

# Post-Fire Vegetation Response in the Bishop Pine Forest at Point Reyes National Seashore

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## Abstract

The effect of the 1995 fire on the regeneration, composition and cover of the Bishop Pine (*Pinus muricata*) forest at Point Reyes National Seashore is examined. The human-caused fire burned over 12,000 acres in and around the National Seashore engulfing most of the bishop pine forest along Inverness Ridge, where fire intensity was the greatest. Bishop pine is a closed-cone pine that typically needs fire in order to regenerate. Past fire suppression policies created a forest of mostly senescent trees with little regeneration. Vegetation data were collected in 1996 and 1997 by sampling transects and quadrats noting species composition, cover, and number of seedlings present. Bishop pine seedling densities after the fire were high, yet variable. Overall seedling density decreased over the two years of study, but remained high. Significant increases in blue blossom (*Ceanothus thyrsiflorus*), fireweed (*Erechtites minima*), lupine (*Lupinus arboreus*), and huckleberry (*Vaccinium ovatum*) were observed over the sampling time. Species diversity increased over time. An inverse relationship between fireweed (*E. minima*) (an exotic species) and seedling survival and density was detected, although long-term effects appear minimal. These data provide a baseline for long-term fire recovery with this National Seashore surrounded by an urban environment.

## Introduction

In October 1995, a wildfire burned over 12,000 acres of the Point Reyes National Seashore. The Vision Fire, named after its ignition point, engulfed most of the bishop pine (*Pinus muricata* D. Don) forest along Inverness Ridge, where fire intensity was greatest.

Prior to the Vision Fire there was some concern about the regeneration of the bishop pine forest. Fire suppression policies in most National Park units had left a legacy of heavy fuel buildup leading to extreme crown fires (Kilgore 1976a). The importance of fire was finally recognized in 1968, when the National Park Service adopted a new administrative policy. Natural fire was recognized as one of the ecological factors that contributed to the viability of plants and animals native to a given habitat (Kilgore 1976a). Monitoring the effects of such fires is one step toward understanding the complexity of the relationships in these unique plant communities.

This study examines the response of vegetation after fire in the bishop pine community. To investigate these responses, thirty permanent plots were established and monitored as part of a long-term study. This information will provide a biological inventory that will assist resource managers in making informed decisions about managing the vegetation community and its response to fire.

Chinook helicopter dropping water on fire.



Regeneration in the bishop pine community is one focus of this study. Bishop pine seedling density in relation to fire intensity within the forest area is examined. Species composition also provides an important basis for the ecological understanding of fire effects upon vegetation. The change in vegetative cover during the first few years following the fire gives an indication of the progression of vegetation change over time. The associations found between and among species during the early regenerative period provide a baseline for future studies. Since the Vision fire was an intense crown fire, and Park Service policy is to minimize such conflagrations, this study will provide a baseline for comparison with vegetation recovery under planned controlled fires. In this manner ecological understanding of species composition and plant community survival under different fire regimes can grow.

### Study Area

Bishop pines form a dense forest of approximately 5,000 acres along the northern portion of Inverness Ridge on the Point Reyes Peninsula, with occasional small islands of trees scattered along the ridge toward Drakes Bay. Fossil records indicate that this forest is a relict of a much greater forest that dates back to the Pleistocene era (Peattie 1981; Sugnet 1984; Vogl et al. 1988). The Inverness Ridge bishop pine population is but one of several discontinuous related populations found scattered in the coastal areas from northern Baja California, Mexico to the California-Oregon border (Forde and Blight 1964; Wehtje 1991). The distribution of bishop pine on Inverness Ridge adheres closely to the granitic rock type (Galloway 1977). The south end of the

ridge bears a forest of Douglas fir (*Pseudotsuga menziesii* Mirbel) growing in association with the Monterey Shale substrate.

The Point Reyes Peninsula supports several rare plant species. Within the bishop pine forest, the Vision ceanothus (*Ceanothus gloriosus* var. *porrectus* J. Howell) occurs. This species is listed as rare by the California Native Plant Society (CNPS) (Hickman 1993). Marin manzanita (*Arctostaphylos virgata*), another rare species, is also found within the bishop pine forest (USDI 1995).

Trees growing in association with bishop pine are: madrone (*Arbutus menziesii*), coast-live oak, (*Quercus agrifolia*), wax myrtle (*Myrica californica*), bay laurel (*Umbellularia californica*), tan oak (*Lithocarpus densiflorus*) and golden chinquapin (*Chrysolepis chrysophylla*). Shrub species include: California coffeeberry (*Rhamnus californica*), huckleberry (*Vaccinium ovatum*), salal (*Gaultheria shallon*), manzanita (*Arctostaphylos* species), bush lupine (*Lupinus arboreus*), and blue blossom (*Ceanothus thyrsiflorus*). Herbaceous species include: morning-glory (*Calystegia purpurata*), peak rush-rose (*Helianthemum scoparium*), hedge nettle (*Stachys ajugoides*), and blackberry (*Rubus ursinus*).

### The Vision Fire

The Vision fire began in the afternoon of October 3, 1995 from the flare up of an unattended illegal campfire. Fueled by high winds (40-50 mph) and a buildup of late summer forest fuels, the fire quickly spread. Pushed by warm offshore winds with low relative humidity, the fire consumed

Inspecting area for hotspots.



12,350 acres by the time it was contained on October 7, 1995. Of the total acreage, 11,600 acres are located within Point Reyes National Seashore. Hot spots continued to flare up after containment with full control of the fire declared at midnight October 16, 1995. Forty-four homes were destroyed in the private community adjacent to Point Reyes National Seashore (PRNS 1997).

Approximately 1,300 acres (11%) of the burn area were listed as high intensity burn, 2,290 acres (19%) were listed as moderate intensity burn, and 8,340 acres (70%) were listed as low intensity burn (USDI 1995).<sup>1</sup> Most of the high intensity burn occurred in the northern third of the fire range in the steep granitic terrain along Inverness Ridge. This area is largely populated by bishop pine forest. Burn intensity for the Bayview Trail area was “moderate”, even though destructiveness seemed to equal the Inverness Ridge Trail upon post-fire observations. Total acreage of bishop pine forest burned was 1,040 acres (USDI 1995).

### Natural History of The Bishop Pine Community

Bishop pines are a member of the closed-cone pine group, which includes Monterey pine (*Pinus radiata*), knobcone pine (*P. attenuata*), and two subspecies of *Pinus contorta* - beach pine (*P. contorta* ssp. *contorta*) and pygmy pine (*P. contorta* ssp. *bolanderi*) (Vogl et al. 1988). The bishop pines possess two needles per fascicle in the adult stage (Schoenherr 1992). The Point Reyes population exhibits a three-needle seedling stage. The needles can vary from a bluish-green form in the northern populations to a more distinct green in southern populations. The Point Reyes population displays the southern green needle color (Millar and Critchfield 1988). The cones of the tree are born in whorls held tight to the tree stem (Peattie 1981). Cones are approximately two inches long with prickly spines (Schoenherr 1992). Cone production was thought to occur by about ten years of age (Krueger 1916) but cone production was evident five years after the fire in the bishop pine along Inverness Ridge Trail. The tree grows tall but twisted in Point Reyes, whereas in the Mendocino pygmy forest the bishop pine is often dwarfed (Duffield 1951). The morphological plasticity of bishop pine throughout its range pays tribute to its climatic and edaphic adaptability.

### Fire and the Bishop Pine Forest Community

Most plant species in fire-dependent ecosystems have developed structures, mechanisms, and functions that depend on fire for their regenera-

tion (Vogl 1980). The plant community of the bishop pine forest at Point Reyes National Seashore is no exception; it is a population that is periodically subjected to fire as part of its natural history (Sugnet 1984). Bishop pines bear tightly closed cones that open only after fire or extreme heat (Vogl et al. 1988; Johnson 1994). These pines produce copious quantities of seeds that prefer the freshly mineralized soil after a fire for germination.

Most Point Reyes' bishop pine stands have come in as a result of fire (Krueger 1916). The last evidence of a large stand-replacing fire, like the recent Vision fire, was in October 1927 (Sugnet 1984). Since bishop pine is a stand-replacing species, another fire before cone production commences could have a severe impact on the bishop pine population.

Plant species have evolved various mechanisms of survival in fire, and a high intensity fire will favor certain species. Seedlings of fire dependant species after a high intensity fire are usually more abundant than resprouting species (Horton and Kraebel 1955). Different fire intensities determine germination of different species (Whelan 1995). Low intensity fires uncover seed banks in only the topmost layers of soil, while higher intensity fires uncover deeper seed banks that have been stored much longer.

Fire frequency is also seen as a determinant of species composition (Keeley 1995); too frequent a fire interval can cause local extinctions by destroying plants before they are able to reproduce. This difference in species maintenance with different fire regimes points to the problem of trying to use fire in a prescribed fashion. Application of only low intensity fire regimes may eliminate certain species that depend upon higher intensity fires. A small test burn on Mount Vision in the 1970's demonstrated that even fires of moderate intensity can destroy stands of mature bishop pine, throwing into doubt the effectiveness of prescribed fire for protecting these adult trees (USDI 1993). Hence, fire prescription for this type of area is difficult, given the chaotic mix nature seems to prefer.

Other species associated with the bishop pine forest, such as wax myrtle (*Myrica californica*) and huckleberry (*Vaccinium ovatum*) reproduce from sprouts after fire. Resprouting strategies employed by many shrub species, as well as abundant production of seeds that need fire to germinate, virtually ensures the continuation of fire-adapted species (Keeley and Zedler 1978). *Ceanothus* seeds are stimulated to germination by the heat of fire, and provide nitrogen-fixing



Serotinous bishop pine cone opening during fire.

qualities to the soil (Daubenmire 1968, Quick and Quick 1961; Biswell 1989; Schoenherr 1992). Another nitrogen-fixing plant, the lupine germinates only after intense fires (Whelan 1995).

## Methods

Data on plant community response to the Vision fire were collected during the summers of 1996 and 1997. Currently a five-year assessment (1995-2000) is underway. Areas under study are located on Inverness Ridge and Bayview Trails. The Inverness Ridge Trail area had been represented in Burn Area Emergency Rehabilitation Plan (USDI 1995) maps as a high-intensity burn, while the Bayview Trail area was listed as a medium-intensity burn. Consequent reconnaissance in early February 1996 revealed little visible difference in the two areas.

Thirty 50-meter line transects were laid out systematically, in random directions, off Inverness Ridge Trail and portions along Bayview Trail. Along Inverness Ridge Trail transects were placed about every 25-30 paces for approximately one mile. These sites were all located approximately 20 to 30 meters off the trail to aid in relocation and uniformity, while preventing disturbance. Bayview Trail sites were located within a large island of burned adult bishop pine trees. Transect direction selection were deliberately placed away from the trail. Topography varied from protected canyon to windswept ridge top, while elevation varied little.

The line-point intercept method was used for sampling vegetation. Seedling density was noted using quadrat sampling along the transect line. General slope, aspect, and elevation data were also recorded for each transect.

Transect beginning and end points were marked with a permanent three-foot rebar, metal tagged with the site number, then located using a Trimble Geo-Explorer II GPS unit (Trimble Navigation 1991).

Thirty 50 meter line transects were sampled for species presence and seedling density and were recorded along with general site information. Species at point intercept were recorded at every meter along a transect line. Species occurrence and height of the tallest species were recorded at each point for a total of 1500 point samples. If no species were found at the point sampled, the substrate of bare ground or litter was recorded. Bishop pine seedlings were counted in 20 square meter sections staggered along each side of the line transect at 5-meter intervals. This provided a total area of 600 square meters (30 x 20m<sup>2</sup>) of

seedling samples. This method was chosen to allow a more accurate view seedling density to be able to document natural thinning in later years.

## Data Analysis

General vegetation and site characteristics were recorded for each transect. These field observations are useful for understanding the general picture of succession. Species lists were tallied for each site for each year sampled. Percent cover and seedling density were obtained.

Paired sample t-tests were performed to determine the significance of changes in species frequencies between 1996 and 1997. Analysis of Variation (ANOVA) was used to find the variance levels of seedling densities. Correlations were performed by transect to show relationships among species, as well as among species and environmental factors. Statistical analyses were performed using SPSS 7.5 (Norusis 1997).

## Results and Discussion

Species present during each of the two years sampled were recorded. Since vegetation was sampled during summer months, many annual species had already died and were not recorded. Consequently, this sample reflects only the occurrence of trees, shrubs, perennials, and hardy annuals.

Overall species numbers were established during the first year, with very little change from the first year to the second, although most transects showed an increase in species diversity. Twenty-eight species were found during the first year, increasing to 32 species the second year. Fewer than half of the total species were represented in any one transect. Also, while species diversity increased very little overall, the distribution of species diversity shifted with passage of time. Fewer species were represented on each site the first year, while 1997 showed a shift toward greater diversity per study area. Inverness Ridge sites that were protected represented the greatest diversity of species both years (26 and 28 respectively), but also contained the largest number of samples. Most species established themselves early, while a few weren't noted until the second year. California man-root (*Marah fabaceus*) vines were seen very early after the fire, (probably spouting from tubers) noted in 1996, but no longer present in 1997. The tiny annual, varied leaf collomia (*Collomia heterophylla*) was likewise seen early and was not seen the second season. Other species were not seen until the second year, especially the tiny, rare *Vision ceanothus* (*Ceanothus gloriosus* var. *porrectus*).

<sup>1</sup>Burn intensity refers to the results of the fire and the intensity of the effects on watershed conditions, especially in regard to released sediments and threat of erosion (USDI 1995).

Pink everlasting (*Gnaphalium ramosissimum*), bush monkeyflower (*Mimulus aurantiacus*), and red flowering currant (*Ribes sanguineum*) all were present in samples only during the second year.

For the most part, the slight increase in species diversity was due to the presence of a single plant representing that species. *Solanum* sp. was found only once, as was *Carex* sp.. Other species were seen but not sampled on the line transects. Of these, the most common was madrone (*Arbutus menziesii*), a gooseberry (*Ribes* spp.), and tan oak (*Lithocarpus densiflorus*). Many other species were quite common along the trail but rarely seen off the trail. These included pink everlasting and bush monkeyflower.

Some species were present throughout all sample areas. Bishop pine and bracken fern were present in every transect. *Ceanothus* was present in all but one transect. Huckleberry was present in all but two transects.

Table 1 lists the 20 most common species for comparison and shows results for the overall landscape area as well as the statistical significance of the changes.

The first year composition shows a large portion of all the areas sampled (17.5%) as bare ground. This composition changed radically by the second year when only 2 percent of the total area sampled was bare ground. When examined by geographic area, more differences are highlight-

ed. Vegetation quickly covered the bare ground on Inverness Ridge protected sites with 20 percent bare ground cover in the first year and only 2 percent in the second year. Exposed sites on Inverness Ridge remained without vegetation in 3 percent of the area after the second year, whereas 15.5 percent of the area was without vegetative cover the first year. On the Bayview sites all but nine percent of the ground was covered after the first year. Vegetation regeneration was obviously more vigorous in the Bayview area. This was expected due to the deeper soils and lower intensity burn. The photos in Figures 1a and 1b illustrate the rapid change in cover of one of the Inverness Ridge protected area sites. Note the tall seedlings in the foreground in the photo on the right and the clump of ubiquitous fireweed in the background.

One of the most striking changes in species composition was the proliferation of blue blossom ceanothus (*Ceanothus thrysiflorus*), which increased significantly from 16.5 percent the first year to nearly 48.5 percent cover the second year. The greatest cover of this plant was found on Inverness Ridge protected sites (56%) as would be expected, although the exposed and Bayview sites also had extensive populations of this species (33% and 39.5% respectively). *Ceanothus* is known to frequently occur on arid sites prone to wildfire (Quick and Quick 1961). These plants are also known for their nitrogen-fixing properties, so the large-scale presence of ceanothus should have a positive effect on the soil along Inverness

**Table 1. Comparison of Vegetation Change in Overall Landscape for 20 most common species. Percent cover calculated from total times species intercepted the transect (hits) divided by 1500 possible hits (50 points X 30 transects). Significance values were calculated using t-tests and are based on 95% confidence levels with 29 degrees of freedom.**

Species Name		Total Hits 96	% Cover 96	Total Hits 97	% Cover 97	Overall % change
<i>Erechtites minima</i>	Australian fireweed	12	0.8	159	10.6	1225.0
<i>Arctostaphylos</i> sp.	manzanita	3	0.2	20	1.3	566.7
<i>Chrysolepis chrysophylla</i>	chinquapin	4	0.3	14	0.9	250.0
<i>Rhamnus californica</i>	coffeeberry	2	0.1	7	0.5	250.0
<i>Lupinus arboreus</i>	bush lupine	86	5.7	261	17.4	203.5
<i>Ceanothus thrysiflorus</i>	blue blossom	248	16.5	728	48.5	193.5
<i>Pinus muricata</i>	bishop pine	165	11.0	443	29.5	168.5
<i>Vaccinium ovatum</i>	huckleberry	61	4.1	124	8.3	103.3
<i>Helianthemum scoparium</i>	rush-rose	16	1.1	28	1.9	75.0
<i>Quercus agrifolia</i>	Coast live oak	3	0.2	5	0.3	66.7
<i>Gaultheria shallon</i>	salal	7	0.5	9	0.6	28.6
<i>Rubus ursinus</i>	Cal. Blackberry	150	10.0	182	12.1	21.3
<i>Polystichum munitum</i>	w. sword fern	10	0.7	12	0.8	20.0
<i>Lotus species</i>	lotus	272	18.1	268	17.9	-1.5
<i>Pteridium aquilinum</i>	w. bracken fern	151	10.1	125	8.3	-17.2
<i>Stachys ajugoides</i>	hedge nettle	31	2.1	20	1.3	-35.5
<i>Rubus parviflorus</i>	thimbleberry	8	0.5	3	0.2	-62.5
<i>Calystegia purpurata</i>	morning-glory	36	2.4	10	0.7	-72.2
- Litter -		297	19.8	76	5.1	-74.4
- Bare Ground -		262	17.5	32	2.1	-87.8
<b>Total Cover</b>			<b>121.6</b>		<b>168.4</b>	

Figure 1a (left)  
1996 transect along Inverness Ridge  
with fireweed in the background  
and very small pine seedlings in the  
foreground.

Figure 1b (right)  
The same transect in 1997, with  
bishop pine seedlings dominating  
the plot.



Ridge (Biswell 1989). The survival of these seeds in a high intensity burn points to the long-term storage of these seeds deep within the soil layer. Regrowth of this species has been rapid. Many plants were over six feet high by the second summer, and stands were very dense. Initial observations in year five found ceanothus continuing its codominance with bishop pine and reaching heights of over 3 meters (Figure 2).

Another nitrogen-fixing species, the bush lupine (*Lupinus arboreus*), increased significantly in overall cover by more than 200 percent, from 6 percent during the first summer, to 17.5 percent during the second summer. Certain legumes will germinate only after intense fire due to seed storage deep within the soil layer (Whelan 1995). This may account for the total lack of lupine cover in the less intense burn area off Bayview Trail. Whether fire intensity is actually a factor is speculative however, since the actual life history of *Lupinus arboreus* off Bayview Trail is unknown. Excluding the Bayview transects, the mean percent cover of lupine in all Inverness Ridge sites was 20 percent. There was a fairly even distribution of *Lupinus arboreus* between the protected and exposed sites at the end of the second season (19% and 22% cover respectively). By year five lupine had virtually disappeared from the site.

Another legume, although relatively small as an individual plant, provided much of the low ground cover in areas where shrubs were not present. Lotus species constituted nearly 18 percent of the total cover by the end of the second

year, changing relatively little from the first year. The most noticeable difference in distribution of this plant occurred in the Bayview sites where occurrence of Lotus dropped significantly from 18.5 percent in 1996 to 2.5 percent in 1997 (Table 1). Lumped together into the general category at the genus level, this group is most likely made up of two separate species, *Lotus humistratus* E. Greene and *Lotus purshianus* (Benth.) Clements and E.G. Clements var. *purshianus*. These plants formed dense mats throughout the study area on what might have otherwise been bare ground.

*Erechtites minima*, the invasive Australian fireweed, presented itself as a formidable challenge to management by its increased presence in the study area. First year sampling found only a dozen of these plants, although many more were seen along the trail, while 159 fireweed plants were found in year two. Fireweed spread dramatically after the first year's seed dispersal, to 10.5 percent of cover by the second summer (Table 1). This overall average is misleading however, since a much larger increase in percent cover (20%) was seen in the xeric sites (Table 1). Figure 3 shows a comparison of a xeric site in 1996 and 1997. Small fireweed plants can be seen covering the ground in the 1997 photo. Park service efforts to eradicate this plant along trails seemed only to increase its presence. Several of these plants were greater than seven feet tall, and its dandelion like reproduction strategy, light wind blown seeds, helps to ensure proliferation of the species. It grows in clumps, sometimes in dense thickets, and appears to have a detrimental effect upon soil stability.



Figure 2: Fall 2000. Bishop pine and  
ceanothus along Inverness Ridge  
Trail.



Figure 3: Xeric site in 1996 (above) and 1997 (below). Within two years after the fire, most of the area is covered by vegetation.

California blackberry (*Rubus ursinus*), occurred in 12 percent of sites in 1997. In places this plant seemed to weave together the ceanothus, making penetration for sampling a thorny challenge. There was little change in overall cover of blackberry (Table 1). Bayview sites exhibited the largest increase (22% to 33%), although this change was not statistically significant.

Bracken fern (*Pteridium aquilinum*) was one of the earliest species to resprout from the charred ground. Its numbers dropped off slightly during the second year from 10 percent to just over 8 percent cover. The drop off was most significant on the exposed sites (15% to 10%).

Cover of huckleberry (*Vaccinium ovatum*) increased significantly in one year to over 8 percent. Judging by the large stumps of charred shrubs remaining, this resprouter will probably gain further dominance in the understory.

The rare Vision ceanothus (*Ceanothus gloriosus* var. *porrectus*) was sampled in only one spot in 1997. Several other sightings were made of this species in 1997. Although the presence of this species outside of the sampling sites was not part of this study, their occurrence was noted.

### Bishop Pine

Bishop pine reproduction was phenomenal – 15,229 seedlings were counted in 1996 and 6,629 were counted in 1997. First year seedling density averaged 25 seedlings per square meter, and ranged from 71 to 33/m<sup>2</sup>, while covering the landscape in 11 percent of the sampling sites. Second year density dropped to 11 seedlings/m<sup>2</sup> ranging from 32. to 2/m<sup>2</sup>. Cover increased to 29.5 percent of the total area sampled.

Clumping of seedlings was also significant. ANOVA runs on data from 1996 and 1997 show a significant rate of variability among density values within each season. Figure 4 shows average seedling density by transect for 1996 and 1997. Figure 5 compares bishop pine seedling cover by transect for 1996 and 1997. These illustrate the inverse relationship between density and cover for the bishop pine seedlings. As density decreased cover increased. Highest densities were found in Inverness Ridge protected sites, with an average of 33 seedlings/m<sup>2</sup> in 1996 and 13 seedlings/m<sup>2</sup> in 1997.

Lower seedling densities were seen near the top of Inverness Ridge, as would be expected. Here, in the drier, exposed area changes were less significant. Seedling density decreased from an average of 6/m<sup>2</sup> to 4/m<sup>2</sup>, while cover increased from four percent to 11.5 percent. Seedling density on

Bayview sites decreased from 23.5 seedlings/m<sup>2</sup> to 15 seedlings/m<sup>2</sup>. Percent cover in the Bayview sites increased dramatically from 14.5 percent in 1996 to 40.5 percent in 1997, although the significance level is low due to the limited sites.

### Associations

One of the more interesting aspects of this study is the representation of species associations. Several bivariate correlations were performed to see if relationships between the presence of certain species were related to the presence of bishop pine seedlings. Two of these tests stand out in particular. The first test was to determine if the thick regrowth of ceanothus was affecting the bishop pine seedlings. There was no apparent linear relationship between seedling establishment and ceanothus regeneration at this time. Although the high density of ceanothus is assumed to contribute to seedling mortality, it was not evident in year two. Other correlations were performed to examine if inverse relationships in seedling density between the sampling years with ceanothus cover existed. These were unexpectedly positively correlated. Future observations may show greater seedling mortality, but since seedlings established themselves well before the explosion of ceanothus, mortality may not have yet occurred. Additionally, there was a greater amount of moisture within the thick ceanothus, and this may have served as a type of nursery environment for the seedlings in the early stages.

In contrast, the effect of fireweed upon seedling establishment is pronounced (Figure 6). Fireweed seemed may have a desiccating effect upon the soil, while ceanothus may provide soil moisture protection. However, it seems doubtful that fireweed will have a serious effect on the reestablishment of the bishop pine forest. Given the head start the seedlings possess, as well as their proliferation, quick growth rates, and ability to colonize poor soil conditions, a new bishop pine forest will develop relatively quickly. Casual observations at year four found little fireweed present.

### Conclusions

Vegetation in Point Reyes National Seashore has demonstrated its resilience to fire. The rapid vegetative regrowth after the 1995 Vision fire characterizes this aspect of the ecosystem in the bishop pine forest. A large portion of vegetative cover after the second year (roughly 85 percent) was composed of three nitrogen-fixing plants. This is typical of early successional stages and indicates a healthy process. As all of these nitrogen-fixing species reproduce from seed, it would

be interesting to compare their composition after this fire with their composition after controlled burns to see if any (or which) nitrogen-fixing species recover.

Nearly 30 percent of the area sampled was covered by bishop pine at the end of the second sampling season. The data suggest we will see another bishop pine forest in the near future, characterized by species that have long been documented as associations within this forest type. Although the invasive fireweed (*Erechtites minima*) increased initially it declined in later years. At this point its influence on the plant community seems minimal. There is a dearth of literature on Australian fireweed and more ecological studies need to be made of this species, especially with regard to its effects on the soil.

### Fifth Year Update

Although detailed data on year five are not available at the time of this writing, initial observations were made. Bishop pine continues to co-dominate with blue blossom ceanothus. Both species reached heights of over three meters. Bishop pine also exhibited cone production five years earlier than previously reported (Krueger 1916). There was some seedling mortality under surviving bishop pines and ceanothus shrubs. Lupine and fireweed have virtually disappeared from the study area. The Bishop pine forest burned in the Mt Vision fire appears to be well on the way to becoming a healthy and vigorous plant community.

This ongoing research documenting the vegetation changes now at five year intervals, along with other research on the vertebrate, invertebrate and fungi population's response to the Vision fire, will help to provide a clearer picture

of fire's effect on the unique natural community at Point Reyes.

### Acknowledgements

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Figure 4.

Comparison of average bishop pine seedling density per square meter by transect. Data shown compares 1996 to 1997. Bars represent +/- one standard deviation.

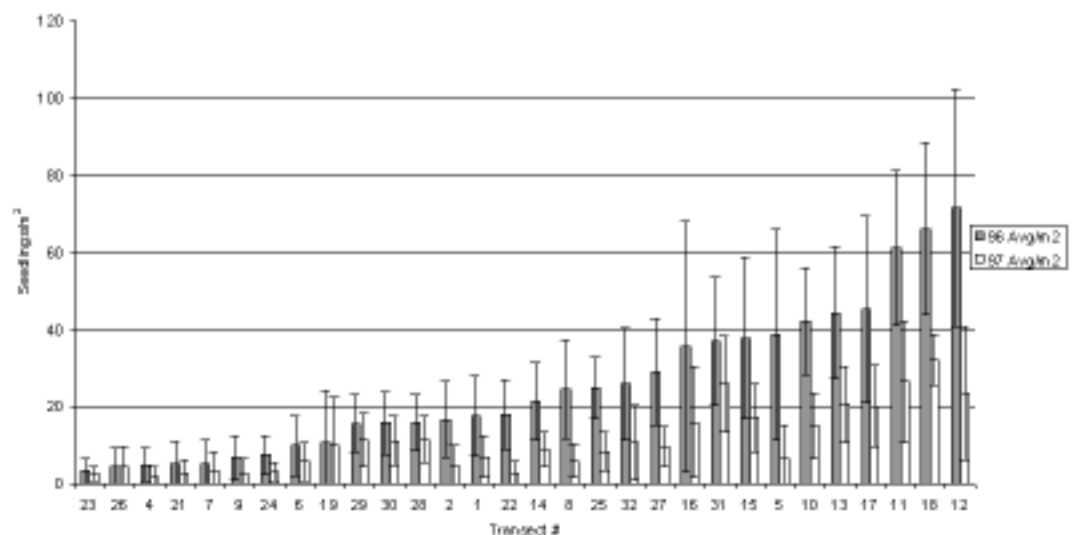




Figure 6. Presence of fireweed increased considerably from 1996 to 1997. Note the large patch with dried flower heads already to seed in August 1997.

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Figure 5.

Comparison of bishop pine seedling percent cover per transect. Data shown compares 1996 to 1997. Percent cover was calculated by dividing the number of hits per transect by the total possible (50).

