The Preservation of the Knobcone Pines on Flicker Ridge

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Introduction

Flicker Ridge lies southwest of the town of Moraga, in the Berkeley Hills (Figure 1). Reaching an elevation of approximately 1100 feet, Flicker Ridge is home to a variety of plant communities, including grassland, oak-madrone woodland, redwood forest, and knobcone pine forest (Rademacher, 1973). A small population of *Pinus attenuata*, or knobcone pine (Figure 2), inhabits the top of Flicker Ridge, the only knobcone community in the Berkeley Hills. The knobcone pine is a fire-dependent species, requiring the heat of wildfires to disperse its seeds. Fire suppression policy practiced throughout this century threatens the knobcone pines on Flicker Ridge. This in turn threatens a wide variety of animals which utilize the knobcone habitat. In order to preserve the Flicker Ridge knobcone community, additional managerial action is necessary. Three possible alternatives are: planting seeds at the site, transplanting seedlings, and prescribed burning of small sections of the community. This paper presents an evaluation of each of these alternatives, as well as the possible consequences of the continuation of the current policy.

Past Studies

Rademacher (1973) studied the evolution of the landscape of Flicker Ridge; much of his research has been useful to this paper. By comparing aerial photographs of the study site taken in 1935 and 1967, Rademacher found competing species closing in on the knobcone pine community. He noted that knobcone seedlings immediately established themselves in five acres burned in 1970, but manzanita and chamise took advantage of the full sunlight, and by 1973 were shading out the knobcone seedlings. Vogl (1973, 1977; Vogl *et al.*, 1977) studied the knobcones inhabiting the Santa Ana Mountains of Southern California, and has also studied the relationship between fire frequency and site degradation. According to Vogl, site degradation occurs when a vegetation type which has historically inhabited an area is displaced.

Axelrod (1980) is an extensive study of the history of closed-cone pines with information about the origin of the knobcone. He theorized that the thicker scales and fewer seeds per cone of the knobcone (Figure 3), compared to other closed-cone species, are probably adaptations to

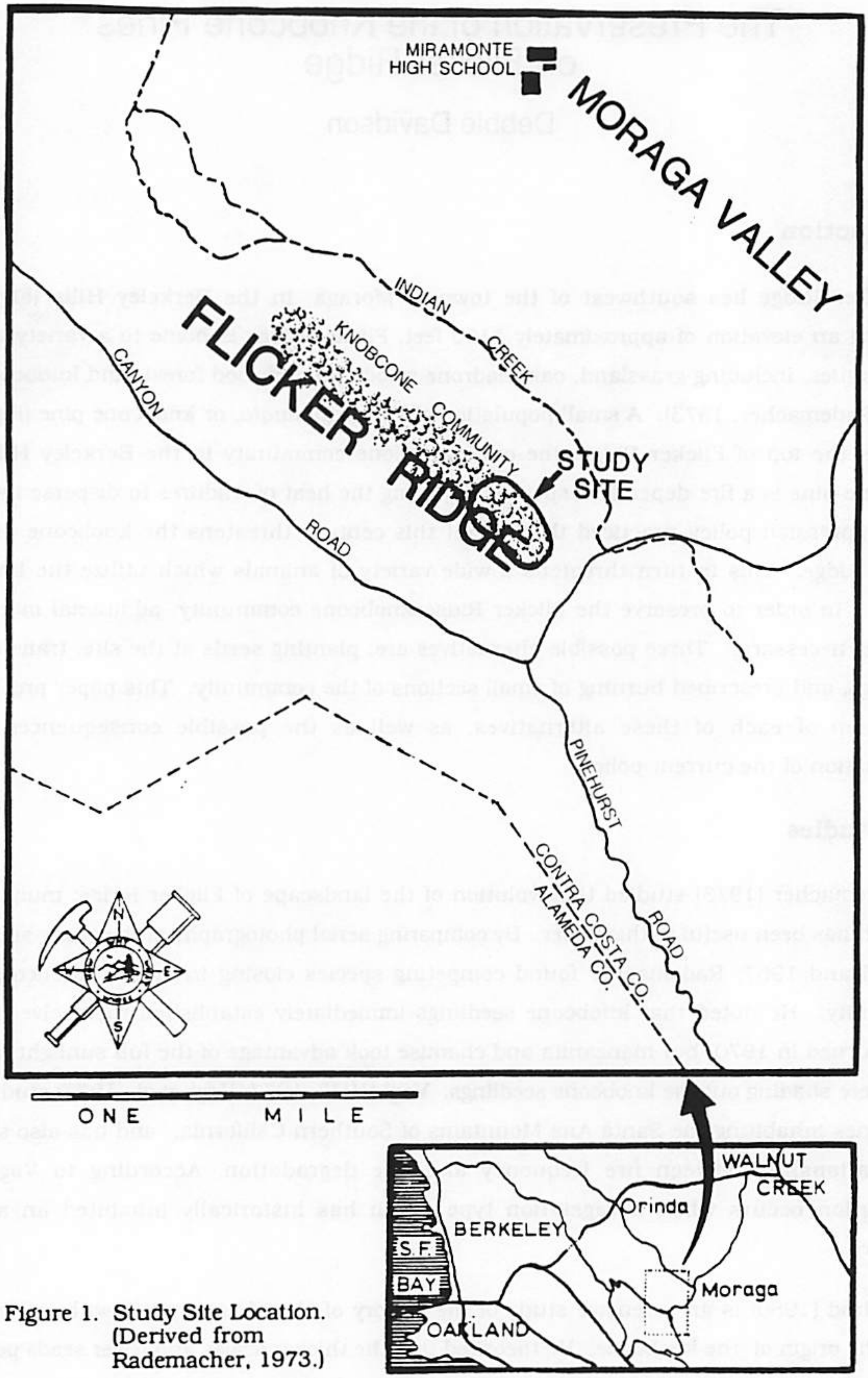

Figure 1. Study Site Location. (Derived from Rademacher, 1973.)

protect the seeds from hot fires and squirrels (the smaller number of seeds per cone are a less efficient harvest for the squirrels). Many studies have been done on prescribed burning, including work by McBride and others (1985) who emphasize the importance of evaluating natural patterns and frequencies of fire intervals before developing a prescribed burn schedule. Johnson (1984) discusses both sides of the prescribed-burn controversy, examining the successes and setbacks of this technique.

Background

Pinus attenuata is one of a group of closed-cone pines which evolved from *Pinus oocarpae* . *Pinus attenuata* originated in Mexico, and migrated northward into California via motion of the San Andreas fault (Axelrod, 1980). *Pinus attenuata* is the most widespread of the closed-cone pine species in California, inhabiting areas along the north and central Coast Ranges and the Sierra Nevada. Knobcone populations are most often found in the transitional zone between lower chaparral and higher coniferous forests. They grow well in shallow, rocky and acidic soils made up of serpentinite or other substrates which contain elements toxic to other species (Vogl *et al.*, 1977). They are not restricted to these areas, but in more hospitable soils competitors such as oak and madrone drive out the knobcones (McBride,1988, pers. comm.). In harsher soils the knobcones confront few competitors. Knobcone pines usually grow in areas which receive low summer rainfall, and thus are prone to wildfires. When these fires are allowed to occur naturally, fuel buildup is prevented. These fires are hot enough to cause the cones to open but not hot enough to damage the seeds. The fire destroys the undergrowth to provide more sunlight for the future seedlings, provides a fertile layer of ash, and temporarily sterilizes the soil of fungi, long enough for the seeds to sprout. After the fire has passed, the heated cones open, releasing small seeds attached to paper-thin wings. Wind currents carry these wings and their cargo away from the parent tree, to fall in the newly burnt soil. Within a few months, new sprouts break the soil surface.

Fire Suppression: Fire suppression has been implemented since 1905, after the passage of the California Fire Suppression Act. Flicker Ridge was mostly private land then, and the fire department established the same year kept fire from invading the area on all but two occasions (McBride, 1988, pers. comm.). East Bay Municipal Utilities District (EBMUD) took control of over 50 percent of the site in 1922, and continued the fire suppression policy. Since 1905, there have been two fires on Flicker Ridge--one in 1952 burned about 12 acres, and another in 1970 burned 5 acres (McBride, 1988, pers. comm.).

Consequences of decreasing the natural frequencies of fires include: increasing fire intensity, fuel build-up, plant decadence, decline in species diversity, decline in plant productivity, and slow recovery after burning (Vogl, 1977). The accumulation of fuel will also increase pH and nutrient content, and reduce soil toxicity (Vogl *et al.*, 1977), all of which invite competitors into knobcone pine territory. This may explain the invasion of oak and madrone into the knobcone pine community on Flicker Ridge. If fire suppression continues without serious efforts to preserve the knobcone, this population has little chance of surviving.

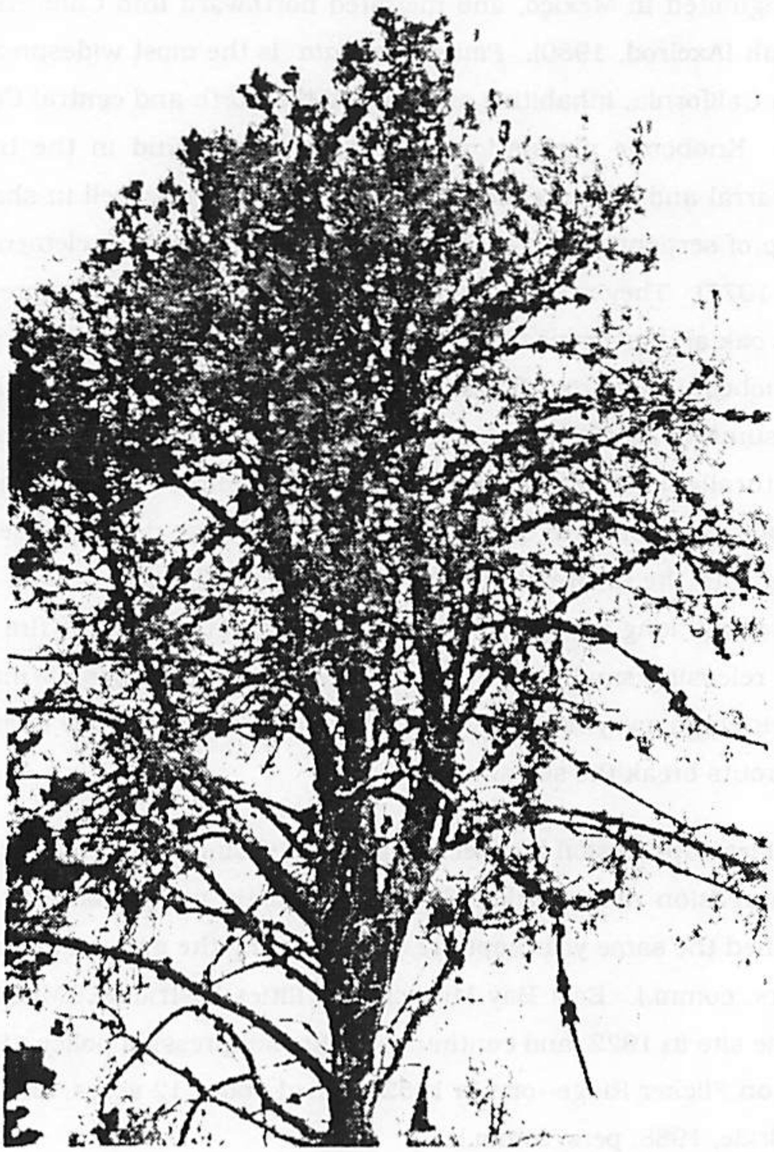

Figure 2. *Pinus attenuata*

Some consequences of fire suppression can already be observed on Flicker Ridge, such as fuel build-up and plant decadence. On the southeast end of Flicker Ridge I have observed a number of dead and decaying knobcone pine trees, adding to the already high amount of dry fuel on the ground.

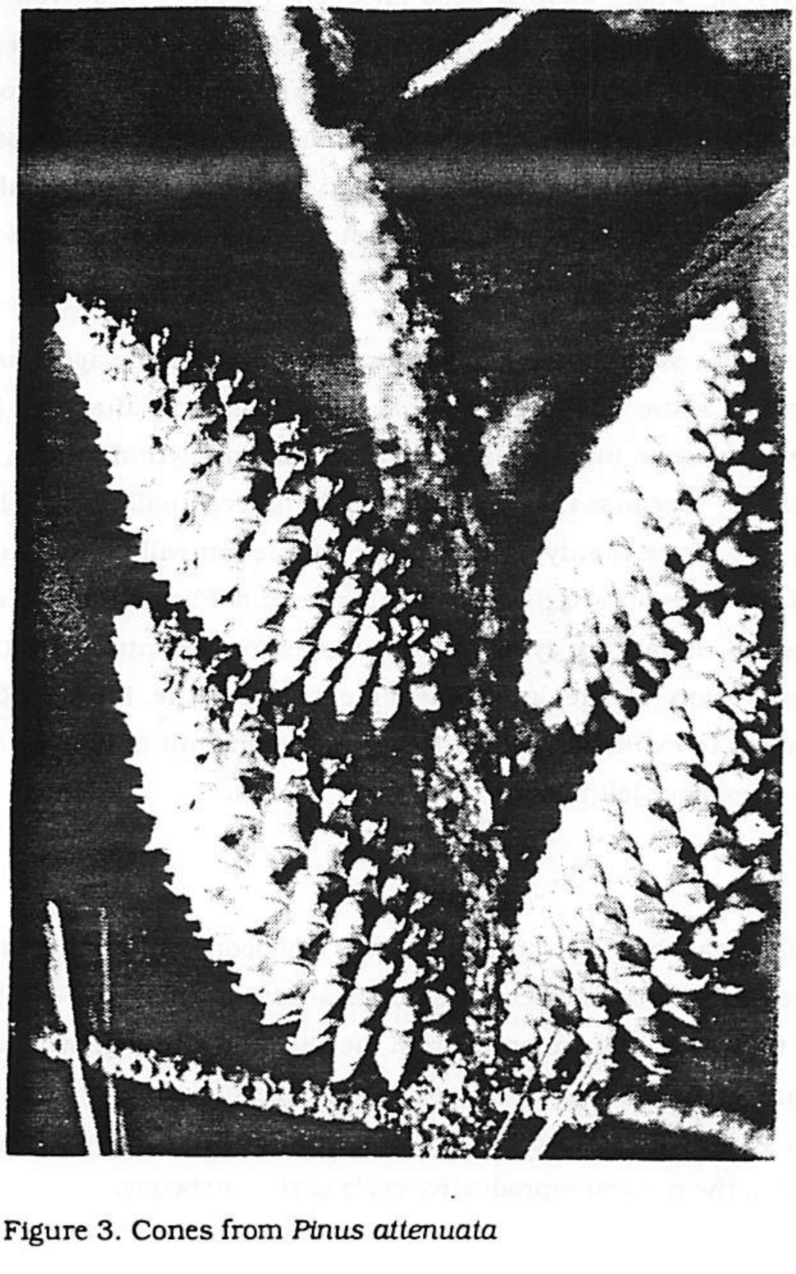

Figure 3. Cones from *Pinus attenuata*

Regeneration at Flicker Ridge: Under better conditions, the seeds released from the dead cones could sprout into new trees replacing the older ones. I noticed two young knobcone trees at the southeast end of the Ridge, growing under a dead tree. One was six inches high, probably two or three years old, and another three feet high, or between eight and ten years old. The latter was being crowded out by a young oak and has little chance of surviving.

The younger seedling is growing on disturbed soil near the footpath. Because of the location of this sprout along the footpath, it should receive more sunlight than its neighbor and has a better chance of survival. Under another dead knobcone I found a third young tree near the footpath. This tree was approximately five feet tall and also has a better than average chance of survival due to its well-lit location. For young sprouts growing in areas off the footpath, most of which is dense with vegetation, chances for survival are small. I did not investigate the northwest section of the Ridge--the privately-owned end--but the physical nature of the unexplored section is similar enough to the southeast end that a comparable scarcity of young knobcones is expected.

Fire-dependent species such as the knobcone pines grow in same age stands--most trees within a stand are the same age--because they all germinated after the last fire. This characteristic makes knobcone pines especially vulnerable to anything which threatens their reproductive capabilities. Because they will all mature and eventually die at the same time, if there are no young to replace the dying trees, this population will be lost and regeneration impossible. Most of the trees observed on the southern end of Flicker Ridge are mature (25-35 years old), and some individuals are dying. If fire suppression is continued without immediate plans for the preservation of the knobcone pine species, the Flicker Ridge knobcone community will be close to extinction within 15 years, the amount of time which the majority of currently mature trees have left to live.

Methodology

A variety of actions can be taken to preserve the knobcone population on Flicker Ridge. This paper evaluates three management possibilities--two of these are supplemented with experimental data. Cones could be removed from the site, and after removing the seeds, these could be nurtured in a greenhouse until the young seedlings are stronger. Seeds could also be replanted on Flicker Ridge. Prescribed burning is a third possible approach and the one that most closely duplicates the natural reproductive cycle of the knobcone.

Alternatives

Alternative 1--Seedling Transplants: Seeds can be manually collected, prepared and allowed to grow into seedlings in a greenhouse or other enclosed area. Only seeds from Flicker Ridge should be used so the genetic character of the community is preserved. (Seedlings which are not from this community may not be well-adapted to the Flicker Ridge environment, and they may combine with the Flicker Ridge community, thus altering its genetic characteristics.) After two or three years of care in a controlled environment, young seedlings can be transplanted onto Flicker Ridge.

On November 5, 1988 I collected 50 cones from Flicker Ridge and placed them on a cookie sheet over a fire in my fireplace. Some cones opened within 25 minutes, after which I removed them to let them cool and open further. By placing the cones in a paper bag and shaking the bag, the winged seeds fell out of the cones. The wings can either be manually separated from the seeds, or the winged seeds can be placed on a large flat surface, such as a cookie sheet. By bouncing the sheet up and down the seeds separate from the wings. I removed the wings manually because it was windy that day. Following a procedure described by Joe McBride, I soaked my collection in cold water for two hours, then drained the water off and placed the seeds in my refrigerator. After 45 days in my refrigerator, the seeds were ready for planting. This procedure speeds up the natural germination process (McBride, 1988, pers. comm.).

On January 25, 1989 I filled 20 pots with moist potting soil and placed approximately 20 seeds in each pot. I set these in an east-facing window in my apartment and watered them once a week or as needed. Five weeks after planting 10 pots contained sprouts (Table 1). These seedlings will be too young to plant on Flicker Ridge during my study.

Alternative 2--Direct Seeding: After seeds are removed as described in Alternative 1, they can be planted at the Flicker Ridge site and left alone to survive with minimal human inputs.

On January 23, I planted seeds at the southwest end of Flicker Ridge. Following a procedure described by Chan, Harris and Leiser (1979) and McBride (1988, pers. comm.), I prepared 20 bottomless containers approximately 6-8 inches deep by removing the bottoms from half-gallon milk cartons and cutting them in half. I placed a wire mesh on top of the container, fastened down with duct tape. This container offers the seeds some protection from predators. Chan, Harris and Leiser suggest digging a hole 4-6 inches deep to hold the container and surrounding this with mulch for one foot to discourage weeds from smothering the seedlings. A local nursery employee advised against using mulch because he doubted its ability to protect the seeds, so I decided to surround only 10 of the 20 containers with a redwood mulch to see if the results would differ (Figures 4-7).

Two weeks after planting, on February 5, I found two of the 20 containers overturned, possibly by a curious animal. Most references estimate a five week interim before sprouts can be seen, so I did not expect to see any sprouts at this time. Three weeks later, on February 25, I found four more containers overturned, leaving a total of six containers surrounded with mulch and eight containers without mulch still intact. Of the remaining containers, two had mold growing over the ground surface within the container. There were no sprouts at this time (Table 1).

	Site seeds with Mulch	Site seeds no Mulch	Indoor seeds
Total Sprouts	0	0	10
Overturned	4	2	0
Mold Growth	1	1	0
Unsprouted	5	7	10
Total	10	10	20

Table 1. Seed Germination and Disturbance

Alternative 3--Prescribed Burning: Harold Weaver and Harold Biswell introduced the idea of managing ecosystems with fire in the early 1950's (McBride *et al.*, 1985). Prescribed burning is often used to limit fuel build-up, but this technology may also be used to preserve a fire-dependent ecosystem. Unlike Alternatives 1 and 2, periodic burning of small sections of the Flicker Ridge knobcone population, perhaps five-acre parcels, could sufficiently sterilize the soil, recycle nutrients, release the seeds, inhibit competitors, and provide adequate sunlight for young seedlings to grow (McBride, 1988, pers. comm.).

Fire history data of the area indicate a fire frequency of 25-35 years (McBride *et al.*, 1985). Because the average life span of the knobcone pine is 35-50 years (Vogl *et al.*, 1977), intervals longer than 35 years between fires in each area would not be beneficial to the species. If each five-acre parcel could be burned every 25-30 years, the knobcones could maintain a healthy population.

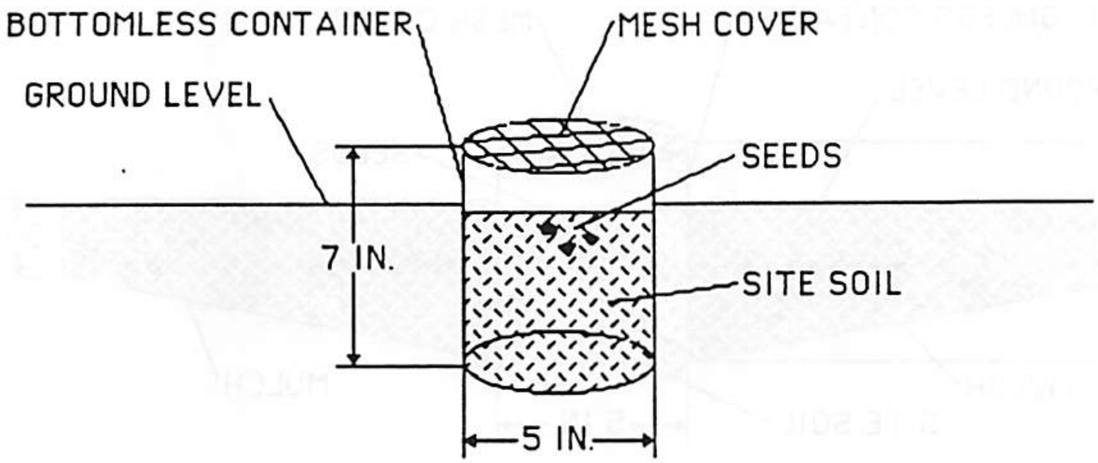

Figure 4. Cross-Section of Planting Without Mulch

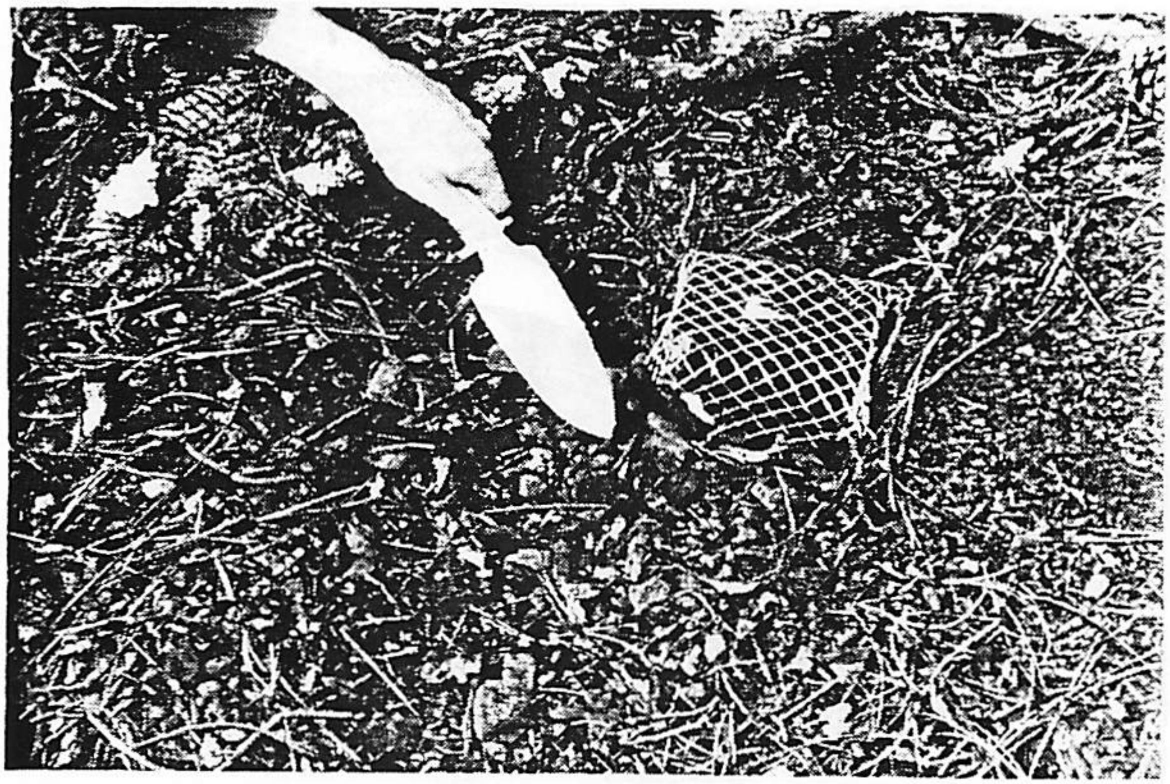

Figure 5. Planting Without Mulch

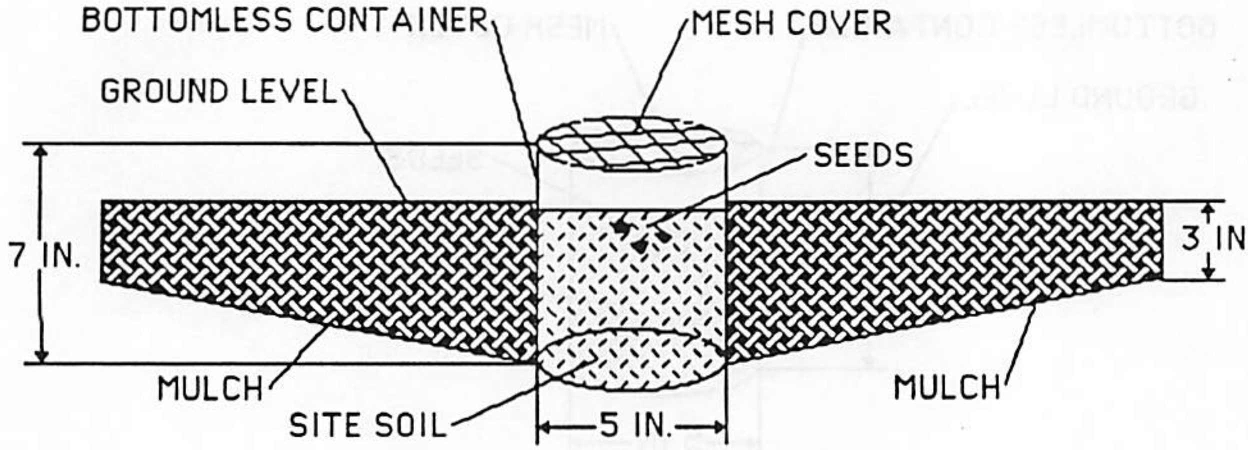

Figure 6. Cross-Section of Planting With Mulch

Figure 7. Planting With Mulch

Fuel accumulation makes this area especially prone to wildfires, and although there are not many buildings nearby, the proximity of Moraga should be considered. The Moraga Fire Marshall expressed concern about the high fuel conditions in this area. Should a prescribed burn program be instigated, the Moraga Fire department should be closely involved with the burning. The San Pablo Fire Marshall suggested that the potential for accidents could be diminished by keeping only small parcels of less than one acre aflame at one time.

Most natural fires occur in the late summer or early fall. The knobcone has adapted to this time schedule, and natural reproduction usually begins at this time (Parker, 1989, pers. comm.). Burning a few days after the first autumn rains would allow the living vegetation to absorb some moisture to keep the temperature of the fire down and minimize the chances of a runaway fire. Waiting a few days would give the ground cover enough time to dry so ignition would not be a problem (Rice, 1989, pers. comm.; Parker, 1989, pers. comm.).

Biswell (1977) recommends not burning areas with a steep slope and avoiding burning on windy days. Wind increases the height of the flames, increasing the temperature, and causes the flames to travel, all of which make the fire more difficult to control. Most of the Flicker Ridge knobcone population inhabits the top of the Ridge, so prescribed burns on steep slopes would not be necessary. Biswell suggests a maximum of 15 acres per day for prescribed burning in heavy fuel conditions, so five-acre parcels should be small enough to control.

The parcel size chosen is also small enough so that if the first five acres burned do not bring the desired results, the entire community is not lost. By using a planimeter on an old vegetation map of Flicker Ridge, prepared in 1964-5, I found the community to be inhabiting approximately 54 acres. Because this map is about 25 years old, a small percentage of these 54 acres have probably been successfully invaded by competing species. A burn of five acres would risk less than 10 percent of this community. After the first five-acre parcel is burned, a five year evaluation period before the next burn should be enough time to monitor the area and decide whether this is an effective action for the survival of the knobcones.

Discussion

Alternative 1--Transplanted Seedlings: Although a sprout rate of 50 percent under indoor conditions is encouraging, the real trial will come after the seedlings are transplanted. The seedlings should be strong enough to overcome the soil fungi, but they probably will not be able to compete for sunlight and nutrients with all of the oak, madrone and chamise invading the site. To maximize the survival rate of these transplanted seedlings, areas on Flicker Ridge could be cleared. This would be labor intensive--areas would have to be manually cleared of existing vegetation and there is no access for heavy equipment--and economically unfeasible. This procedure is also ecologically questionable because healthy vegetation would be destroyed with no promise that the knobcone seedlings would have a high survival rate.

Care of the seedlings would involve many hours of labor, with a low survival rate. The cost of this care could be minimized if students at the University of California at Berkeley and other local universities could volunteer for this work.

Alternative 2--Direct Seeding: Although my results of 0 percent sprout rate for seeds planted directly at the site could be due to experimental errors, additional attempts at this method would probably not show promising results. While the containers offered some protection from small predators, they did not inhibit animals large enough to overturn them.

Unlike the transplanted seedlings of Alternative 1, seeds planted at the site must combat the local soil fungi, which proliferates during long periods of fire suppression. The fungi feeds on the contents of the seeds, leaving a lifeless hull.

The mold growing within two of the containers may have been caused by the containers themselves. The containers might be far enough above the ground to shade out the corners, making it harder for rainwater to evaporate and causing mold to grow.

The mulch recommended by Chan, Harris and Leiser was not useful; I did not find any weeds growing near any of the containers, with or without mulch. The redwood mulch I used may actually attract curious animals, since four of the containers surrounded by mulch were overturned, whereas only two of the containers without mulch were overturned. The mulch was an added expense in money and labor with no benefit.

Any survivors of this experiment would compete for sunlight and nutrients with other stronger species. I planted my seeds along the side of the footpath where there are fewer competing plants, but there is only room for approximately 100 plantings in this area. Even in the unlikely event of a 100 percent survival rate, 100 trees would not be enough to ease the threat to the knobcone community. The best way to maximize the results of this alternative would be to clear parcels of land, an action already described as unfeasible.

Alternative 3--Prescribed Burning: By burning five-acre parcels at intervals of 25-30 years, the knobcone community would be exposed to an environment which most closely duplicates the natural conditions in which they thrive. This action would probably have to be contracted out to a prescribed burn specialist or supervised by the Moraga Fire Department.

Carol Rice, a prescribed burning specialist (1989, pers. comm.), estimates the cost of each burn to be approximately $1,000. The cost could be partially funded by the California state government. The California Department of Forestry oversees the Vegetation Management Program, a program instigated in an effort to control chaparral habitats, primarily to limit fuel build-up. Sites eligible to receive management funding under this program must be covered by at least 50 percent chaparral and the need to reduce fuel must exist (Orrick, 1989, pers. comm.). Much of the 54 acres of knobcones do not fit into this category because only small sections of the Ridge are covered by 50 percent chaparral. However the first burn could be performed in one of the areas which contains 50 percent chaparral, and the need to reduce existing levels of fuel would not be difficult to support. If the Department of Forestry agrees to fund this project under the Vegetation Management Plan, the State will pay for up to 90 percent of the cost of the burn (Orrick, pers. comm., 1989), reducing the burden on EBMUD to approximately $200 for each burn.

EBMUD is only responsible for approximately half of the knobcone community. The private owners of the rest of Flicker Ridge might be encouraged to split the cost of prescribed burning with EBMUD because this action would reduce fuel build-up and thus reduce the chances of a wildfire on their land. The project would be spread out over a number of years, so large sums of money would not be required at one time. EBMUD would have enough time to plan their budget and raise funds for this project.

Even though prescribed burning is the most effective method for managing knobcone communities, positive results are not guaranteed. Two possible consequences of a prescribed burn may have a negative impact on the knobcone community. A newly burned parcel of land is temporarily fertilized by nutrients in the ash. These nutrients will attract all local species, not just the knobcone (Parker, 1989, pers. comm.). Competing species could take over the site before the knobcone seedlings are established. The site could be periodically weeded, but this would involve additional labor costs unless a student volunteer could be encouraged to monitor the site. New vegetation growth will also attract animals which will eat much of the new growth and seeds (Parker, 1989, pers. comm.). A temporary fence around the burned area, possibly 2-3 feet high could limit the number of predators, but this method would not inhibit the predators who find their way under the fence and into the burned area.

Conclusions/Recommendations

The first two alternatives discussed are labor intensive and are not expected to show encouraging results--the small number of surviving trees from either of these alternatives would not be worth the time and money invested in them. Prescribed burning offers the best solution because it allows the knobcone reproductive system to follow its natural course with minimal dependency on human inputs.

Without the pressure of deadlines and with careful planning, a prescribed burn program could be implemented safely at Flicker Ridge, further promoting prescribed burning as an effective management tool and offering the Berkeley Hills knobcone population a means of survival.

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