woodlands, and areas encroached by Douglas-fir since 1850, are shown in Figure 3 and Appendix E. Douglas-fir invasion is subjectively placed in four categories:

1) Little encroachment - Douglas-fir mostly present as clumped small seedlings or large individual trees.

2) Moderate encroachment - Fir occurs as dense thickets of saplings; the fir is subcanopy in the oak woodlands.

3) Heavy encroachment - Prairie is gone; fir is codominant with the oaks.

4) Advanced conversion to conifer forest - No prairie remains; fir dominates and oaks, if present, are dead.

Table 2 shows an estimate of Douglas-fir density and size in areas representative of the first three categories (Reed 1987): Category 4 was not sampled because the area had already largely converted to conifer forest and no live oaks remained.

Fir establishment varies by area, but numbers from the Child's Hill inventory are useful for estimating the problem. Category 2 areas are experiencing the greatest rate of encroachment as seen by the number of seedlings. By the time an area reaches category 3, the dense shade from the Douglas-fir inhibits establishment of new seedlings.

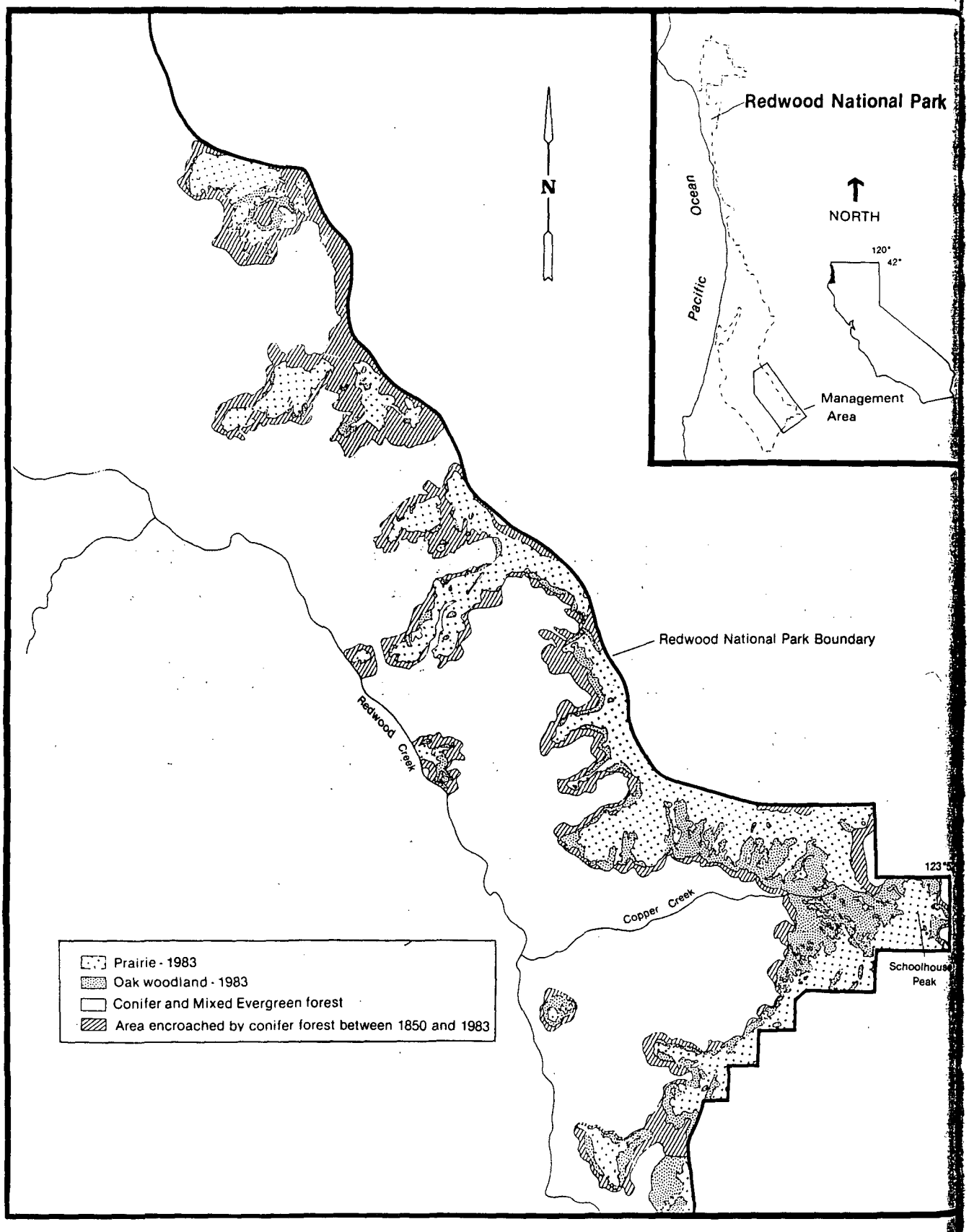

Figure 3. Conifer Forest Encroachment in the Bald Hills, 1850-1983. Adapted from Sugihara and Reed (1987a).

TABLE 2. DOUGLAS-FIR DENSITY IN THE CHILD'S HILL AREA, 1987 (Adapted from Reed 1987).

Category	Douglas-fir per acre (hectare)		Mean DBH inches (cm)		Douglas-fir seedlings[1] per acre (hectare)	
1	12	(30)	0.2	(0.53)	48	(120)
2	204	(505)	3.0	(7.5)	93	(230)
3	775	(1,919)	6.5	(16.51)	17	(41)

[1] Seedlings are trees shorter than 1.4 meters tall.

Fossil pollen records for northwestern California indicate that Douglas-fir has become a more important forest tree over the last 2,000 to 6,500 years. This has been attributed to a probable southward stabilization of the airstream/storm tracts as well as to a more equitable, less seasonal, and more maritime climate. A more maritime climate would favor the growth of Douglas-fir (West 1983,1990,1991).

Several past and present land-use practices also contributed to the trend of conversion to coniferous forest. Cessation of burning by the Native Americans and early settlers and the more recent suppression of lightning fires allow the fire sensitive Douglas-fir to become established. Natural fires caused by lightning are common, particularly inland of the park. It is probable that during the prehistoric period, fires started in (or burned into) the Bald Hills. Present fire suppression is very effective; lightning-caused fires seldom spread or burn large areas. Thus a natural check of Douglas-fir invasion is absent.

Livestock probably also contributed to increased fir invasion. As areas were grazed and trampled, bare ground increased, providing better seedbeds for fir establishment. Species composition also shifted from perennials to annuals. Annual species do not form as dense cover and compete poorly with invading fir.

Logging adjacent old-growth redwood forests may have also affected the oak woodlands. Douglas-fir is now a much more important component of the coniferous forest and fir seed is therefore more plentiful. Some prairie areas (and perhaps oak woodlands) were purposely seeded or planted with conifers.

Roads constructed through prairies and oak woodlands exposed bare roadcuts which were colonized much more rapidly by Douglas-fir than vegetated ground. Accelerated runoff from roads increased gullying. Gullies, like roadcuts were rapidly colonized by Douglas-fir.

Non-native species. Another problem is replacement of native species with naturalized non-natives, especially perennial grasses. Tall oat grass (Arrhenatherum elatius), velvet grass (Holcus lanatus) and sweet vernal grass (Anthoxanthum odoratum) are increasing (Hektner et al. unpublished data). Non-native perennial grasses are gaining dominance in the prairies, much as they have in other California coastal grasslands (Heady et al. 1977; Foin and Hektner 1986).

Declining Wildlife Habitat. Accompanying the loss of the prairies and oaks themselves is the loss of the associated oak understory and wildlife habitat. Stands such as that seen in Figure 4 with dense fir canopies will be devoid of herbaceous or shrubby layers for many years. The loss of the forage and cover further reduces wildlife diversity. Species dependent on acorns will be stressed.

Figure 4. Douglas-fir Encroached Area Devoid of Understory.

Before timber harvest began in the region, Roosevelt elk used both forests and grasslands for food and cover, but the prairies and coastal shrublands probably provided the bulk of available forage. Elk habitat was greatly expanded by logging. A rapid increase in population, which should have accompanied the appearance of clearcut logged areas, has probably been suppressed by illegal hunting. After the expansion of Redwood National Park in 1978, new groups of elk became established or increased in number in areas previously used only lightly. With protection, the elk population should continue to expand in the lower Redwood Creek and Bald Hills areas. The growing population centered in the park will soon (5-15 years) run into declining habitat conditions as the second-growth forest canopy closes and the extensive browse now available is suppressed in the shaded understory. Elk will become habitat limited and concentrated on the park-protected prairies and oak woodlands. Animal numbers or reproduction may be reduced, with elk age distributions skewed toward older animals with constricted ranges. Habitat may be degraded by concentrated use and the general vigor and appearance of the various elk groups could decline.

The quality of grassland forage is also a concern. An analysis of the Bald Hills elk diet through pellet analysis showed that the elk were not eating the most common non-native grasses, Arrhenatherum elatius, Holcus lanatus or Cynosurus echinatus (Hofstra 1989). If these species continue to increase, preferred elk forage may become further limited.

V. MANAGEMENT STRATEGIES

A variety of strategies will be implemented in the Bald Hills to achieve the park's goals of restoring and maintaining the diversity of plants and animals that prevailed when the area was first visited by Europeans. Strategies may be implemented concurrently and are not necessarily mutually exclusive. For clarity, they are described separately here:

Resource Protection. Routine park protection activities are ongoing. These include protection of threatened and endangered species, wildfire suppression, control of off-road vehicles, elimination of trespass grazing, control of poaching and related actions.

Cultural Resources Compliance. All park actions which have the potential to affect cultural resources are subject to review by the park archaeologist. For undertakings which have 'no effect' on cultural resources, an archeological clearance is obtained from the National Park Service (NPS) Western Archeological and Conservation Center, as per the agreement between the NPS and the California State Historic Preservation Office. Compliance actions for other undertakings is determined by the 1990 "Programmatic Agreement among the National Park Service (U.S. Department of the Interior), the Advisory Council on Historic Preservation and the National Conference of State Historic Preservation Officers." In addition, local Native Americans with traditional ties to lands now within the park, are regularly consulted regarding proposed park projects.

All actions carried out under the Bald Hills Vegetation Management Plan will be designed or modified in order to avoid adverse impacts to cultural resources.

Watershed Rehabilitation/Revegetation. Implementation of the on-going watershed rehabilitation program will treat gullies and remove unneeded roads and logging skid trails in the prairies and oak woodlands. Techniques employed and specific roads and trails will be identified in a separate updating of the 1981 Watershed Rehabilitation Plan. The resulting disturbed areas may be revegetated with seed or transplants collected from nearby native species.

Exotic Plant Control. Several non-native species are targeted for control because of their noxious or invasive nature. These include scotchbroom (Cytisus scoparius), himalaya berry (Rubus discolor), thistle (Cirsium arvense and C. vulgare and Silybum marianum) and tansy ragwort (Senecio jacobaea). Control efforts are underway for scotch

broom and tansy ragwort; control strategies are being developed for the others.

Many of the non-native grasses and forbs have naturalized and cannot be removed. Literature (Amme 1983) and initial results of previous prescribed burns (Hektner et al. unpublished data) suggest however that it may be possible to develop prescribed burning strategies to inhibit at least some of the more aggressive non-native species such as tall oatgrass (Arrhenatherum elatius), velvet grass (Holcus lanatus) and dogtail (Cynosurus echinatus). Specific strategies have not yet been developed.

Roadside Maintenance and Vista Clearing. Redwood National Park, in conjunction with Humboldt County, has implemented a vegetation control program along the county's Bald Hills Road. Manual removal of Douglas-fir, along with other trees and shrubs encroaching on the road is done to maintain road width and line-of-sight for driving safety, and to maintain proper drainage. Where Douglas-fir growing on the roadcuts has crowded out the prairie vegetation, tree removal has been extended off the road edge, thereby maintaining the grasslands while reestablishing and maintaining vistas across the prairies.

Elk Management. Of the wildlife species in the area, elk have the greatest potential for impacting the condition of the vegetation. Following the analysis of Grenier et al.'s (1990) elk research data, an elk management plan will be developed.

Prescribed burning. In order to perpetuate fire-adapted natural systems, such as the Bald Hills prairies and oak woodlands, fire must be re-introduced to the system. Ideally this would be accomplished by allowing lightning-caused fires to burn, however extensive private timber and ranchlands lie adjacent to the park boundary. As described in the National Park Service's Fire Management Policies (USDI 1990a) and Redwood National Park's Fire Management Plan (USDI 1985), fire management actions must be designed to avoid economic losses to adjacent landowners. Prescribed burning is a compromise between free ranging natural fires and the full suppression policies of park neighbors. A prescribed burn is a management fire set under predetermined conditions to achieve specified objectives. On the Bald Hills, it will be in lieu of frequent low intensity natural fires.

A prescribed burn plan (see Appendix F) will be prepared for each proposed burn. The plan describes physical and biological characteristics of the site. It defines treatment objectives in terms of resource values. All

constraints that bear upon how prescribed burning can be applied are identified. The fire prescription specifies the type of fire behavior desired, environmental conditions under which the fire is likely to behave and desired burning techniques. Tasks performed before, during and after the fire are identified and assigned to appropriate personnel. Needed equipment and supplies are listed and project costs determined.

Most prescribed burning will be done in August, September, and October. Burning may be tried experimentally during dry winter or spring periods and if successful, would be implemented on a larger scale, environmental conditions permitting. Each area will be burned on a five to ten year cycle. Ignitions will be designed to allow mosaics of burned and unburned areas such as would happen in lightning-caused fires.

Manual removal of Douglas-fir. Douglas-fir that have invaded the prairies or oak woodland and are now too large to be killed by a prescribed burn will be cut or girdled. Past prescribed fires have shown this to be trees ten or more feet tall, typically about ten years old (Sugihara and Reed 1987b). Most fir will be cut. Girdled trees frequently take several years to die and in the process produce "stress crops" of cones resulting in a flush of new seedlings. The dying trees are also unsightly and present safety hazards as they rot and unexpectedly fall. However, at least three to four of the largest Douglas-fir per acre may be girdled and left as snags for wildlife habitat. In less visible, none visitor use areas, where the fir is codominant with the oaks, additional fir may be girdled rather than cut in order to minimize damage to oaks. Final decisions on whether to cut or girdle will be made on a case-by-case basis.

Downed trees within sight of the Bald Hills road will be moved out of view or will be stacked and burned. Most remaining fir will be left to decay or be burned in the future.

Restoration of Native Species. Some areas will be seeded with locally collected native seed to bolster native plant populations. Ground scarification to remove competing vegetation prior to seeding will be tested. Successful techniques will be implemented on a larger scale. Areas that have been prescribed burned or where Douglas-fir has been removed may also be reseeded or planted with native species.

Visitor Use Development. To date, the primary visitor development planned for the Bald Hills area is a network of

hiking trails (USDI 1984). A Development Concept Plan will be prepared for the Bald Hills that will lay out a strategy for additional long-term visitor development and use. Vegetation management strategies can be adjusted to accommodate visitor developments without compromising the long-term goals of this plan.

VI. PROPOSED MANAGEMENT PLAN

The management strategies described in the previous section under **Resource Protection, Cultural Resource Compliance, Watershed Rehabilitation - Revegetation, Exotic Plant Control, Roadside Maintenance and Vista Clearing** and **Elk Management** are already being implemented under the auspices of Redwood National Park's Resources Management Plan. All will continue under the proposed management plan. Limited prescribed burning and manual removal of Douglas-fir has been done in an experimental mode. This plan proposes to continue on-going management activities and shift from an experimental mode to full implementation.

Three components are proposed:

Management to Control Encroachment. Earlier in this document, the Bald Hills vegetation was divided into four categories, based primarily on extent of Douglas-fir invasion. Those categories are:

1. Little or no encroachment

2. Moderate encroachment

3. Heavy encroachment

4. Advanced conversion to conifer forest

These categories represent a continuum from no Douglas-fir to complete replacement of the former oak or prairie vegetation types with Douglas-fir. They may also be a slight misnomer. For example, when one Douglas-fir becomes established in a prairie, the grasses and forbs under the drip line of the Douglas-fir are shaded out and rapidly disappear. Thus those few square feet are "converted" to Douglas-fir, even though the surrounding area remains prairie. The degree of encroachment (little versus advanced) refers to the relative degree of Douglas-fir invasion.

Management strategies also represent a continuum, from resource protection actions only, to large-scale cutting of substantial numbers of second-growth Douglas-fir. This plan proposes to implement the same strategies in Categories 1 through 3. The mix or intensity of strategies will vary however, depending upon the encroachment problem. For those areas with little encroachment, limited cutting of individual fir will occur, with a primary reliance on prescribed burning. In areas of moderate encroachment, more cutting of fir will be required before prescribed burning. Areas that are approaching advanced conversion will be

almost exclusively cut, with little use of fire as a maintenance tool for several years.

Category 4 areas, areas completely converted to conifers with little evidence of oak woodlands or prairies remaining, will receive no action. These areas, comprising a total of 812 acres, are now almost exclusively conifer forests, with trees ranging up to four feet in diameter and up to 150 years old. Removing these trees is possible and the areas could be converted back to oak woodlands or prairies, but the short-term results would be similar to clear-cut logging. In addition, the goal of this plan is not to recreate the hypothesized 1850 prairie/oak woodland/conifer forest boundary, rather is to mimic natural processes and maintain a diverse bald hills ecosystem.

Little or no encroachment: Areas with little or no encroachment (Category 1) are primarily prairie with some oak woodlands. Prescribed burning on a five to ten year recurrence interval will be used to maintain them. Manual removal of selected conifers will also occur in the prairies. Some areas may be reseeded or planted with native species. Park protection activities will continue. No action will occur in permanent study plot areas.

Moderate encroachment: Areas moderately encroached (Category 2) need both manual conifer removal and recurring prescribed burning. Emphasis will be placed on prescribed burning. Some areas may be reseeded or planted with native species. Park protection activities will continue. No action will occur in permanent study plot areas.

Heavy encroachment: Areas heavily encroached by Douglas-fir (Category 3) require manual removal of the firs initially, followed by recurring prescribed burning and reseeding or planting with native species. They represent groves of young Douglas-fir growing in the middle and edges of prairies. Oaks are common and viable among the fir. Park protection activities will continue. No action will occur in permanent study plot areas.

Advanced conversion to conifer forest: Areas where Douglas-fir have overtopped the oaks, and the oaks are dead or dying (Category 4), have little or no oak woodland understory remaining. In general the areas will not be treated, although limited manual removal of individuals may occur and occasional surface fires may be allowed to burn into these stands. Park protection activities will continue.

Restoration of Native Species. Areas where Douglas-fir has been removed may be reseeded or planted with species native to the oak woodlands and prairies. The decision to plant or

reseed will be made on a case-by-case basis, depending upon the potential for natural revegetation. Where native prairie or oak woodland species are expected to return naturally, no additional revegetation will be done. Where natural revegetation is expected to be slow, such as in the Category 3, heavily encroached areas, seed of nearby native species will be collected and sown on the burned or cleared area. Native tree and shrub seedlings may also be transplanted onto the site, or may be propagated for planting on the site.

Trials to test the effectiveness of removing existing vegetation prior to seeding with natives will be conducted in prairie areas dominated by non-native perennial grasses, such as Elk Camp Prairie and Upper Gann's Prairie. The tests will include hand-hoeing, scraping the grass off at ground level with a D-4 bulldozer and discing the ground to a depth of approximately six inches, prior to seeding. No herbicides will be used. Total acreage will not exceed one acre. If the trials are successful, the techniques will be implemented on a larger scale where appropriate.

Restoration of Wildlife Habitat. Wildlife habitat will be restored or maintained as a result of the vegetation management activities mentioned above. For example, restoration of native species will restore preferred elk forage. Young grass in elk diets is approximately twice as digestible as mature or senescent grass (Hobbs et al. 1981; Baker and Hobbs 1982). Burning should increase the availability of young grasses and improve forage quality.

Prescribed burning will help to decrease the frequency and occurrence of disease in elk because of improved nutritional quality of the forage and reduced parasite infestation (Hofstra 1989). The prescribed burning that has recently been instituted at Elk Prairie in Prairie Creek Redwoods State Park, located approximately 10-15 miles to the northwest has resulted in visible improvements in the condition of the elk living there (Hofstra 1989).

Ten Year Management Priorities. Approximately 90 percent of Category 1 (1786 acres) and approximately 50 percent of Category 2 areas (131 acres) will be treated with prescribed burns within ten years. All Category 3 areas (144 acres) will be treated with manual removal of Douglas-fir within five years. Approximately 50 percent of Category 3 areas will also be prescribed burned within ten years, primarily years five through ten. Seeding and planting with native species will be ongoing throughout the ten years. Appendix E (Figures 5 - 17) illustrate existing vegetation and the encroachment categories that will guide management

strategies for the Bald Hills. For management purposes, the area was divided into twelve units.

Gann's Unit The Gann's unit (Figure 6) consists of several small remnant prairies surrounded by Douglas-fir and old-growth redwood forest. It is the closest of the units to the coast and its species composition is more like that of the coastal prairies than of the prairies further inland (Veirs 1981). The lower prairies are dominated by native perennial grasses while the upper, largest prairie, adjacent to the Bald Hills road, is dominated by non-native grasses. Most Douglas-fir encroachment occurred over fifty years ago, but encroachment is still happening. On the north side of the Bald Hills road the prairie was plowed and planted with Douglas-fir in the 1960s. Only 15 percent of the 1850's prairie remains today.

Douglas-fir around the perimeter of the remaining prairies will be manually removed and the unit will be prescribed burned. A small area of the prairie adjacent to the Bald Hills road (less than one-half acre) will be experimentally tilled and seeded with native prairie species.

Elk Camp Unit The Elk Camp unit (Figure 7) is approximately three miles inland from Gann's prairie and is the northwestern most of the ridgetop prairies which were nearly continuous in 1850. Non-native species dominate the prairies and perennial grasses, especially tall oatgrass (Arrhenatherum elatius), are steadily increasing. Douglas-fir is encroaching slowly on the prairie margins and rapidly in the few remaining oak stands. This is the only area in the park where Sugihara and Reed (1987a) found evidence of pre-settlement forest encroachment.

Douglas-fir will be manually removed from approximately 25 acres each of Category 2 and 3 areas. All Category 1, 2 and 3 areas will be prescribed burned with the exception of approximately five acres of prairie. A long-term monitoring site which was established in 1982, will remain unburned for comparison with burned areas. A second area, totalling less than one-half acre, will also be left unburned and will be experimentally tilled and seeded with native prairie species.

Dolason Unit The Dolason unit (Figure 8) has undergone some of the most rapid Douglas-fir encroachment found anywhere in the park. One-half of the 1850's prairie/oak vegetation is now converted to conifer forest. Vistas from the Bald Hills road are completely blocked and the once extensive prairie is fragmented into many pockets. The few remaining oaks are restricted to narrow bands on the forest margin. The prairies are dominated by a mix of native and non-native

annual and perennial grasses and non-native perennial forbs.

Douglas-fir will be removed from approximately 30 acres of Category 2 and 3 areas. These and Category 1 areas will be prescribed burned.

Count's Hill Unit Count's Hill (Figure 9) is the only unit extending from the ridgetop to Redwood Creek. The prairies are dominated by a mix of annual and perennial grasses and one sedge. Most Douglas-fir encroachment is along the forest margin with the exception of a large area in the vicinity of a former barn site in the northwest corner.

Douglas-fir will be removed from approximately 32 acres of Category 2 and 3 areas and the entire unit prescribed burned.

Manezes Unit The Manezes unit (Figure 10) is the northwestern most section of what is now continuous Bald Hills. The unit is predominantly open prairie from the ridgetop to about midslope; oaks form a narrow fringe on the forest margins, with a few extensions into the grasslands. Douglas-fir invasion is mostly restricted to oak stands and forest margins. Isolated pockets of Douglas-fir occur on knolls and along stream channels within the open prairie. The grasslands are dominated by perennial grasses.

Douglas-fir will be cut in approximately 70 acres of oak woodlands. The entire unit will be prescribed burned.

Child's Hill Unit The Child's Hill unit (Figure 11) extends downslope about halfway to Redwood Creek. The upper portions are open prairie dominated by perennial grasses with fingers of oak woodland extending upslope into the grassland from extensive oak woodlands at the base of the prairie. Douglas-fir invasion is moderate and spotty through most of the upper and middle parts of the unit. Lower portions are being rapidly and densely encroached.

Much of the area can be managed by prescribed burning. Douglas-fir were experimentally girdled in a 16 acre area in 1986. After four years, an herbaceous understory is beginning to reappear. Douglas-fir seedlings, apparently a "stress-cone crop" from girdled fir are also becoming established. Douglas-fir in the remaining 35 acres of Category 2 and 3 areas will be cut. The Category 3 areas will not be prescribed burned within the next ten years. A long-term prairie monitoring site established in 1980 will remain unburned for comparison with burned areas.

Copper Creek Unit The Copper Creek unit (Figure 12) is composed almost entirely of oak woodlands and grassy glades.

The vegetation is highly diverse, and the oak woodlands are the most extensive of any area in the park. Douglas-fir invasion is also more advanced than anywhere else. Large areas of oak woodland have become colonized in the past 30 years and are becoming dominated by conifers. Most of the oak canopy is still intact but understory species have not survived in the dense shade. Encroachment is most active at lower elevations and on stream banks, but is widespread throughout the unit. One-tenth hectare long-term monitoring plot was established in this unit in 1985.

The long-term monitoring plot will not be treated. Douglas-fir will be cut on 44 acres of Category 2 and 3 areas. The entire unit will be prescribed burned, with the exception of the long-term monitoring plot.

Schoolhouse Peak Unit The Schoolhouse Peak unit (Figure 13) includes oak woodland and prairies above the Bald Hills road. The unit tends to be drier than other areas and most Douglas-fir invasion is found on the slopes with a northwestern aspect. The prairies are dominated by non-native annual grasses and perennial forbs. Two one-tenth hectare long-term monitoring plots were established in this unit in 1985.

Most of the unit can be managed with prescribed burning. Fir on approximately 33 acres each of Category 2 and 3 areas will be cut. Long-term monitoring plots will not be treated.

Lyons Ranch Unit The Lyons Ranch unit (Figure 14) is located on the ridgetop separating Copper and Coyote Creeks. Like Schoolhouse Peak, the unit is generally dry. The prairies are dominated by non-native annual grasses and perennial forbs. The oak stands are primarily along the forest margins and on rocky knolls. Douglas-fir establishment is restricted to the oak woodlands.

Douglas-fir on about 20 acres of Category 2 areas will be cut. The entire unit will be prescribed burned.

South Boundary Unit The South Boundary unit (Figure 15) is composed of two isolated lower slope prairies, each surrounded by sizable oak stands. Mixed evergreen stands dominated by maple, madrone, California bay and tanoak surround the oak woodlands. Douglas-fir invasion is primarily along stream channels and in oak stands near forest margins.

Douglas-fir will be cut on approximately 10 acres of Category 2 and 3 areas. All areas will be prescribed burned.

Tick Unit The Tick unit (Figure 16) is a small, steeply sloped, and isolated pocket prairie just south of Copper Creek. Well-developed oak woodlands are found on the lower slope. Most Douglas-fir encroachment is along stream channels and in oak stands on the margins of adjacent second-growth redwood forests. The prairie is dominated by non-native annual grasses and perennial forbs. A one-tenth hectare, long-term monitoring plot was established in the oak woodland in 1985.

Scattered Douglas-fir will be cut on eight acres of oak woodland. With the removal of the K and K road in 1990, the unit will be difficult to access. If acceptable prescriptions can be developed, the unit will be managed with prescribed burning. If burning is deemed infeasible, Douglas-fir will be removed manually. The long-term monitoring plot will not be treated.

Pig Pen Unit Almost half of the Pig Pen unit (Figure 17) is already in an advanced conversion to conifer forest stage. Douglas-fir has rapidly invaded the areas disturbed during the 1981 watershed rehabilitation activities. Pig Pen is an isolated unit surrounded by redwood forest. It is the only unit located on the banks of Redwood Creek. If acceptable prescriptions can be developed, the unit will be managed with prescribed burning. If burning is not feasible, the Douglas-fir on approximately seven acres of Category 2 and 3 areas will be cut.

VII. MONITORING AND RESEARCH NEEDS

Monitoring. Results of the proposed management actions will be monitored to either affirm that resource objectives are being met or to identify problems and modify management actions accordingly.

A number of studies and monitoring plots are already in place to evaluate long-term changes in untreated prairies and oak woodlands and to evaluate the effects of prescribed burning and Douglas-fir removal. One hundred and eighty, one-eighth square meter permanent monitoring plots have been established in Elk Camp and Child's Hill prairies to compare changes over time in burned and unburned grasslands. One site (Stagecoach Stop in the Child's Hill unit) has been sampled annually since 1980, another in Elk Camp prairie has been annually sampled since 1982. Two additional sites (Manezes and South Pasture), totalling 133 plots have been sampled in staggered years. Results are reported in Hektner et al. (1983) and Martin and Hektner (1988). Annual sampling will continue at the Stagecoach and Elk Camp sites. Manezes and South Pasture will be sampled at least every five years. All unburned plots will remain unburned for comparative purposes.

Fourteen 100 foot line transects were established in Gann's Prairie in 1974. They have been resampled eight times and will be resampled every five years to monitor long-term changes in species composition.

Four, one-tenth hectare permanent oak woodland long-term monitoring sites were established in 1985. Data collected include the location of all trees, diameter at breast height (dbh) for all trees taller than 4.5 feet and a list of all plant species. Percent cover of each plant species and the number and location of tree seedlings were sampled in 24, one square meter plots. These sites will not be burned and will be resampled at least once every five years.

Five study sites have been established to monitor the effects of prescribed burning on the oak woodlands. Each site has 24 one square meter plots that have been resampled annually to compare trends in vegetation patterns due to burning. Approximately 1000 oaks have been tagged to compare natural sprouting levels with those induced by fire and to predict potential changes in stand structure.

Two monitoring sites have been established to document understory recovery in areas where Douglas-fir was experimentally girdled or cut in 1986. The plots will be resampled annually for at least five years.

All prescribed burns will follow guidelines established in NPS-18, Fire Management Guidelines for the National Park Service (USDI 1990a) and will at a minimum be monitored using standardized methods established for National Park Service Western Region parks (USDI 1991). Basic data such as fire weather and fire behavior, size, location and immediate post-fire effects will be recorded for all burns. Monitoring to identify long-term trends will be done on selected "representative" burns. Twelve grassland monitoring plots and ten oak woodland plots have been established to date. At least 58 more grassland and 20 oak woodland plots will be established in 1991/92. Additional sites to monitor long-term effects of the prescribed burning, similar to those described above, will be established as needed.

Prescribed burns on steep slopes or near stream channels may induce soil erosion or bank sloughing. Erosion and stream bank stability will be monitored on sensitive prescribed burn areas.

Prairie gullies are commonly invaded by Douglas-fir trees. The removal of trees from these sites may adversely affect gully wall stability and lead to accelerated gully erosion. This has the potential to decrease earthflow stability and increase sediment delivery to Redwood Creek. Douglas-fir invaded prairie gullies proposed for treatment will be assessed by geologists for stability concerns and monitoring will be implemented to determine the effects of tree removal on gully erosion. If treatments are found to adversely affect gully stability and produce unacceptable levels of erosion, prescriptions will be modified to eliminate or lessen future management impacts.

The U.S. Geological Survey established monitoring in the mid-1970's to research earthflow movement on three prairies in the Bald Hills area (Harden et al. 1981). These sites (in Count's Hill prairie and two prairies upslope of the former K & K road) will be periodically re-surveyed by National Park Service staff to monitor long-term movement rates of these large landslides and to help examine the influence of tree removal on their movement and stability.

Precipitation on and adjacent to the prairies has been monitored since 1975. Five sites (one continuous recorder and four storage raingauges) will continue to be used to measure rainfall.

Research. Additional research or monitoring needs have been identified and await funding. Parenthetical citations refer to corresponding project statements in Redwood National Park's 1990 Resource Management Plan update:

The year to year herbaceous species composition appears to be greatly influenced by seasonal weather patterns and continues to change in response to the removal of cattle. Additional long-term monitoring is needed to follow vegetation changes in treated and untreated areas and adjust management actions if appropriate. (RM-9)

The effect of those changes on wildlife, and conversely the effect of wildlife on the vegetation, needs to be monitored. Proposals for studying and monitoring the Bald Hills elk population and herd conditions are included in the Draft Elk Management Plan (USDI 1986a) and the Draft Roosevelt Elk Study Proposal (USDI 1986b). A combination of techniques would be used including radio telemetry to estimate animal density, pellet counts on permanent transects, permanent photopoints and exclosures to monitor deer and elk forage use. Other wildlife species to be monitored and techniques to be used will be identified in a future Inventory and Monitoring Plan (Hofstra 1989). (N-64, N-88, N-119 and N-121)

Techniques and prescriptions for prescribed burning in areas inaccessible to vehicles are needed. (N-52)

Several non-native perennial grasses, especially Arrhenatherum elatius, Holcus lanatus and Anthoxanthum odoratum are dramatically increasing in the prairies. The effects on native species and techniques for controlling them, warrant investigation. (RM-9)

Little is known about the pre-settlement plant species composition. Studies using opal phytolyths might identify plant species no longer present. (RM-9)

Sugihara and Reed (1987a) described the location of the prairies and oak woodlands relative to the conifer forest at the time of European settlement in the 1850s. Further studies are needed to identify vegetation shifts prior to settlement. (RM-9)

Fire history information for the oaks is based upon a limited number of tree cross-sections. Additional fire history information is needed for the oak woodlands as well as for the adjacent conifer stands. (N-52)

The lichens of the Bald Hills oak woodlands were inventoried by Denison and Sillett in 1989. Their observations suggest that fire could have a "devastating" short-term effect on lichens. Monitoring is needed to determine both the short and long-term effects. (N-52, RM-9 and N-93)

Sturhan (in preparation) documented soil moisture and temperature regimes in oak woodland and four forest types. A similar study is needed for the prairies since soil moisture may play an important role in prairie distribution. (N-55)

Gordon (1980) and Popenoe (1987) did preliminary analyses of relationships between the Bald Hills vegetation and soil chemistry. A follow-up could help resolve questions about vegetation history. (N-55)

Certain cultural resources research needs are relevant to vegetation management research. More detailed correlation of vegetation and cultural resources distributions would be useful in order to determine if vegetation types are important variables in site location. Detailed histories, both human and vegetation, of specific places, for example certain prairies, might yield information about how one affects the other. Additional data on contemporary Native American use of the Bald Hills plant species, should be obtained. (C-9)

VIII. ROLES AND RESPONSIBILITIES

Superintendent - As administrative head of Redwood National Park, the Superintendent is responsible to the Regional Director and the Director of the National Park Service for all work and activities, including vegetation management.

Deputy Superintendent - shares the responsibility for overall direction of park operations with the Superintendent. All vegetation management activities will be initially approved by the Deputy Superintendent.

Chief, Research and Resources Management - reports to the Deputy Superintendent and is responsible for all resource management and research activities including vegetation management. The Chief of Research and Resources Management supervises the execution of prescribed burns in cooperation with Protection personnel.

Supervisory Botanist - reports to the Chief, Research and Resources Management and is responsible for all vegetation management activities including preparation and implementation of vegetation management plans, vegetation research and long-term monitoring. The Supervisory Botanist is responsible for preparation of Park Project Clearance Forms on all vegetation management projects that will disturb vegetation or soil. The Supervisory Botanist prepares the burning prescriptions and prescribed burn plans and may also act as a prescribed burn boss. She is responsible for pre- and post-burn monitoring and evaluation of fire effects.

Botanist - is delegated responsibility to plan, organize and implement vegetation management plans, conduct vegetation studies and long-term monitoring. The Botanist provides day to day technical supervision of ongoing projects.

Archaeologist - reports to the Chief, Research and Resources Management and is responsible for cultural resource management. The archaeologist monitors the effects of vegetation management projects on cultural resources.

Fish and Wildlife Ecologist - reports to the Chief, Research and Resources Management and is responsible for all wildlife and fisheries studies and management. The Ecologist monitors the effects of vegetation management projects on wildlife and recommends changes if necessary.

Geologist, Geomorphology Branch - reports to the Chief, Research and Resources Management and is responsible for monitoring soil erosion on sensitive prescribed burn sites,

assessing gully stability and continuing to monitor earth flow movement.

Biological Technicians - Technicians in the Research and Resources Management Division collect and analyze pre- and post-treatment monitoring data and assist in monitoring of fire weather and behavior during prescribed burns.

Labor Foreman - The foreman supervises Research and Resources Management labor crews in implementation of vegetation management projects such as Douglas-fir removal and exotic plant control.

Prescribed Burn Boss - The prescribed burn boss is responsible for burn plan implementation and preparation of the post-burn evaluation report. This position is typically held by someone in the Research and Resources Management or Protection Divisions. The Prescribed Burn Boss may also prepare burning prescriptions and plans.

Prescribed Burn Crew - Anyone within the park with at least "Fire Fighter" training and qualifications, who assists with prescribed burns.

Safety Officer - The Safety Officer participates in all prescribed burns and has direct authority from the Superintendent to ensure that safety is a priority concern; training is obtained, unsafe acts and safety hazards are eliminated and proper techniques are implemented.

IX. PUBLIC INFORMATION

Information regarding the Bald Hills vegetation management program will be provided through interpretive programs, public notification, scientific articles and conference presentations.

-The Bald Hills vegetation management plan will be made available to other agencies, adjacent landowners and interested persons.

-Information about the program will be incorporated into the Park Visitor Guide.

-Informational handouts detailing the program will be prepared and periodically updated. Handouts will be available for distribution at the park visitor centers.

-The program will be discussed in informal talks with all park divisions and surrounding communities.

-The program will be discussed during Redwood National Park/Humboldt State University (HSU) summer field seminars, in presentations to HSU classes and during park staff-led field trips for HSU classes.

-The vegetation management program will be incorporated into interpretive displays, walks, talks and other programs.

-Adjacent landowners, the North Coast Unified Air Quality Management District and the California Department of Forestry and Fire Protection (CDF) will be notified by letter of proposed burns.

-Burn plans for each prescribed burn will be available for public review. The CDF Fortuna and Trinidad offices will be sent copies automatically.

-Protection and Interpretation personnel will keep backcountry users informed of any prescribed burning.

-During prescribed burns near the Bald Hills road, traffic control staff will answer visitor questions.

-The National Park Service Western Region Prescribed Fire Specialist will be notified by phone prior to all prescribed burns so that he can address any questions coming in to the Regional Office.

-Results of the program will be reported in scientific journal articles, technical reports and at scientific conferences.

X. ENVIRONMENTAL COMPLIANCE

Public review of the Draft Bald Hills Vegetation Management Plan and Environmental Assessment occurred from October 4, 1991 to November 8, 1991. During the public review period, seven letters or comments were received. Three supported the proposed alternative to maintain existing prairies and oak woodlands through prescribed burning, manual removal of Douglas-fir and reseeding and replanting with native species. Two supported Alternative Two, which would also treat areas that are now almost exclusively conifer forests, with little or no vestiges of prairies or oak woodland remaining. Two did not express a preference. One writer said that the fossil record suggests that fire does not significantly alter long-term successional trajectories such as the expansion of Douglas-fir, and that the role of Indian burning needed further qualification. Western Region asked that discussions of vista clearing, hazard tree abatement, cultural landscapes and the effects of climate change on Douglas-fir advancement be expanded. Two writers thought we should consider use of herbicides.

Based on the analysis of environmental consequences, public review of the assessment, and the ability of the mitigation measures to reduce or eliminate impacts, the National Park Service has determined that the project is not a major federal action significantly affecting the human environment. A copy of the Finding of No Significant Impact is found in Appendix H.

Individual projects or portions of projects, including prescribed burning and manual removal of Douglas-fir are subject to an internal park project clearance procedure. That procedure subjects all projects which have the potential to impact vegetation, disturb soil, wetlands, floodplains, cultural resources or change visitor use patterns to a review process. A Park Project Clearance form is filled out by the project initiator and circulated to Division Chiefs and staff specialists (Supervisory Botanist, Fish and Wildlife Ecologist, Environmental Specialist, Geologist, Archeologist, Landscape Architect, Safety Officer and Access Coordinator). 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 measure or project modifications will occur prior to initiation of a project.

A Park Project Clearance form will accompany each prescribed burn plan when it is circulated to the Superintendent and

Deputy Superintendent for initial review and to all divisions and staff specialists for comment. The clearance is incorporated as part of the burn plan submitted to the burn plan library of the Western Region Office of the National Park Service.

Redwood National Park will comply with the requirements of the North Coast Unified Air Quality Management District for each prescribed burn. It is not expected that other permits will be required prior to any burn. However, if review of the prescribed burn plan and accompanying park project clearance identifies a need for additional permits, such permits will be obtained prior to implementation of the burn.

A park project clearance will be also prepared each year for areas proposed for cutting and will list and describe the actions to be taken at specific sites.

XI. LITERATURE CITED

Agee, J.K. 1987. The forests of San Juan Island National Historical Park. Rept. CPSU/UW 88-1. NPS Cooperative Park Studies Unit College of Forest Resources, University of Washington, Seattle, WA. 83 p.

Amme, D. 1983. Gorse control at Jughandle State Reserve: Resource restoration and improvement. Prepared for California Dept. of Parks and Recreation. Sacramento, CA. 61 p.

Amme, D. and B. M. Pitschel. 1989. Restoration and management of California's grassland habitats. Proceedings of the Society for Ecological Restoration and Management annual meeting. January 16-20, 1989. Oakland, CA.

Anderson, M.V. and R.L. Pasquinelli. 1984. Ecology and management of the northern oak woodland community, Sonoma Co., California. M.A. Thesis. Sonoma State University. 125 p.

Arguello, L.A. 1991. Personal communication. Student trainee-biology, Redwood National Park.

_____. 1990. Draft study plan, The effects of prescribed burning on Arrhenatherum elatius and Danthonia californica, two perennial bunchgrasses in the Bald Hills prairies of Redwood National Park. Humboldt State University M.S. thesis project in progress.

Baker, D. L., and N. T. Hobbs. 1982. Composition and quality of elk summer diets in Colorado. Journal of Wildlife Management. 46:694-703.

Barnhart, S.J., J.R. McBride, C. Cicero, P. Da Silva and P. Warner. 1987. Vegetation dynamics of the northern oak woodland. p. 53-58 In: Plumb, T.R. and N.H. Pillsbury, Tech. Coord., Proceedings of the Symposium on Multiple-Use Management of California's Hardwood Resources. November 12-14, 1986. San Luis Obispo, CA. U.S. Department of Agriculture. For. Serv. Gen. Tech. Rep. PSW-100.

Benson, J.R. 1983. Archaeological test excavations at four sites in Redwood National Park, Humboldt County, California. Redwood National Park, Arcata, CA. 191 p.

Bickel, P.M. 1979. A study of cultural resources in Redwood National Park. U.S. Department of the Interior, National Park Service, Denver Service Center, Denver, CO. 198 p.

Burcham, L.T. 1981. California range land: An historic-ecological study of the range resource of California. Center for Archaeological Research at Davis. University of California, Davis.

Clover, J.R., T.D. Hofstra, B.G. Kuluris, M.T. Schroeder, B.C. Nelson, A. M. Barnes, and R.G. Botzler. 1989. Serologic evidence of Yersinia pestis infection in small mammals and bears from a temperate rainforest of north coastal California. J. Wildl. Manage. 25:52-60.

Davenport, D.R. 1982. The Quercus garryana woodland of Redwood National Park and its use by breeding birds. Senior thesis, Humboldt State University, Arcata, CA. 24 p. On file at Redwood National Park, Orick CA.

Davy, J.B. 1902. Stock ranges of northwestern California: notes on the grasses and forage plants and range conditions. U.S.D.A., Bureau of Plant Industry Bulletin 12. 81 p.

Denison, W.C. and S.C. Sillett. 1989. Epiphytic lichens growing on Oregon white oak in the Bald Hills, Redwood National Park. Report for Redwood National Park by Northwest Mycological Consultants, Inc. 56 p. On file at Redwood National Park, Arcata, CA.

Eidsness, J. 1988. A summary of cultural resource projects, Redwood National Park. Redwood National Park, Arcata, CA. 136 p.

Foin, T.C. and M. M. Hektner. 1986. Secondary succession and the fate of native species in a California coastal prairie community. Madroño 33:189-206.

Gizinski, V. 1985. Annadel State Park oak woodland management plan. State of California, Department of Parks and Recreation. Santa Rosa, CA. 4 p.

Gordon, B.R. 1980. Soils of the Bald Hills area of Redwood National Park. M.S. Thesis, Humboldt State University. Arcata, CA. 76 p.

Greene, L.W. 1986. Lyons Ranch Historic District National Register of Historic Places Inventory - Nomination Form. U.S. Department of the Interior, National Park Service, Denver Service Center. Denver, CO. 26 p.

_____. 1980. Historical overview of the Redwood Creek basin and Bald Hills regions of Redwood National Park, California. U.S. Department of the Interior, National Park Service, Denver Service Center. Denver, CO. 52 p.

Grenier, J.J. 1989. Personal communication. Wildlife Biologist, Redwood National Park.

Grenier, J.J., R.T. Golightly and T.D. Hofstra. 1990. Habitat use of Roosevelt elk (Cervus elaphus roosevelti) in Redwood National Park, CA. Manuscript submitted for inclusion in Proceeding of the Western States and Provinces Elk Workshop, May 15-17, 1990.

Grenier, K.H. 1989. Vegetation patterns in grasslands of Redwood National Park, California. M.A. Thesis, Humboldt State University, Arcata, CA. 81 p.

Griffin, J.R. 1977. Oak woodland. p. 384-415 In: M.G. Barbour and J. Major, eds., Terrestrial vegetation of California. Wiley Interscience, New York, NY.

Griffin, J.R. and P.C. Muick. 1990. California native oaks: past and present. Fremontia 18:4-11.

Hagans, D.K. and W.E. Weaver. 1987. Magnitude, cause and basin response to fluvial erosion, Redwood Creek basin, northern California. p. 419-428 In: Beschta, R.L., T. Blinn, G.E. Grant, F.J. Swanson and G.G. Ice, ed. Erosion and sedimentation in the Pacific Rim. IAHS Publication No. 165.

Harden, D.R., R.J. Janda and K.M. Nolan. 1978. Mass movement and storms in the drainage basin of Redwood Creek, Humboldt County, California: U.S. Geological Survey, Open-file Report 78-486. 161 p.

Harden, D.R., H.M. Kelsey, S.D. Morrison and T.A. Stevens. 1981. Geologic map of the Redwood Creek drainage basin, Humboldt County, California: U.S. Geological Survey, Water Resources Inventory Open-file map 81-496, Scale 1:62,500.

Hayes, J.F. 1985. An analysis of Redwood National Park artifacts. 8489-5-0169, 8480-5-0302. U.S. Department of the Interior, National Park Service, Redwood National Park, Crescent City, CA. 143 p.

Heady, H.F., T.C. Foin, M.M. Hektner, D.W. Taylor, M.G. Barbour and W.J. Barry. 1977. Coastal prairie and northern coastal scrub. p. 733-760 In: M.G. Barbour and J. Major, ed. Terrestrial vegetation of California. Wiley Interscience, New York, New York.

Heizer, R.F., ed. 1972. George Gibb's journal of Redick McKee's expedition through Northwestern California in 1851. Archeological Research Facility, University of Department of Anthropology, California, Berkeley. 88 p.

Hektner, M.M., R.W. Martin and D.R. Davenport. 1983. The Bald Hills prairies of Redwood National Park. p. 70-78 In: C. Van Riper III, L.D. Whittig and M.L. Murphy, ed. Proceedings of the first biennial conference of research in California's National Parks. September 9-10, 1982, Cooperative Parks Study Unit. University of California, Davis, Davis, California.

Hobbs, N. T., D. L. Baker, J. E. Ellis, and D. M. Swift. 1981. Composition and quality of elk winter diets in Colorado. Journal of Wildlife Management. 45:156-171.

Hofstra, T.D. 1989. Personal communication. Fish and Wildlife Ecologist, Redwood National Park.

Iverson, R.M. 1984. Unsteady, nonuniform landslide motion: theory and measurement. Unpublished Ph.D. dissertation. Stanford University, Palo Alto, CA.

Janda, R.J., M. Nolan, D.R. Harden and S.M. Colman. 1975. Watershed conditions in the drainage basin of Redwood Creek, Humboldt County, California as of 1973. U.S.G.S. Open-file report 75-568. U.S. Geological Survey. Menlo Park, CA. 266 p.

Kartesz, J.T. and R. Kartesz. 1980. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. University of North Carolina Press. Chapel Hill. 498 p.

Kertis, J. 1986a. Vegetation dynamics and disturbance history of Oak Patch Natural Area Preserve, Mason County, Washington. M.S. Thesis, University of Washington. 95 p.

_____. 1986b. Oak patch preserve management plans. p. 95-103 In: Kertis, J. 1986. Vegetation dynamics and disturbance history of Oak Patch Natural Area Preserve, Mason County, Washington. Unpublished report on file with the Washington Department of Natural Resources, Seattle, Washington. 103 p.

Keter, T.S. 1989. Overview of the prehistoric and historic grasslands of the North Fork Basin of the Eel River. Paper presented at the 23rd Annual Meeting of the Society for California Archaeology. Marina Del Rey, CA. 14 p.

_____. 1987. Indian burning: managing the environment before 1865 along the North Fork. Paper presented to the Society for California Archaeology. April 16, 1987, Fresno, CA. 16 p.

_____. 1986. Relationships between culture and environmental change along the North Fork. Paper presented to the Society of California Archeology. March 28, 1986. Santa Rosa, CA. 9 p.

King, A.G. and P.McW. Bickel. 1980. Resource evaluation at nine archeological sites, Redwood Creek basin, Redwood National Park, California. National Park Service, Redwood National Park, Arcata, CA. 167 p.

Lane, F.D. 1983. Former resident and rancher in the Bald Hills area of Redwood National Park. Personal communication.

Lemos, J.C. and W.W. Hines. 1974. Ecological study of Roosevelt elk. Proj. No. W-70-R-4, Job Prog. Rep. Portland: Oregon Wild. Comm.

Mandel, R.D. and D.W. Kitchen. 1979. The ecology of Roosevelt elk in and around Redwood National Park. Report for National Park Service, Contract PX 8480-8-0045. 69 p.

Martin, R.W. and M.M. Hektner. 1988. Dynamics of the Bald Hills prairies of Redwood National Park. Abstract. Third Biennial Conference of Research in California's National Parks. September 13-15, 1988. Cooperative National Parks Resources Studies Unit and the Institute of Ecology, University of California, Davis, California.

Nolan, K.M., D.R. Harden and S.M. Colman. 1976. Erosional landform map of the Redwood Creek Drainage basin, Humboldt County, California, 1974-74. U.S. Geological Survey, Water Resources Inventory Open-file map 76-42, Scale 1:62,500.

Nolan, K.M., D. Marron and H.M. Kelsey. eds. In press. Physical and biological processes in the Redwood Creek drainage basin. U.S.G.S. Professional paper 1454.

Oxford, J. (editor). 1987. ACORN: Association for California Oak Resource News, Symposium edition. Natural Resource Management Department, California Polytechnic State University. San Luis Obispo, CA. 93407. 11 p.

Pearsall C.E., G.D. Murray, A.C. Tibbetts and H.S. Neall. 1943. The quest for Qual-a-wa-loo. College Publishing Company, San Francisco.

Plumb, T.R. 1980. Response of oaks to fire. p. 202-215 In: T.R. Plumb, tech. coord., Proceedings of the Symposium on the Ecology, Management, and Utilization of California oaks. June 26-28, 1979, Claremont, CA. U.S. Department of Agriculture, For. Serv. Gen. Tech. Rep. PSW-44.

Plumb, T.R., and N.H. Pillsbury, tech. coord., 1987. Proceedings of the symposium on multiple-use management of California's Hardwood Resources. November 12-14, 1986. San Luis Obispo, CA. U.S. Department of Agriculture, For. Serv. Tech. Rep. PSW-100.

Popenoe, J.H. 1991. Draft interim soil survey of the lower Redwood Creek basin, Redwood National Park. National Park Service, Redwood National Park. Orick, CA.

_____. 1987. Soil series descriptions and laboratory data from Redwood National Park. Redwood National Park Technical Report 20. National Park Service, Redwood National Park. Orick, CA.

Reed, L.J. 1990. Variation in annual acorn production in the Oregon white oak (Quercus garryana) woodlands of Redwood National Park. M.S. thesis in progress. Humboldt State University, Arcata, CA.

_____. 1987. Multistage stratified random sampling to estimate density and DBH of Douglas-fir trees in Oregon oak woodlands of Redwood National Park. Unpublished report on file at Redwood National Park, Orick, CA.

Reed, L.J. and N.G. Sugihara. 1987. Northern oak woodlands - ecosystem in jeopardy or is it already too late? p. 59-63 In: Plumb, T.R. and N.H. Pillsbury, tech. coord., Proceedings of the Symposium on Multiple-use Management of California's Hardwood Resources. November 12-14, 1986. San Luis Obispo, CA. U.S. Department of Agriculture, For. Serv. Gen. Tech. Rep. PSW-100.

Saenz, L. 1983. Quercus garryana woodland/grassland mosaic dynamics in northern California. M.A. Thesis, Humboldt State University. Arcata, CA.

Saenz, L. and J.O. Sawyer, Jr. 1986. Grasslands as compared to adjacent to Quercus garryana woodland understories exposed to different grazing regimes. Madroño 33:40-46.

Shoup, L.H. 1983. An interpretation and assessment of the significance of the historic cultural properties of Redwood National Park. Redwood National Park, Crescent City, California. 63 p.

Silen, R. R. 1958. Silvical characteristics of Oregon white oak. U.S. Department of Agriculture, For. Serv. PNW Silvical Series No. 10. 13 p.

Steinberg, S. 1989. Coyote Project Progress Report -- 1989, Redwood National Park. On file at Redwood National Park, Arcata, CA.

Steinberg, S. 1990. Coyote Project Progress Report -- 1990, Redwood National Park. On file at Redwood National Park, Arcata, CA.

Stevens, M.C. 1965. A preliminary study of the movement, distribution, abundance, and sex and age composition of the Roosevelt elk in and adjacent to Prairie Creek Redwoods State Park. Unpub. M.S. Thesis. Humboldt State College, Arcata, CA. 122 p.

Stover, A.M. 1987. Personal communication. Former Bald Hills area resident, Arcata, CA.

_____. 1983. Personal communication. Former Bald Hills area resident, Arcata, CA.

Sturhan, N. K. In preparation. Soil moisture and temperature regimes in Redwood National Park. M.S. Thesis, Humboldt State University. Arcata, CA.

Sugihara, N.G., M.M. Hektner, L.J. Reed, J.M. Lenihan. 1983. Oregon White oak woodlands of Redwood National Park: description and management considerations. p. 177-182 In: Van Ripper III, C. Whittig, L.D., Murphy, M.L. eds. Proceedings, First Biennial Conference on Research in California's National Parks. September 9-10, 1982. Davis, CA. Cooperative Park Studies Unit, Univ. of California, Davis.

Sugihara, N.G. and L.J. Reed. 1987a. Vegetation ecology of the Bald Hills oak woodlands of Redwood National Park. Technical Report 21, Redwood National Park, Orick, CA. 88 p.

_____. 1987b. Prescribed fire for restoration and maintenance of bald hills oak woodlands. p. 446-451 In: Plumb, T.R. and N.H. Pillsbury, tech. coord., Proceedings of the symposium on multiple-use management of California's Hardwood Resources. November 12-14, 1986. San Luis Obispo, CA. U.S. Department of Agriculture, For. Serv. Gen. Tech. Rep. PSW-100.

Sugihara, N.G., Reed, L.J. and J.M. Lenihan. 1987. Vegetation of the Bald Hills oak woodlands. Madroño 34(3):193-208.

Sullivan, M. 1934. The transcript journal of Jedediah Smith. Fine Arts Press, Santa Anna, CA.

Thilenius, J.F. 1968. The Quercus garryana forests of the Willamette Valley, Oregon. Ecology 49(6): 1124-1133.

Thompson, L. 1916. To an American Indian. Cummins Print Shop. Eureka, CA. 214 p.

Tunnison, J.T. 1973. A synecological study of the oak-dominated communities of Bennett Mountain, Sonoma County, California. M.A. Thesis, Sonoma State College. 143 p.

USDI. 1991. Western Region Fire Monitoring Handbook. National Park Service, San Francisco, CA.

_____. 1990a. Fire Management Guidelines. NPS-18. National Park Service, Washington, D.C.

_____. 1990b. Revised Resources Management Plan, Redwood National Park. National Park Service, Redwood National Park, Crescent City, CA.

_____. 1990c. Roosevelt elk study 1989 progress report, Redwood National Park. On file at Redwood National Park, Arcata, CA.

_____. 1988. Management Policies. National Park Service, Washington, D.C.

_____. 1987. Statement For Management, Redwood National Park. National Park Service, Redwood National Park, Crescent City, CA. 62 p.

_____. 1986a. Draft Elk Management Plan. Redwood National Park, Arcata, CA.

_____. 1986b. Draft Roosevelt Elk study proposal. Redwood National Park, Arcata, CA.

_____. 1985. Fire Management Plan, Redwood National Park. National Park Service, Redwood National Park, Crescent City, CA. 190 p.

_____. 1984. Backcountry Trail Plan, Redwood and Skunk Cabbage Creeks, National Park Service, Redwood National Park, Crescent City, CA. 50 p.

_____. 1983. Elk live trapping and relocation environmental assessment. Redwood National Park, Arcata, CA. 11 p.

Veirs, S.D., Jr. 1987. Vegetation studies of Elk Prairie, Prairie Creek Redwoods State Park, Humboldt County, California. Cooperative Park Studies Unit, National Park Service, Redwood National Park, Arcata, Ca. 113 p.

_____. 1981. Prescribed fire plan, Gann's Prairie, Redwood National Park. On file at Redwood National Park., Orick, CA. 11 p.

Walter, T. 1985. Prairie gully erosion in the Redwood Creek Basin, California. Redwood National Park Technical Report 16. National Park Service, Redwood National Park, Arcata, Ca. 24 p.

West, G. J. 1991. Pollen analysis of A-M Lake, Mendocino National Forest, California. Report prepared for Mendocino National Forest, Willows, CA. Purchase Order # 40-91z9-1-0252.

_____. 1990. Holocene fossil pollen records of Douglas-fir in Northwestern California: Reconstruction of past climate. p. 119 - 122. In: J.L. Betancourt and A.M.

Mackay, ed. 1990. Proceedings of the Sixth Annual Pacific Climate (PACLIM) Workshop, March 5-8, 1989: California Department of Water Resources, Interagency Ecological Studies Program Technical Report 23.

_____. 1983. Pollen analysis of sediments from a marsh adjacent to HUM-558: A record of ridgetop vegetation and fire in the Six Rivers National Forest. In: W. Hildebrandt and J. Hayes. Archeological Investigations on Pilot Ridge, Six Rivers National Forest. Report on file Six Rivers National Forest, Eureka, CA.

Wistar, I.J. 1937. Autobiography of Issac Jones Wistar, 1827-1905. Half a century in war and peace. The Wistar Institute of Anatomy and Biology. Philadelphia, PA. 202 p.

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