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Erosion Control Effectiveness of Vegetative Practices After the 1993 Southern California Wildfires

The attached publication "Erosion Control Effectiveness of Vegetative practices After the 1993 Southern California Wildfires" provides information on the effectiveness of USDA – NRCS Technical Guide practices for the treatment of burned areas in Southern California.

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United States Department of Agriculture
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EROSION CONTROL EFFECTIVENESS OF VEGETATIVE PRACTICES AFTER THE 1993 SOUTHERN CALIFORNIA WILDFIRES

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ABSTRACT

A team of USDA - Natural Resource Conservation Service specialists evaluated study sites at the Topanga and Laguna burn areas for erosion control effectiveness of vegetative practices after the 1993 southern California wildfires. The USDA - NRCS Emergency Watershed Protection Program was used to install the vegetative practices. The fire impacts on the geology and soils of the study sites were analyzed. Team observations indicated that hydroseeding was effective in controlling erosion and aerial seeding was not effective.

INTRODUCTION

The USDA - NRCS Emergency Watershed Protection Program (EWP) is for relieving the imminent threat to lives and property as a result of watersheds damaged by natural occurrences. This includes floods, fires, drought, windstorms, volcanic actions, and earthquakes.

The purpose of this study was to evaluate and document the effectiveness of USDA - NRCS Technical Guide practices for the treatment of burned areas in Southern California.

A team of specialists with expertise in geology, plant materials and soil science evaluated twenty study sites covering examples of practices installed at the Topanga and Laguna burn areas. Aerial seeding, virgin wood mulch hydroseeding, recycle-paper mulch hydroseeding and bonded fiber matrix hydroseeding vegetative practices were evaluated for erosion control effectiveness and observed plant response.

GEOLOGY

I. Methods

Study plots were established at 20 sites in the Laguna Beach, Old Topanga, and Kinneloa burn areas in January 1994, approximately two months after the fires (Figures 1 through 6, Appendix B). Study sites were chosen based on access, the type of measure installed, and aspect, and included:

* Seven control sites where no seeding or mulching was done (3 at Laguna, 3 at Topanga, 1 at Kinneloa);
* Four aerially-seeded sites on south-facing slopes (2 each at Laguna and Topanga);
* Two aerially-seeded sites on north-facing slopes (1 each at Laguna and Topanga);
* Five hydroseeded sites using different mulches (1 conventional + 1 bonded fiber matrix at Laguna; 1 recycled fiber + 1 conventional at Topanga; 1 conventional at Kinneloa);
* Two straw bale catchment sites (1 each Topanga and Kinneloa).

The geology, geomorphology, cover, and erosion conditions of each site were generally described and compared to observations made in April, 1994. Small (12- and 20-feet long; drainage areas a fraction of an acre) debris fences were installed at two sites in the Laguna area to help quantify sedimentation.

To assess spatial and temporal variations in the post-fire erosion hazards at the sites, field observations and data were supplemented wi published descriptions of local and regional geology, slope stability, and erosion and sediment processes; newspaper reports of debris flow activity; regional fire histories; and daily rainfall totals.

Landslide and dry ravel hazards for each study site were qualitatively evaluated based on observations and published information (e.g. Tan and Edgington, 1976; Morton et. al, 1976; Ryan, 1992). Each site was rated for each of these hazards on a scale of 1 (low) to 6 (high). Landslide hazard ratings reflect site conditions in both burned and unburned states, while dry ravel hazard ratings are assumed to reflect conditions in the weeks and months following the fires. For example, T6 is assigned a landslide hazard rating of 6 because it is located on the toe of a landslide which could become active under the right conditions, but has been assigned a low dry ravel rating because of the site's relatively gentle slope, it's position on the landscape, and because dry ravel was not evident during the site visit.

The Universal Soil Loss Equation (USLE) should not be applied directly to evaluate sediment production potential from steep, undeveloped, burned chaparral areas in southern California. USLE was not used by the SCS/NRCS emergency teams for any phase of the emergency response. USLE does, however, provide a systematic means of documenting conditions at a specific site that combine to create a low or high sheet and rill erosion potential - namely, steepness, slope length, rainfall, erodibility (texture of the soil), and cover. Hydrophobicity as a contributing factor must be considered separately. The EWP follow-up team used USLE factors to help compare the different sites' susceptibility to sheet and rill erosion and track the changes in the magnitude of the hazard through time as the slopes begin to recover. In the geology section results are reported without a numeric values, emphasizing the point that the numbers in their absolute sense are not applicable to this situation.

In addition, predicted or 'design' post-fire sediment yield rates for the watersheds where study sites were located are reported and compared to field observations. Depending on data availability and the fact that different teams worked on different fires, SCS/NRCS engineers and resource specialists used different assumptions and models to help evaluate the sediment hazard for planning and design of alternative measures [For this reason, reported sediment yield results can only very generally be compared between the fire areas]. For the Topanga fire area, the SCS EWP team used an empirical formula derived by Scott and Williams (1978) for estimating sediment yield in the Western Transverse Ranges. Los Angeles County provided SCS engineers estimates of debris production by a 50-year storm for debris basin areas burned by the Kinneloa fire. Erosion and sedimentation data were not readily available for watersheds burned by the Laguna Beach fire area; SCS engineers and resource specialists assumed a sediment yield associated with a 10-year storm of 150 cubic yards per acre.

Figures 1 through 3 in Appendix B depict the chronologies of the study plots in the three fire areas and document dates of project installation, site visits and photographs, and rainfall data.

II. Results

Geology of the Study Sites: All study sites in the Laguna Beach area are underlain by Tertiary sandstones and siltstones (Table 1, Appendix B). While the San Andreas, San Jacinto, Elsinore-Whittier, and Newport-Inglewood Faults pose seismic hazards in the region, neither the Laguna Canyon nor the Temple Hills Faults (which pass close to the study sites) are considered active. One site (L5) is located on or near a landslide in the Vaqueros Formation, which has been described as particularly prone to landslides (Tan and Edgington, 1976).

Located near the south-central margin of the Santa Monica Mountains, the Topanga/Malibu fire area is structurally very complex and geomorphically young and active (Table 2, Appendix B). The east-west trending Malibu Coastal fault zone and detachment thrust faulting have created chaotic structures, seemingly randomly oriented fractures and shears, and deep weathering of bedrock material (Robertson, 1992). The slopes in the burned area are largely underlain by well-bedded to massive sandstone with lesser amounts of conglomerate, siltstone, mudstone, basalt and basalt breccia, andesite, and minor amounts of shale (Treiman, 1993). Most of the study sites in the Topanga area are underlain by sedimentary formations that dip generally towards the north. One site (T3) is underlain by fill material from a house pad that overlies volcanic deposits. One site (T6) is located on the toe of a landslide deposit.

The Kinneloa fire area is located on the southern flank of the San Gabriel Mountains, which are extremely rugged and tectonically and geomorphically active (Table 2, Appendix B). Almost the entire burn area consists of a complex of igneous and metamorphic rocks and lies within and above the Sierra Madre fault system (Barrows and Spittler, 1993). These geologic and geomorphic conditions are responsible for the region's reputation as a natural laboratory for debris production and flows. Los Angeles County has responded by installing more than 100 large debris basins along the San Gabriel Mountain front - equivalent to an average of one every 700 yards (McPhee, 1989).

Sediment production, and debris flow activity in southern California: The "fire-flood sequence" of sediment production and debris flows in southern California has been extensively researched and described in the literature. In the weeks and months following a fire, the rate of dry ravel (the dry, unconsolidated down-slope flow of particles on steep slopes) dramatically increases, leaving cone-shaped deposits along road cuts, at the base of steep hill-slopes, and in stream channels. With the advent of the rainy season, rates of surface runoff, sheeting, and rilling increase over non-burn years where the fire has destroyed the vegetative cover and created and/or intensified hydrophobic (water-repellent) layers in the soil. Debris flows occur when increased streamflows mobilize sediment stored in the channel from past years as well as from the increased post-fire erosion and delivery (Figure 10, Appendix B).

Post-fire debris flows are most common in small watersheds, where they do not require a particularly long period of antecedent rainfall. They occur during the earliest post-fire storms and tend to diminish in frequency as the rainy season progresses (Wells, 1987). Post-fire debris flows from large watersheds occur only during heavier storms and usually require a period of antecedent precipitation. The size and behavior of these very large and often disastrous flows result from the size and geometry of the watershed (Wells, 1987).

The following is taken from a study by Wells (1984 in Wells, 1986) of erosion and sedimentation processes in the San Gabriel Mountains:

* "...70 to 85 percent of the sediment production in certain areas was found to be associated with fire." [Results of other studies by Wells suggest that dry ravel and the formation of extensive rill networks are the principal sources of increased production.]
* "During (the) 21-year period (of study), the mean denudation rate, inferred from measurements of sediment deposited in debris basins at canyon mouths, was 4 mm per year (equivalent to 21 cubic yards per acre). In the post-fire periods, the rate was 11 mm per year (58 cubic yards per acre); and during the intervening non-fire years, 1.4 mm per year (7.4 cubic yards per acre)..."

Results of Wells' research are most comparable to the Kinneloa fire area and reflect erosion and sedimentation conditions unique to the San Gabriel Mountains, whose steep slopes and fractured granitics and metamorphics are particularly prone to dry ravel (Krammes, 1965). By comparison, the Santa Monica Mountains and the San Joaquin Hills above Laguna Beach probably receive a proportionally higher share of their total yield from sheet and rill erosion and deep-seated landslides (distinguished from surficial slope failures such as micro-debris flows),

Ancient and active landslides are common landforms in the mountains above Malibu and are/were triggered by increased pore pressures associated with increased subsurface moisture (rainfall, leaking water lines, private sewage disposal systems, landscape irrigation), loss of lateral support (sea level drop, coastal erosion, streambank erosion), weathering, the relative orientation of geologic discontinuities and slope (Robertson, 1992), and earthquakes. Landslides are also common near Laguna Beach, particularly on north- and east-facing slopes (Tan and Edgington, 1976). The impact of wildfires on deep-seated landslide activity is not clear but is assumed to be less significant when compared to wildfire's impacts on dry ravel production and rilling.

Post-fire sediment yield from all sources for a given frequency storm depends in part on the recent fire and flood history of the watershed and volume of sediment stored in the channel. Assuming approximately equivalent volumes of pre-fire sediment storage, post-fire sediment yield from all sources from a given frequency storm would be expected to be higher for the San Gabriels and the Kinneloa fire area.

The volume of material that is actually transported as debris flows also depends, at least in part, on climatic factors such as antecedent moisture, and intensity and duration of rainfall events. Heavy rainfall such as what occurred in 1978 and 1980 may trigger debris flows even in unburned watersheds, although Wells (1982) argues that

> "Fires play a more important role in sediment production than do even the most severe storms. Sediment production from freshly burned catchments during relatively minor storms frequently exceeds that from the most severe storms. The worst sedimentation events occur, of course, when a severe storm strikes a recently burned watershed..."

<u>Rainfall and debris flows during the winter of 1993-94</u>: Fortunately for southern California, the winter of 1993-94 was relatively dry, with November through March totals running roughly 60 to 85 percent of average. Table 1-B summarizes rainfall data for the three fire areas:

Table 1-B.

Rainfall Data from Stations Near the Study Sites, 1993-94

	Laguna Beach Station CA4647	Topanga Ranger Station CA8967	Altadena Station CA0144
Average Annual Rainfall (in)	12.44	24.00	20.77
Avg. Rainfall Nov. thru Mar. (in)	10.31	21.17	17.28
Total Rainfall 1993 Water Year (in)	22.88 (184% of avg)	48.6 (203% of avg)	40.89 (197% of avg)
Total Rainfall Nov. 1993 thru Mar. 1994 (in)	8.66 (84% of avg)	14.58 1/ (69% of avg)	10.96 (63% of avg)

Rainfall totals for the 1993 water year indicate that the burned areas received roughly twice their average rainfall the year before the fire, including unusually high storm activity in June. The wet year prior to the fire may have reduced sediment storage at least locally in some of the watersheds, thereby reducing the post-fire debris hazard (this speculation is made without the benefit of detailed hydrologic information or an evaluation of 1992-93 debris flow activity).

Despite Mother nature's reprieve, residents of the Laguna, Topanga, and Kinneloa fire areas did not pass through the winter unscathed; storms and ensuing debris flows occurred on November 11, January 27, February 7, 17, and 20, and March 7. One-quarter to one-half inches of rain fell in one hour at Laguna Beach in January, triggering debris flows that deposited six to 18 inches of mud onto and temporarily closing six miles of Laguna Canyon Highway. Tables 3 through 5 in Appendix B is a partial summary of debris flow activity as excerpted from newspaper and in-house reports.

Erosion and Sedimentation at the Study Sites: Table 6 in Appendix B summarizes observations pertaining to the geology and erosion hazards at the seeded and control study plots. Observations regarding the straw bale sites are discussed separately. A cursory evaluation of Table 6 in Appendix B suggests the following:

1/ Data was not available from the Topanga Ranger Station in January or February 1994; data from the Old Topanga Canyon Station were used without adjustment to approximate totals for these two months.

Predicted Potential Erosion Hazards Following the Fires

1. Sheet and rill erosion at four of the Laguna Beach sites (L2, L3, L8 L7) contribute a relatively significant portion of the total sediment production potential; these sites are on relatively gentle slopes (25 to 40 percent) where the landslide hazards do not appear to be great. Loss of cover by wildfire at these sites increased potential sheet and rill erosion roughly 10 to 30 times over prefire conditions.

2. Sheet and rill erosion at the Topanga study sites contribute a smaller fraction of the total sediment production potential than sheet and rill erosion at Laguna Beach. The landscape around the Topanga study sites is geomorphically less mature/more active and is hence steeper and more prone to landslides and dry ravel. Loss of cover by wildfire increased potential sheet and rill erosion at the Topanga study sites as much as 50 times, although the increase in the dry ravel hazard and/or the existing landslide hazard may be proportionally greater. Sheet and rill erosion at two of the sites (T1, T7) may contribute a moderately significant portion of the total sediment production potential locally.

3. Rilling appears to have contributed a significant portion of the total sediment production at Kinneloa. Evaluation of the study sites is complicated, however, by the fact that the process of rilling is so intricately tied to dry ravel and debris flow production - in our limited observations, most of the rills were actually micro-debris flows through dry ravel deposits. Total sediment production potential at study sites at Kinneloa are therefore considered to be overwhelmingly dominated by dry ravel processes.

Actual Erosion as Observed Following the Fire.

4. Sheet erosion and minor rilling were the dominant erosion processes on most study plots at Laguna and Topanga as observed in April. This may vary from regional assessments because of specific sites and locations. Estimated volumes of sediment collected by silt fences set up at plots L7 and L8 at Laguna Beach suggest equivalent erosion rates on the order of 1 ton per acre over a period of three months.

5. Dry ravel dominated at the Kinneloa sites, with the apparent bulk of the sediment production having occurred before our first visit in January.

6. Dry ravel cones were observed in the Topanga and Laguna Beach burn areas but were mostly confined to bases of steep road cuts, hill-slopes, and stream channels, where study plots were impracticable. Small debris cones were observed at T8, where they crossed one corner of the 100 m2 plot where it encroached on a slope break formed by a sandstone outcrop, and at T4, which was located in a steep swale veneered with dry ravel deposits. In both cases, the bulk of the dry ravel had occurred by January, with approximately

two inches of debris added to the cones at T8 between January and April.

7. Vegetation (mostly mustard) was found in profusion at the base of the debris cones at T8 and the Kinneloa sites. Increased moisture availability appeared to be the primary cause. Delivery of ravel accumulations to the first-order channel down slope of T8 was limited by the band of vegetation, effectively reducing the slope's contribution to total sediment yield to higher order channels and the mouth of the watershed. The filtering effect of vegetation was apparent at Kinneloa as well, although the trapped debris lay at the edge of a steep first-order drainage and would likely be remobbilized during a future event.

8. While landslide activity was not observed at or near any of the study sites, it is likely that landslides and rockfalls did occur locally. Landslides occurred as a result of the January 17 Northridge earthquake, and perhaps along stream channels where increased flows may have undermined the toes of unstable slopes. Note that it was a relatively dry year following the fires; the threshold of storm intensity and/or duration above which slope failures occur throughout the region appears to have not been reached that season.

9. In his assessment of potential erodibility of the Laguna Beach fire area, using Adjustment Transposition Factors defined in Gatwood et al (1992), Tan (1994) concluded that "erosion rates...decreased about 30% within the 8-month period following the (Laguna Beach) fire of October 27, 1993." The results reported by Wayne Sheldon in table 3-C are comparable.

Observed Impacts of EWP Cost-Shared Measures on Sediment Production Rates:

10. The February 7 storm provided the major test of structural measures installed at Topanga and Kinneloa.

    * Timber and rail structures, debris racks, and risers placed in a drainage near Pepperdine University prevented mud from flowing into dormitories.
    * Approximately 30 to 40 inches of debris and sediment were trapped behind debris racks and steel pipe risers in Big Rock Canyon, reducing the volume of material that reached Pacific Coast Highway and Santa Monica Bay.
    * K-rails installed in Las Flores Mesa were overtopped and partially failed.
    * By trapping and diverting debris and sediment, debris barriers and debris racks at Kinneloa's Pasadena Glen area effectively reduced damages.

11. At Laguna Beach, debris flows generated by storms filled, at leas once, rock and wire gabion checks installed in the channel drainin the watershed where study site L6 is located. Chain-link fences

installed by someone else across the same channel were damaged or destroyed by debris flows.

12. Unlike structural measures, which are installed to reduce sediment yield by reducing delivery, seeding and mulching attempt to reduce sediment yield by reducing erosion rates at the source. Unfortunately, their relative effectiveness is more difficult to assess, and the impacts of vegetative measures on long-term sediment production rates and the ecology of the region is the subject of current debate.

13. Observations suggest that hydromulch provided protection from sheet and rill erosion immediately on application. The degree to which the mulches were intact and offering erosion protection when we observed the sites in April varied; mulch at T3 (which was apparently applied with a solids content below specifications), had significantly degraded and was failing as platy fragments up to one foot or so in diameter. Sheet and rill erosion at T1 had 'sliced' through the mulch and was attacking the underlying soil, although protection was still afforded areas where the mulch was intact. At the other end of the spectrum, the bonded fiber matrix applied at L2 was only slightly degraded, with an essentially intact mat up to 1/4" thick.

14. Evidence of sheet erosion was observed at all aerially seeded and control sites. The degree of sheet erosion observed in April did not appear to be directly correlated to either percent cover or to whether sites were or were not seeded.

15. Slight to moderate post-fire rilling had occurred at most of the sites to varying degrees. Where good cover was established by April (as at T5), rills were present but obscured, and the potential rill erosion rate declined between January and April as growing vegetation offered increasing protection. Rilling was most apparent on some of the plots where cover was poor and where flow was concentrated as it was forced around cobbles and boulders at rocky sites such as at T8. However, the degree of rilling observed in April did not appear to be directly correlated to either percent cover or to whether sites were or were not seeded.

15. Average percent reduction of potential sheet and rill erosion at the study sites 5.5 months post-fire, over cover conditions immediately following the fire, are estimated using USLE:

	Laguna Beach Sites	Topanga Sites	All Sites
All sites	61% (n=5)	85% (n=4)	72% (n=9)
Seeded sites	83% (n=3)	88% (n=2)	85% (n=5)
Control sites	29% (n=2)	83% (n=2)	56% (n=4)
North slopes	52% (n=2)	82% (n=2)	67% (n=4)
South slopes	68% (n=3)	88% (n=2)	76% (n=5)

The low percent reduction reported for control sites compared to seeded sites (56 vs. 85 percent) is explained by the poor vegetative recovery at the Laguna control sites, L7 and L8, which may have b... due to drier conditions inland or to some other factor.

17. The percentage of cover observed in April, from species included in the aerial seed mixes at the Topanga and Laguna Beach aerially seeded sites (n=6) ranged from 0 to 44 percent and averaged 16 percent. From this, it is speculated that aerial seeding accounted for between 0 and 15 percent of the total cover and therefore accounts for 0 to 15 percent of the 85 percent reduction in the potential sheet and rill erosion hazard over cover conditions immediately after the fire, for a maximum potential reduction in sheet and rill erosion over post-fire conditions of 13 percent.

where sheet and rill erosion contributes a relatively minor portion of the total sediment yield hazard from all sources (i.e. where dry ravel and/or landslides are prominent), the effects of aerial seeding on the sediment yield/debris flow hazard were in this case insignificant.

18. Based on this preliminary evaluation, it is concluded that aerial seeding was not effective in reducing the hazards associated with post-fire sediment production and yield. In the future, when wildfires occur, the feasibility and potential effectiveness of aerial seeding should be questioned, particularly for those watersheds where landslides and or dry ravel dominate over sheet and rill erosion as the processes that contributes to the post-fire sediment yield.

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SOILS

A. Methods

1. Soils - Appendix C-1 shows the soils as mapped at each evaluation site. Three different soil surveys were involved. For the Topanga sites the 1967 Soils of the Malibu Area, CA was used (9). For the Laguna Beach sites the 1978 Soil Survey of Orange County and western part of Riverside County, CA was used (12). The only soil survey available for the Kinneloa sites was a 1917 Soil Survey of the Pasadena Area, CA (5). On-site soils data was determined to evaluate the soil factors for the Universal Soil Loss Equation (see below). The on-site determination did not always agree with the soils as mapped. Sometimes surface textures were slightly different or soil depths were slightly different. These differences are recognized as soil inclusions in the map units. Most of the map units are steep upland types where it is common to find numerous inclusions.

   The normal range in pH values of the surface soil is given for most of the soils. One of the soil properties that was evaluated was the pH of the surface 1/4 inch which contained the wood-ash following the fire. Ulery et.al. has reported very high pH values in wood-ash and surface soil following a fire (8). He reports that compounds causing the high pH are soluble and tend to be lost after going through a wet season. One compound persisted for 3 years and maintained the pH above the normal pH.

2. The Universal Soil Loss Equation - One question that arises following a fire is whether or not sheet erosion is going to be a problem when the winter rains come. One approach to determine potential erosion is application of the Universal Soil Loss Equation (USLE) (13). The general equation is:

$$A = R * K * LS * C * P$$

where

A	Computed soil loss per acre per year
R	Rainfall and runoff factor
K	Soil erodibility factor
LS	Topographic factor derived from the slope gradient and slope length
C	Cover and management factor
P	Support practice factor

The USLE method was developed to predict annual soil loss from sheet and rill erosion for agriculture conditions. This usually means some kind of tillage condition. This tillage condition is considered when applying the C factor. The equation does not account for deposition and does not predict sediment yield. The soil loss predicted is for the soil moved off a particular slope segment. It does not predict erosion where overland flow is the dominant erosive process. It is useful for a long-term average soil loss from a typical uniform slope. The values obtained from this equation should be looked at as best available estimates rather than as absolute numbers. When applied to a specific site, as in our plots, and where local information is obtained it seems to be a valid use of the equation. It was used to evaluate each site and follow conditions over time or establish trends.

Immediately after the fire the C factor is eliminated except for the below gro root network. When this is considered a C factor of about 0.45 could be used. This would roughly reduce the A value by about one half. A C value of 1 was used in the calculations. (See Appendix C-2)

There were no practices present. Thus the equation A=RKLS would give an estimate of the potential for sheet and rill erosion to occur. Once vegetation started to come back an adjustment for the C factor would need to be made.

On-site soils information needed to determine the K value was obtained. This included such things as surface soil texture (sand, silt, and clay percentages), estimated organic matter content, soil structure, rock fragment content, type and amount of roots, soil depth, and kind of parent material. Length of slope and percent slope was measured so the LS factor could be determined. R values were determined using the standard NRCS method using the 2 year-6 hour storm data. With this information the A value can be calculated.

The erosion index is determined by the equation

$$EI = A/T$$

where A Computed soil loss per acre per year
T Soil loss tolerance or permissible soil loss

The T values were determined from the above soil information. The T value is the maximum rate of soil erosion (from rainfall or wind) that will permit a high level of crop productivity to be sustained economically and indefinitely. The area burned by the fires is not used to grow crops, mainly because of the steep slope, but the erosion index values can be used comparatively to evaluate erosion rates (13). This only addresses the erosion by sheet and rill erosion. It does not address erosion from dry ravel (surface movement by gravity), landslides, gully or soil creep (6).

3. Soil hydrophobicity - Soils that have been heated by fire can develop water repellency. This is especially true of southern California chaparral soils (3, 4, 7). Natural water repellency due to vegetation is also present. We measured the amount of hydrophobic properties in the soil and followed it over time. The depth and thickness that it occurred, the strength and if it was continuous or discontinuous over a length of one foot was determined. The procedure was to place a drop of water on the soil to see if it repelled the water from soaking into the soil. This was done in 1/4 inch increments starting from the surface of the soil to where no repellency was observed or to a depth of 1 foot if no repellency occurred. To determine the strength of the water repellency the following times that repellency was present was used.

0 - 5 sec.	5 - 10 sec.	10 - 40 sec.	>40 sec.
not hydrophobic	slight	moderate	strong

4. Fire intensity - An attempt to evaluate the fire intensity at each site was made. This information may help explain soil hydrophobicity and/or whether a seed source is still in the soil. Criteria from the USDA-Forest Service 1981 FSH was used (11). Indicators that can be used to identify fire intensity are: 1. depth and color of ashes, 2. size and amount of live fuel consumed, 3. litter consumed, 4. plant root crowns consumed, and 5. soil crusting. Some of this information is shown in the pictures taken during the Jan. 11-14, 1994 establishment of the sites (see photos of each site). Each site was rated low, medium or high for both the litter or duff layer and for the brush canopy. The following criteria was used.

Table 1-C Fire Intensity Criteria

Property	Degree of Impact Low	Medium	High
Litter or Duff Layer	Majority of duff layer is unburned or only slightly scorched. Note: Pre-fire duff may be sparse or absent in some areas.	Duff consists of partially burned or charred pieces of twigs, and leaves, etc. and is still intact on surface and recognizable. organic residue.	Most or all of original duff has been burned to powdered ash (either black or white) with no recognizable charred pieces or
Brush Canopy	Brush canopy is mostly unburned or leaves intact but may be highly scorched and will probably fall to the ground.	Most leaves have burned off limbs but many skeleton limbs and branching above ground surface.	Both leaves and skeleton have been burned off. Surface consists mostly of burned stumps a few inches above ground.

B. Results

1. Soils - Table 2-C shows the pH values taken at three different time periods for each site. The normal pH's ranged from 5.6 to 7.3. The first observation on Jan. 11, 1994 ranged from 5.5 to 8.0. Many pH's were higher than the normal range reflecting the wood ash influence. The effects of winter rainfall lowered some of the pH's especially if they were 8.0 on the first reading. The pH's that were in the normal range to start with tend to stay the same over time. Even after the third observation taken on May 16 to 19, 1994, some values were higher than the normal pH value. Nutrient availability related to these higher pH's may be affected.

Table 2-C Surface pH after the fire

Site	pH of surface 1/4 inch 1/11/94	4/11/94	5/16-19/94
T1-HVF	8.0	6.8	6.8
T2-SB	8.0	8.0	---
T3-HRF	8.0	8.0	8.0
T4-HC	7.0	7.5	---
T5-AC-S	7.5	7.5	7.5
T6-AS-N	6.5	6.3	6.5
T7-AC-N	6.5	6.5	6.5
T8-AS-S	6.3	6.3	6.8
T9-AS-S	6.5	6.3	6.5
L1-HS	8.0	7.5	7.5
L1-BFM	6.0	6.3	6.0
L3-HC	5.5	6.3	6.0
L4-AS-S	7.3	7.8	7.5
L5-AS-N	5.8	6.3	6.3
L6-AS-S	7.5	7.0	7.3
L7-AC-N	6.5	6.5	6.3
L8-AC-S	6.3	6.3	6.3
K1-SB	6.7	6.5	---
K2-HS	8.0	6.5	---
K3-HS-C	8.0	7.5	---

2. Erosion evaluation (USLE) - Appendix C-2 shows the various values used to calculate the Universal Soil Loss Equation i.e., R, K, and LS values. From this data the A value or potential soil loss per acre per year can be determined. This assumes no C or cover and management factor. The A value ranged from a low of 17 to a high of 453 tons per acre per year. This high value was at site T4 which had a higher K value. Sites T8 and T9 have low K values because of the numerous coarse fragments on the surface.
The erosion index is when the A value is divided by the T value. The T value being the permissible soil loss. The erosion index values ranged from 8 to 453 tons per acre per year. The T value takes into account how deep the soil profile is, deeper soils are allowed to erode more while shallow soils are allowed to erode less. The mode for the EI value is 27 and the average is 65. This indicates that the sites after the fire have a high potential for sheet and rill erosion to take place.

Table 3-C shows the potential erosion (A value) as determined by the USLE at different time periods reflecting different cover situations (C value). The top part of this table groups the mulch and the straw bale sites and the bottom part groups the aerial seeded or aerial control sites. Before the fire, the C value reflects the cover observed in nearby areas that had not been burned. The R, K, and LS values were as given in Appendix C-2 using site specific information. When the A values before the fire are compared to the T values it is noted that the A values are almost always equal or less than the T values. The vegetative cover is protecting the soil from large amounts of sheet and rill erosion. After the fire when the cover is burned off but some root structure is still present (C=0.45) the A values are much higher than the prefire A value and T values.

This shows there is potential sheet and rill erosion due to the loss of vegetative cover. Almost six months after the fire, in April, 1994, plants had begun to grow and give some cover protection. The total cover values were converted to new C values. The C values for the hydromulch sites are just for the vegetation and not the mulch. The A values are considerably less than the after fire A values. By the end of six months, 53 percent of the observed sites had erosion at or near the T value.

Table 3-C Potential Erosion at Hydroseeded Sites

SITES	Before Fire		After fire			Data for 4/94				
	C	A	C	A	T	Cover Native	Cover seeded	Cover Total	C	A
T1-HVF	0.011	2	0.45	95	2	20%	10%	30%	0.17	36
T2-SB	0.011	2	0.45	68	2	--	--	--	--	--
T3-HRF	0.011	2	0.45	81	5	80%	--	80%	0.028	5
T4-HC	0.011	5	0.45	204	1	--	--	--	--	--
L1-HS	0.007	1	0.45	30	3	8%	13%	21%	0.22	15
L2-BFM	0.007	1	0.45	24	2	10%	30%	40%	0.13	7
L3-HC	0.007	1	0.45	20	2	20%	--	20%	0.22	4
K1-SB	0.011	2	0.45	85	2	--	--	--	--	-
K2-HS	0.011	1	0.45	21	2	16%	14%	30%	0.17	8
K3-HS-C	0.011	1	0.45	21	2	80%	--	80%	0.028	1

Table 3-C Potential Erosion at Aerial seeded sites (contiued)

SITES	Before Fire		After Fire			Data for 4/94				
	C	A	C	A	T	Cover Native	Cover seeded	Cover Total	C	A
T5-AC-S	0.011	3	0.45	122	2	80%	--	80%	0.028	8
T6-AS-N	0.011	1	0.45	52	2	55%	20%	75%	0.038	4
T7-AC-N	0.011	2	0.45	72	2	40%	--	40%	0.13	20
T8-AS-S	0.011	1	0.45	12	2	60%	--	60%	0.067	2
T9-AS-S	0.011	1	0.45	8	1	55%	10%	65%	0.057	1
L4-AS-S	0.011	1	0.45	28	2	50%	--	50%	0.069	4
L5-AS-N	0.011	1	0.45	24	2	25%	20%	55%	0.067	4
L6-AS-S	0.011	1	0.45	11	1	44%	6%	50%	0.069	2
L7 AC-N	0.011	1	0.45	19	2	5%	--	5%	0.34	15
L8-AC-S	0.011	1	0.45	11	3	15%	--	15%	0.28	7

3. Hydrophobicity evaluation - Table 4-C shows the hydrophobicity over time at each site. All but two sites were hydrophobic on the first observation in Jan. 1994. During the three observations, the strength ranged from

slight to strong. The depths ranged from 0 to 6 inches while thickness being 0.5 to 5.5 inches. Only one site that was hydrophobic was not continuously so over a distance of 1 foot. The second and third observations were done in April and May. Some rainfall had occurred and one would expect the hydrophobic layer to move down into the profile. Only in a few cases was this true. Most of the surface soils that were hydrophobic in Jan. were also in May. The strength decreased, stayed the same, or increased with time (i.e. there was no definite trend). Where there was any hydrophobic layers, they were continuous. It was noted that if the soil was moist due to rainfall the soil would not be hydrophobic; the lower boundary was often controlled by the moisture content. The fact that these soils are almost always hydrophobic means more runoff and more potential erosion until the surface layer was moisten (1, 2, 10). The fact that the water repellency tended to be near the surface may suggest that the fire did not get hot.

Table 4-C Hydrophobicity Evaluation

Site	1/11-14/94			4/11-14/94			5/16-19/94		
	Depth in.	Stre	Cont	Depth in.	Stre	Cont	Depth in.	Stre	Cont
L1-HS	0.0-2.0	Mod.	Yes	0.5-1.5	Str.	Yes	0.5-1.5	Str.	Yes
L2-BFM	2.0-3.0	Str.	Yes	0.5-1.5	Mod.	Yes	0.5-1.5	Str.	Yes
L3-HC	0.5-1.0	Mod.	Yes	0.5-1.0	Mod.	Yes	0.5-1.0	Str.	Yes
L4-AS-S	Not Hydrophobic			0.5-1.5	Str.	Yes	0.5-1.5	Mod.	Yes
L5-AS-N	0.5-1.5	Str.	Yes	0.5-2.0	Str.	Yes	Not Hydrophobic		
L6-AS-S	1.0-5.0	Str.	Yes	0.5-6.0	Mod.	Yes	0.5-2.5	Str.	Yes
L7-AC-N	0.5-1.0	Str.	Yes	0.5-1.0	Mod.	Yes	0.5-1.5	Str.	Yes
L8-AC-S	0.5-1.5	Str.	Yes	0.5-3.0	Str.	Yes	0.5-1.5	Str.	Yes
K1-SB	1.0-2.0	Mod.	Yes	0.0-6.0	Mod.	Yes	---	---	---
K2-HS	1.0-6.0	Str.	Yes	0.0-6.0	Str.	Yes	---	---	---
K3-HS-C	1.0-5.0	Str.	Yes	0.0-6.0	Str.	Yes	---	---	---
1-HVF	0.0 2.5	Str.	Yes	0.25-1.25	Str.	Yes	0.5-1.5	Str.	Yes
T2-SB	0.0-1.0	Mod.	Yes	0.5-1.5	Sli.	Yes	---	---	---
T3-HRF	1.0-3.0	Sli.	No	2.0-3.0	Sli.	Yes	Not Hydrophobic		

Table 4-C Hydrophobicity Evaluation (contiued)

Site	1/11-14/94 Depth in.	Stre	Cont	4/11-14/94 Depth in.	Stre	Cont	5/16-19/94 Depth in.	Stre	Cont
T4-HC	2.0-3.0	Mod.	Yes	---	---	---	---	---	---
T5-AC-S	0.5-1.5	Sli.	Yes	0.5-2.0	Mod.	Yes	1.0-1.5	Mod.	Yes
T6-AS-N	0.5-1.5	Mod.	Yes	Not Hydrophobic			0.25-3.0	Str.	Yes
T7-AC-N	Not Hydrophobic			Not Hydrophobic			Not Hydrophobic		
T8-AS-S	0.5-1.5	Mod.	Yes	0.5-3.0	Str.	Yes	0.5-3.0	Mod.	Yes
T9-AS-S	0.0-0.5	Mod.	Yes	0.5-4.0	Str.	Yes	0.25-4.0	Mod.	Yes

4. Fire intensity evaluation - Table 5-C shows the ratings for fire intensity for litter layer and brush canopy. Pictures of the sites also show this condition. At all of the sites the litter was completely burned to powdered ash. Eight of the twenty sites had a medium rating for brush canopy and the rest were a high rating. The lack of seed source with the high litter rating did not seem to be related. Even with a high fire intensity on litter there may or may not be seed available.

Table 5-C Fire intensity ratings

Site	Fire Intensity Litter	Brush Canopy	Site	Fire Intensity Litter	Brush Canopy
T1-HVF	High	High	L2-BFM	High	Medium
T2-SB	High	High	L3-HC	High	Medium
T3-HRF	High	High	L4-AS-S	High	High
T4-HC	High	High	L5-AS-N	High	High
T5-AC-S	High	Medium	L6-AS-S	High	High
T6-AS-N	High	High	L7-AC-N	High	High
T7-AC-N	High	Medium	L8-AC-S	High	High
T8-AS-S	High	Medium	K1-SB	High	Medium
T9-AS-S	High	High	K2-HS	High	Medium
L1-HS	High	High	K3-HS-C	High	Medium

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VEGETATION

METHODS

A total of 20 sites were selected to evaluate the effectiveness of reseeding after a wildfire. There are 9 sites in the Topanga area, 8 sites in the Laguna Beach area, and 3 sites in the Kinneloa area. A site in the Topanga area was abandoned due to reseeding efforts of the land owner. Sites T4, T5, T7, L3, L7, L8, and K3 were control sites for adjacent reseeded sites. Aerial seeded sites were selected with both north and south aspects and their control sites were selected with corresponding aspects.

The methods of application were hydroseeding and aerial seeding. The seeding rates were determined on a site by site bases and in concurrence with the local community. Seed applied in the Laguna Beach area was required to meet a minimum standard of 80 percent pure-live seed and 5 percent or less weed seed based on the aggregate of pure-live seed and other material. Refer to appendix D-2 for a listing of seed mixes and the locations they were used. The fiber and tackifier materials used in

Table 1-D

SPECIES USED TO RESEED AFTER SOUTHERN CALIFORNIA WILDFIRES			Cost of seed per pound
'Hykon' rose clover	*Trifolium*	*hirtum*	$ 3.00
'Zorro' annual fescue	*Vulpia*	*myuros hirsuta*	10.00
'Blando' brome	*Bromus*	*hordeaceus hordeaceus*	4.50
California brome	*Bromus*	*carinatus*	10.00
Arroyo lupine	*Lupinus*	*succulentus*	10.00
Purple needlegrass	*Stipa*	*pulchrara*	40.00
California poppy	*Eschscholtzia*	*californica*	18.00
Nodding stipa	*Stipa*	*cernua*	50.00
Foothill stipa	*Stipa*	*lepida*	96.00

hydroseeding were evaluated for effectiveness and for any detrimental effects they may have had on seed germination. Refer to appendix D-2 for a listing of hydro-mulch materials.

Sites L4, L5, L6, L7, L8, T5, T6, T7, T8, and T9 were evaluated by a modified method proposed by Jon E. Keeley, Dept. of Biology, Occidental College, Los Angeles, CA 90041. At each of these site a 1 square meter, a 10 square meter and a 100 square meter plot was established. In the 1 square meter plot all seedlings were counted, in the 10 square meter plot only seedlings of woody species were counted, and in the 100 square meter plot only the resprouting woody species were counted. This method will provide limited objective and quantitative data based on actual numbers of plants. Other data presented for these sites was based on subjective and qualitative methods.

Sites L1, L2, L3, T1, T2, T4, K1, K2, and K3 were evaluated based on subjective and qualitative methods only. Refer to SCS, "National Plant Materials Manual", 1990. part 540.16 and SCS "PMC/250", 1989. part 6.0".

Results

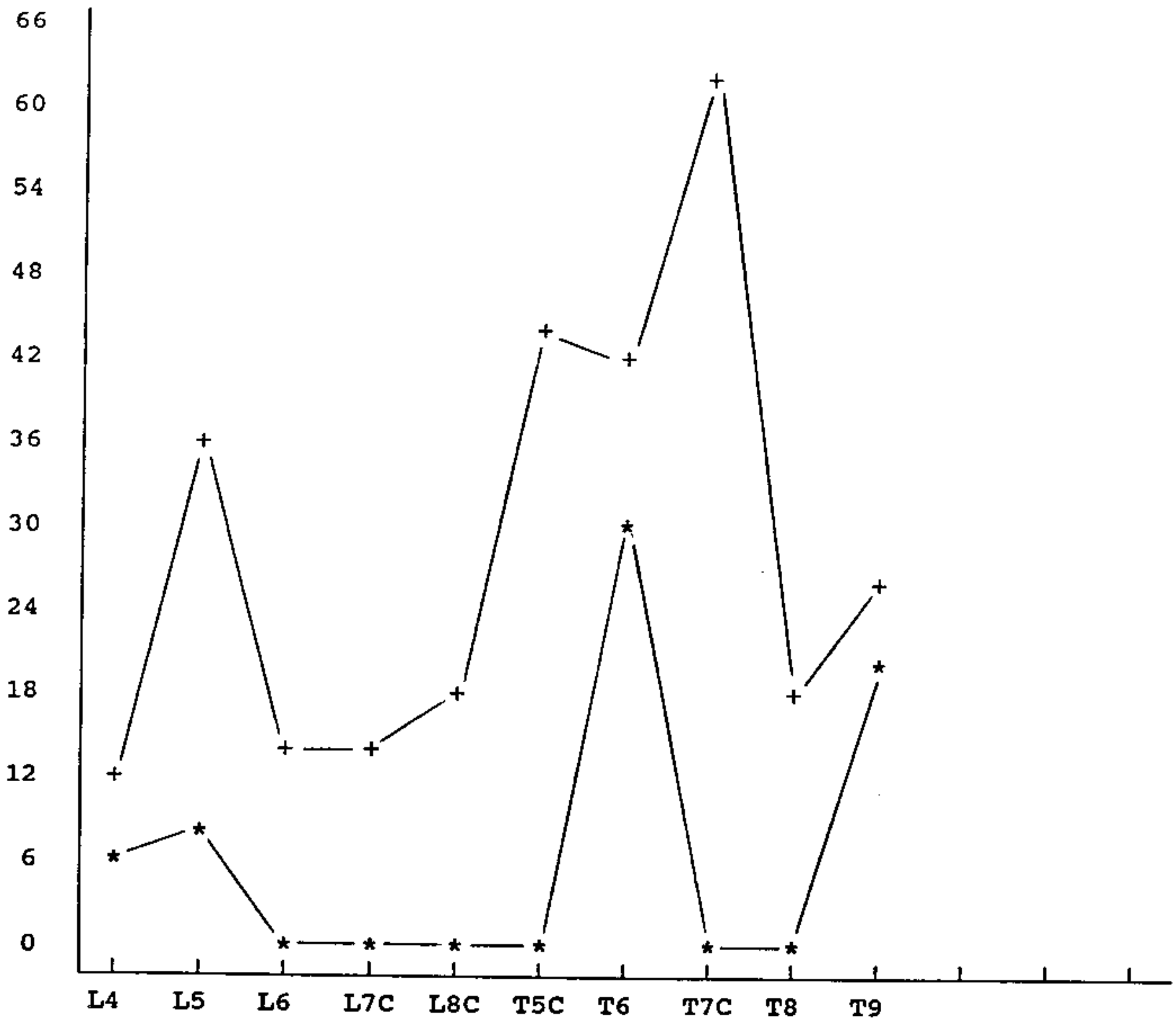
<u>Aerial seeded</u>
Quantitative data was collected for the aerial seeded sites in the Laguna Beach and Topanga areas. Qualitative data was collected for both aerial and hydroseeded sites at Laguna Beach, Topanga, and Kinneloa. When the quantitative data was reviewed, it was found that of the species seeded in the Laguna Beach area only the 'Zorro' annual fescue was found in the 1 square meter sites. At the Topanga sites, 'Zorro' annual fescue and 'Hykon' rose clover was found in the 1 square meter sites, refer to table 2-D. When the number of plants per square meter were compared to the total quantity of seed applied per square meter at the Laguna sites, it was found that the plants equaled 0.5 percent of the seed. At the Topanga sites, the total number of plants to the total quantity of seed

Table 2-D

GERMINATED SEED COUNTED IN ONE SQUARE METER AT EACH OF THE SITES native species in one square meter are included at bottom of table												
SPECIES SEEDED BY AIR	SEED SQ METER	L4	L6	L8 C	L5	L7 C	SEED SQ METER	T5 C	T8	T9	T6	T7 C
'Zorro' annual fescue	1458	7	--	--	8	--	444	--	---	---	30	---
'Hykon' rose clover	NA	--	--	--	--	--	158	--	---	21	---	---
California brome	NA	--	--	--	--	--	32	--	---	---	---	---
'Blando' brome	NA	--	--	--	--	--	63	--	---	---	---	---
Purple stipa	11	--	--	--	--	--	NA	--	---	---	---	---
Nodding stipa	74	--	--	--	--	--	NA	--	---	---	---	---
Foothill stipa	53	--	--	--	--	--	NA	--	---	---	---	---
TOTAL SEED PER ONE SQUARE METER	1596	7			8		697			21	30	
NATIVE SPECIES	NA	12	13	19	36	13	NA	45	17	27	44	63
TOTAL NUMBER OF PLANT PER SQUARE METER	NA	19	13	19	44	13	NA	45	17	48	77	63

applied per square meter was equal to approximately 4 percent. Of the 6 aerial seeded evaluation sites in the Laguna Beach and Topanga areas, 4 were found to contain 1 seeded species per square meter site. This compares to an average of 3.6 resident species per square meter for all of the 10 aerial seeded and control evaluation sites, refer to table 2-E, graph 1-D, and Appendix D-3. The resident plant population per square meter ranged from 12 to 63 plants with 50 percent of the sites having a plant population of 27 or greater. This compares with an aerial seeded plant population ranging from 7 to 30 plants per square meter and with 33 percent of the sites having an aerial seeded species plant population of 21 or greater. The <u>total</u> plant population per square meter ranged from 13 to 77 with 50 percent of the sites having a plant population of 44 or greater. Reestablishment of ground cover naturally or by seeding is the

Graph 1-D The number of resident plants and aerial seeded plants at each site, one square meter.



* = aerial seeded species and + = resident species
C =control sites
'Zorro' annual fescue only at sites L4, L5, T6.
'Hykon' rose clover only at site T9.

most effective erosion control following a fire(1). After investigating a fire that killed a ponderosa pine forest in South Dakota, Orr (1970) concluded that total ground cover of native and seeded vegetation must equal or exceed 60 percent density for minimum tolerable control of runoff and erosion (1). When the entire 100 square meter site in the Laguna Beach and Topanga areas were observed, it was found that many of the aerial seeded species were present. But, since the number of herbaceous plants per site were determined based on 1 square meter, the extent to which the seeded population might exist over the total 100 square meters was not determined, refer to table 3-D. Since many of the aerial seeded species were found on control sites and in areas where they were not included in the seed mix, the question is presented whether this was due to an over flight by the applicator or whether a resident seed population was present after the fire.

A case can be made for the seed being present prior to aerial seeding by considering the variety and quantity of resident species found in the 100 square meter sites, refer to appenmdix E-4. This scenario is most plausible in areas where a species was not included in the seed mix,

Table 3-D

GERMINATED SEED FOUND AT OR NEAR EACH OF THE 100 METER SITES												
SPECIES SEEDED BY AIR	SEED SQ METER	L4	L6	L8 C	L5	L7 C	SEED SQ METER	T5 C	T8	T9	T6	T7 C
'Zorro' annual fescue	1458	X	--	X	X	X	444	--	X	X	X	---
'Hykon' rose clover	NA	--	--	--	--	--	158	--	---	X	---	X
California brome	NA	X	--	--	--	--	32	--	---	---	---	---
'Blando' brome	NA	--	--	--	--	--	63	--	---	X	---	X
Purple stipa	11	--	--	--	--	--	NA	--	---	---	---	---
Nodding stipa	74	--	--	--	--	X	NA	--	---	X	---	---
Foothill stipa	53	X	X	--	X	X	NA	--	X	---	---	X

i.e. nodding stipa, foothill stipa, annual fescue, softchess, rose clover, and California brome. An example of this would be foothill stipa which was seeded at the rate of 53 seed per square meter. This species was present on both seeded and control sites in the Laguna Beach area as well as being found in the Topanga area, where it was not seeded. It should be noted that some of the resident species present are species which have resprouted from a remaining root system or from bulbs, refer to appendix D-3. There was approximately 32 different resident species dispersed through the 10 evaluation sites. The 32 species are identified in this report but, numerous Forbes which went unidentified were also present and are recorded as forb species. The varied and abundant resident plant community which existed after the fires could lead to the conclusion that there is more viable seed remaining in the soil after a fire than was first thought.

Factors influencing seed survival include maximum soil temperatures, duration of heat, and the amount of water seeds have absorbed prior to a fire (2). When dry, seeds can tolerate temperatures over 100 degrees F., but moist conditions result in complete mortality at temperatures above 70 degrees F (2). Some of the resident species being found, i.e. Phacelia, Fire poppy, etc., are fire influenced plants that appear after a fire. In the case of Phacelia and Fire poppy, the seed of these plants will remain dormant until a fire and then germinate. These plants may dominate the plant community during the first year following a fire and produce seed which will remain dormant until the next fire. There rapid growth and effectiveness for short term erosion control may require further consideration. Perennial herbs are conspicuous in the first spring after a fire, and their presences results from resprouting of bulbs or other buried parts (3). Included are all of the bulb-forming monocots such as species of *Allium, Bloomeria, Brodiaea, Calochortus,* and *Chlorogalum*, as well as dicots such as *Paeonia californica*, and *Marah macrocarpus* (3). Seeds of these species do not require fire for germination, and their seedlings are generally uncommon in the first season after a fire (3).

Hydroseeded

The hydroseeded sites at Laguna Beach, Topanga, and the Kinneloa did not have 1 square meter, 10 square meter, and 100 square meter sites. Plant

Table 4-D

GERMINATED SEED FOUND AT OR NEAR EACH SITE											
HYDROSEEDED SPECIES	SEED SQ METER	L1	L2	L3 C	SEED SQ METER	T1	T3	SEED SQ METER	K1	K2	K3 C
'Zorro' annual fescue	1658	X	X	X	NA	--	--	834	---	X	---
'Hykon' rose clover	NA	--	--	--	243	X	--	518-	---	---	X
California brome	NA	--	--	--	NA	--	--	201	---	---	---
'Blando' brome	NA	X	X	--	739	X	--	NA	---	---	---
Purple stipa	116	--	--	--	NA	--	--	NA	---	---	---
Arroyo lupine	3	--	--	--	NA	X	--	NA	---	---	---
California poppy	32	X	X	X	NA	X		63	---	X	X
Foothill stipa	NA	X	X	X	NA	--	--	NA	---	---	---
Nodding stipa	NA	X	X	X	NA	--	--	NA	---	---	---

data was collected for an undetermined area around a photo stake at each site, refer to appendix D-5. Because of this there is a lack of data based on plant population of either hydroseeded species or resident species. The existence of species at the sites is all that was established from this data, refer to table 4-D.

Of the seeded species at Laguna Beach, 'Zorro' annual fescue and California poppy were found. The seeded species found in the Topanga area were 'Hykon' rose clover, and 'Blando' brome. The seeded species found in the Kinneloa area included 'Zorro' annual fescue and California poppy. In the Laguna Beach area, Hydroseeded species which where found at the control sites were: 'Zorro' annual fescue, 'Blando' brome, California poppy, foothill stipa, and nodding stipa. In the Topanga area, species which were present but not seeded are arroyo lupine and California poppy. The Kinneola area had 2 species which were hydroseeded and found in the control sites, 'Hykon' rose clover and California poppy.

Unlike the aerial seeding, it would be impossible to over-seed the control sites without visible evidence remaining. For this reason it would appear that those species which where seeded and are evident in the control sites is due to the remaining resident seed and not seeding efforts. Although not hydroseeded at any of the sites, foothill stipa and nodding stipa were present at some of the Laguna Beach sites. As these species do not reproduce vegetatively, from roots or bulbs, the theory that there was a resident seed source after the fires has again been confirmed.

SUBJECTIVE AND QUALITATIVE EVALUATIONS

The subjective and qualitative planting evaluations of the seeded species were made and the evaluations are in Appendix D-5 through D-13. Each seeded spices which was present was evaluated for a number of

Table 5-D RELATIVE VALUE OF STANDS OF AERIAL SEEDED SPECIES AND NATIVE/RESIDENT SPECIES, (1 excellent to 9 none)

Species	L4 AS-S	L6 AS-S	L8 AC-S	L5 AS-N	L7 AC-N	T5 AC-S	T8 AS-S	T9 AS-S	T6 AS-N	T7 AC-N
Zorro Fescue	4	9		3			9	7	3	
Native/Resident	4	4	7	6	8	4	3	4	2	6
Hykon Rose Clover							9	6	9	
Blando Brome							9	7	9	

characteristics, of which the relative value of the stand of the species planted being the most important. As table 5-D shows, aerial seeded Zorro Fescue performed the best on north aspect slopes and its performance was poor on south aspect slopes. On one of the ten aerial seeded and control sites Zorro Fescue had a better stand than the native/resident species, on one site it was the same, and on eight of the aerial seeded and control sites the native/resident species had a better stand. Both Hykon rose clover and Blando brome had one aerial seeded site where they had a poor stand and two sites where they had no stand. Other aerial seeded species such as perennial California brome, purple stipa, nodding stipa, and foothill stipa did not have a stand which could be attributed to the seed applied. As table 6-D demonstrates, hydroseeded Zorro Fescue had a fair to good stand on four of the five sites where it was planted and a poor stand on one of the five sites. Hykon rose clover did not have a stand on two of the four sites where it was planted and two of the four sites had a fair to good stand. Blando brome had a poor stand at one site and no stand at another site. At three of five sites, California poppy had a fair to good stand and at two of the five sites it had a poor stand. Other hydroseeded species such as Arroyo Lupine, Purple Needlegrass, and perennial California Brome did not have a stand which could be attributed to seeding efforts

Table 6-D RELATIVE VALUE OF STANDS OF HYDROSEEDED SPECIES
(1 excellent to 9 none)

Species	K2 HMHM	K3 HS-C	T1 HVF	T3 HRV	L1 HS	L2 BFM	L3 HC
Zorro Fescue	4	2			8	3	4
Hykon Rose Clover	9	2	6	9			
Blando Brome			7	9			
Calif. Poppy	3	2			8	7	4

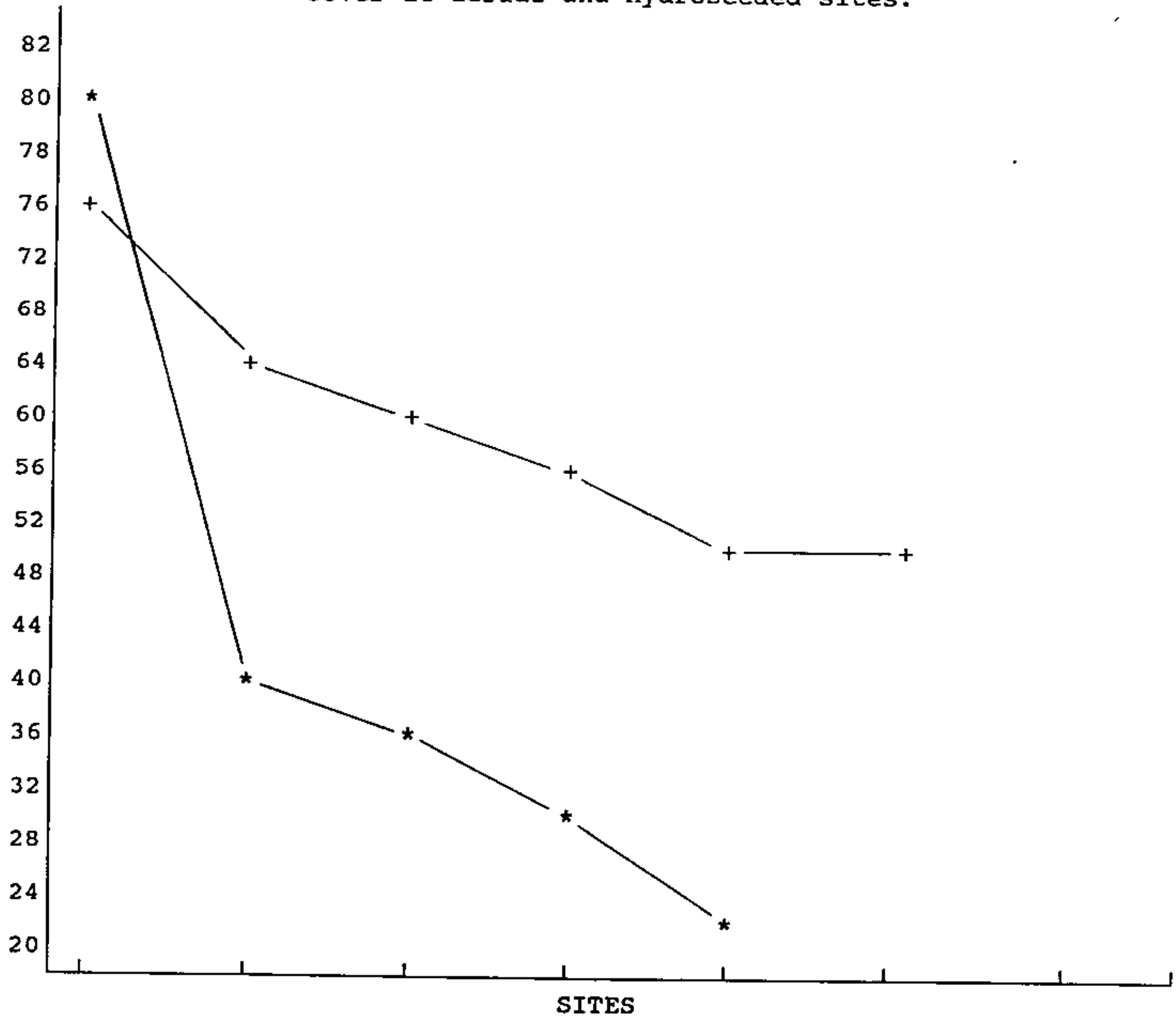
Table 7-D EROSION CONTROL EFFECTIVENESS OF HYDROMULCH
(based on the USLE and presented in an effort
to show a change in potential sediment load)

SITES	Before Fire	After Fire		Hydromulch Directly After fire		
	A	A	T	Cover	A	C
T1-HVF	2	95	2	95%	21	0.1
T3-HRF	2	81	5	95%	18	0.1
T4-HC	5	204	1	--	--	--
L1-HS	1	30	3	95%	7	0.1
L2-BFM	1	24	2	95%	5	0.1
L3-HC	1	20	2	--	-	--
K2-HS	1	21	2	95%	5	0.1
K3-HS-C	1	21	2	--	-	--

Hydromulch provided effective erosion control protection when first applied and as it degraded, over time, the protection provided decreased correspondingly (Table 7-D). It appears that hydromulches which use virgin wood fiber,(T1-HVF), and bonded fiber matrix, (L2-BFM), retain the highest amount of mulch cover after six months.

The following graph shows that there was an average thirty percent difference in plant cover between aerial and hydroseeded sites. This difference may have been due to the effects of the hydromulch itself. Hydromulch may have suppressed seed germination or seedling emergence. The suppressed growth was observed in the resident as well as the seeded species.

Graph 2-D The range in percent ground cover at aerial and hydroseeded sites.



* = Hydroseeded sites and + = Aerial Seeded sites

One year after the Luguna fire the copolymer material was still intact in some places. It takes two things to break down the material-heat and water. When we get the vegetation going, it helps decompose the mulch and the polymer. The only difficult scenario involves landslide, where water will get behind and from above the material will give out (4).

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OBSERVATIONS

Observations

A. Seeding and Mulching

1. The fire intensity rating for both litter and brush canopy did not seem to correlate with the amount of seed germination. You could not conclude where there was a high rating that no viable seed was present.

2. Qualitative observations (pictures) give the impression that the N aspect sites have a higher plant establishment but quantitative plot data do not always support this.

3. High soil pH did not seem to be related to poor seed establishment. Sites with lower pH did not have high seed germination as well as the high pH sites. High pH values after the fire become lower with time.

4. In the evaluated plot area, the hydrophobic soil layer was still present in the surface soil six months after the fire.

5. Almost all sites had hydrophobic properties that were continuous over a one foot length. The continuity of hydrophobic layers over longer length was not determined. The strength of hydrophobicity varied over time.

6. Not many seeds that were aerial seeded actually grew compared to a 1994 Cal Trans study.

7. It was observed that the two aerial seeded control sites (L-7 and L-8) were heavily vegetated based on stump counts. This caused a hot fire which may have led to low seed viability.

8. Neither introduced or native species which were seeded performed as well as expected.

9. In the Laguna Beach and Topanga areas, the best results of seeded species was found in draws and on benches. It is speculated that this could be due to gentler slopes, deeper soil, higher fertility, higher moisture status, or a concentration of seed by rainfall and wind.

10. Potential sheet and rill erosion as determined by the USLE increased after the fire due to loss of cover. Steep slopes are an important factor in the high potential erosion values. About one half of the plots had returned to at or near prefire potential sheet and rill erosion levels in a six month time period.

11. Collection devices which were installed to estimate sheet and rill erosion from the control sites were filled by April, 1994. Rills were not dominant and most of the erosion was due to sheet erosion.

12. Six months after the fires, estimated rates of potential sheet and rill erosion were reduced by:

    * 21 to 95 percent (average 66 percent) for control/unseeded sites (n=6);
    * 82 to 92 percent (average 86 percent) for aerially seeded sites (n=6).

13. The relative contributions of sediment from sheet and rill, dry ravel, and landslide processes varied between burn areas and study sites:

    * Evidence of sheet erosion and low to moderate degrees of rill erosion were observed at all sites in January and April.
    * Evidence of dry ravel was most apparent at the Kinneloa study plots, which are underlain by extensively sheared and fractured granitics. The San Gabriel Mountains have a well-documented history of dry ravel and debris flow production.
    * Dry ravel cones were not observed at any of the study plots at Laguna Beach or Topanga, although dry ravel was obvious as early as November elsewhere in the burn areas, particularly along road cuts and stream channels.
    * Landslide-type failures did not occur at any of sites between November and April. Two sites one each in Topanga and Laguna Beach were located on or near landslide masses and are particularly prone to failure.

14. The bonded fiber matrix and virgin wood fiber mulches appeared effective in the short term in reducing rainfall impact energy. However, it did suppress seed germination or seedling emergence by about 30 percent. Based on visual estimates of the remaining mulch at the study sites six months after the fire, it appears that hydromulch used along the urban/wildland interface did reduce sheet and rill erosion.

15. Application of hydromulch reduced potential sheet and rill erosion at the study sites by an estimated 78 percent. This protection was provided immediately following application and was not dependent on climatic conditions. As mulch decayed and was disturbed, the degree of protection declined over time.

B. Straw Bales

1. The USDA-Soil Conservation Service installed straw bales on a very limited basis; no straw bale debris catchment structures were placed across active channels with drainage areas exceeding one acre.

2. The uppermost of three straw bale debris catchment structures near Hastings Canyon in the Kinneloa area filled with sediment within two weeks following installation, and had started to fail by gullying around the west embankment. The lower two straw bale catchments were partially filled with debris, and bales showed no overt signs of failure when observed in January.

3. By April 1994, all five straw bale structures observed at Kinneloa and Topanga had filled with debris. None of the structures had completely failed, although weak spots and small holes were observed, particularly under and through contacts between bales where they crossed the most active (deepest) part of the drainages. The straw at all sites 3 to 4 months after installation was noticeably drier and weak, crunbling to the touch and generally unable to support a person's standing weight.

RECOMMENDATIONS

Recommendations

1. Continue to evaluate and document results from using Technical Note 36, "Determining Viability of Resident Seed After Wildfires", to determine if adequate viable seed is present after fires.

2. Continue the evaluation of existing aerial seeded plots at Laguna Beach and Topanga to determine the impact of aerial seeding on native resident vegetation.

3. For future studies it is recommended to use replicated 1 meter plots within each test site to document the variability of seed establishment.

4. Locate or develop methods and procedures to evaluate sediment production from dry ravel-type processes following a fire. The U.S. Forest Service has proposed a qualitative method that may serve as a valuable starting point.

5. Need more research on specific questions such as:
   a. How much seed to apply to achieve adequate seedlings per square foot.
   b. Determine species and mixes to plant in each MLRA.
   c. Determine if aerial seeding is appropriate on slopes greater than 65 percent due to poor seed establishment.
   d. Determine hydromulch effects on seed germination and seedling establishment.
   e. Evaluate the use of RUSLE for after fire use.
   f. Identify and evaluate new mulch materials, application techniques and other technology.

6. Hire a plant ecologist with experience in fire ecology.

7. Determine the range of seeding dates following a fire for each MLRA.

8. Conduct a literature search on the effects of fire.

9. Evaluate the competiveness of perennial grasses in an annual grass environment.

10. Evaluate how the EWP program can encourage the endangered species habitat.

11. Refine the Damage Survey Report (DSR) process to better reflect the concepts of ecosystem-based assistance, and to help emergency teams locate burned areas where seeding is likely to be cost effective and environmentally feasible.

12. Work with federal, state, and county agencies to ensure that all participating groups have access to and use the same appropriate erosion/sediment yield prediction models, alternative development and evaluation criteria, and supporting data.

13. The placement of straw bale debris catchments should be restricted to small (< one acre±) drainage areas where the hazard to life is not critical. Cost estimates, feasibility evaluations, and the final agreement to install straw bale structures should assume and/or include provisions for their removal by a designated party by the end of the first wet season following the fire.

14. Need to have joint interagency training for staff personnel Need to schedule training annually in the non-fire season.

15. Need to have all agencies use the same procedures.

APPENDIX

Appendix A-1 Site Descriptions

A photograph of each site taken shortly after the fire and at various time periods following the fire is given in Appendix A. A brief summary description of each site is also given with the photos with references to the source of some of the information. Location maps are located in Appendix C, figures 1 through 6.

The site numbers are somewhat descriptive. The T represents the Topanga fire, the L represents the Laguna Beach fire, and the K represents the Kinneloa fire.

Laguna Beach Fire of 11-2-93

Study Site L-1

Hydromulched and Seeded 11-29-93±

Loc: W 1/2, SE 1/4, Sec 24, T7S, R9W (Laguna Beach 7.5')
Elev: 500' **Slope:** 45%
Aspect: S25E
Geology: Sandstone beds dip downslope
Soil Series: Cieneba-Rock Outcrop complex (6)
Vegetation: Coastal Scrub (1)

1-13-94

4-14-94

5-19-94

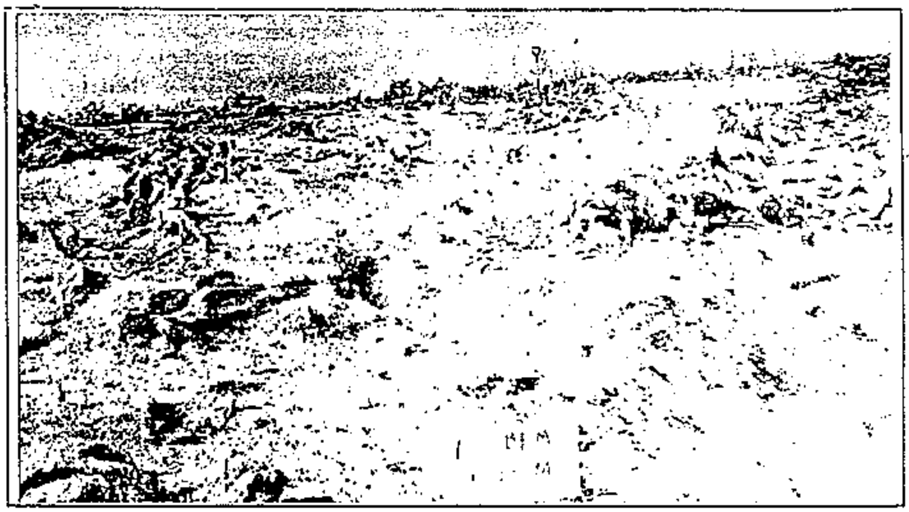
Laguna Beach Fire of 11-2-93

Loc: W 1/2, SE 1/4, Sec 24, T7S, R9W (Laguna Beach 7.5')
Elev: 600' **Slope:** 32%
Aspect: S75E
Geology: Fine- & Medium-grained sandstone beds dip downslope
Soil Series: Cieneba-Rock Outcrop complex (6)
Vegetation: Coastal Scrub (1)

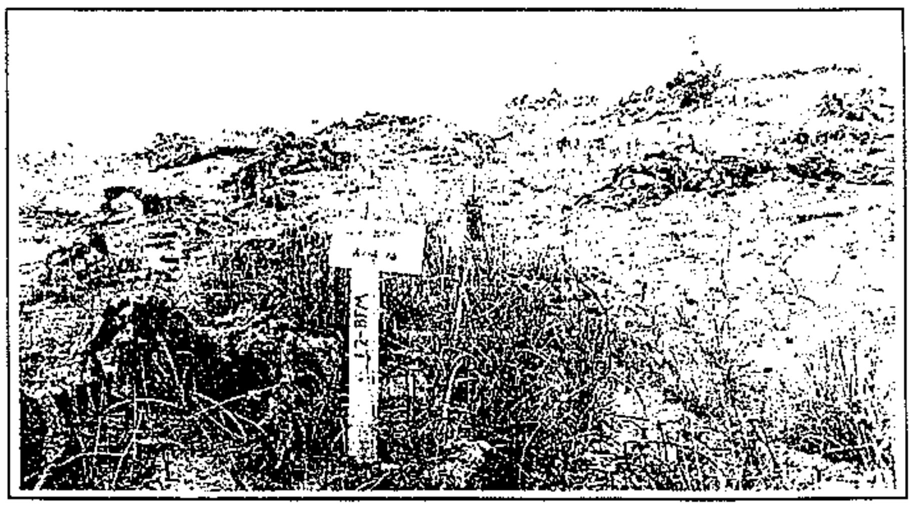
Study Site L-2

Hydromulched and Seeded 11-22-93±
(Bonded Fiber Matrix)

1-13-94



4-14-94



5-19-94

Laguna Beach Fire of 11-2-93

Study Site L-3

Control -
No Seeding or Mulching

Loc: W 1/2, SE 1/4, Sec 24, T7S, R9W (Laguna Beach 7.5')
Elev: 600' **Slope:** 34%
Aspect: S75E
Geology: Fine- and medium-grained sandstone beds dip downslope
Soil Series: Cieneba-Rock Outcrop complex (6)
Vegetation: Coastal Scrub (1)

1-13-94

4-14-94
(left 1/3 of photo shows edge of bonded fiber matrix application)

5-19-94

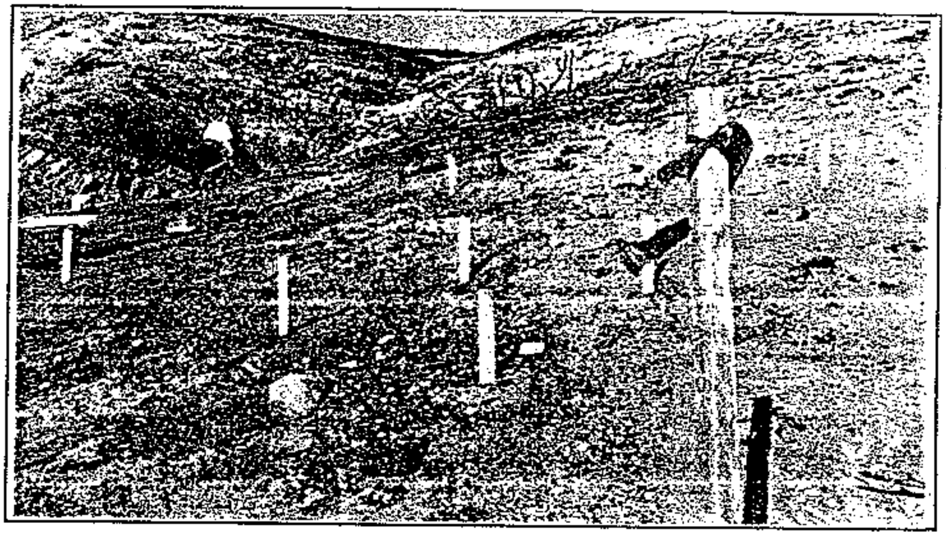
Laguna Beach Fire of 11-2-93

Study Site L-4

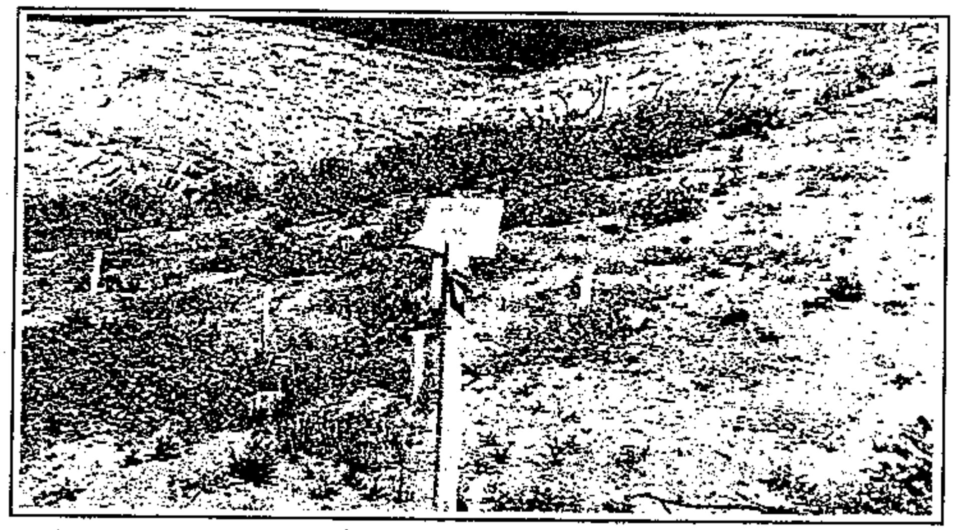
Aerially Seeded 11-15-93±

Loc: SE 1/4, SE 1/4, Sec 182, near T7S, R9W
(Laguna Beach 7.5')
Elev: 250' **Slope:** 38% **Aspect:** S15W
Geology: Siltstone & sandstone beds dip obliquely into slope; near Laguna Canyon Fault
Soil Series: Cieneba-Rock Outcrop complex (6)
Vegetation/Habitat: California Sagebrush-California Buckwheat scrub

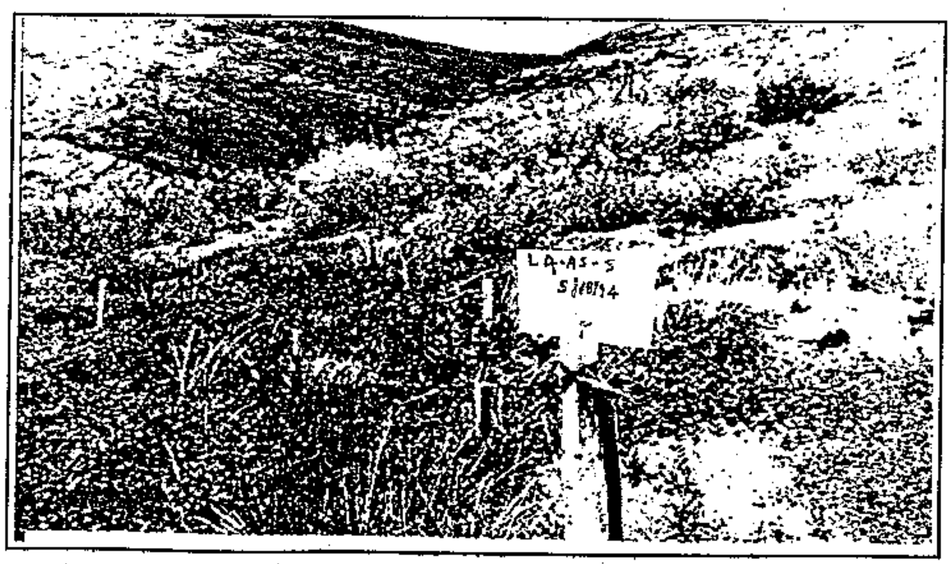
1-13-94



4-13-94



5-18-94



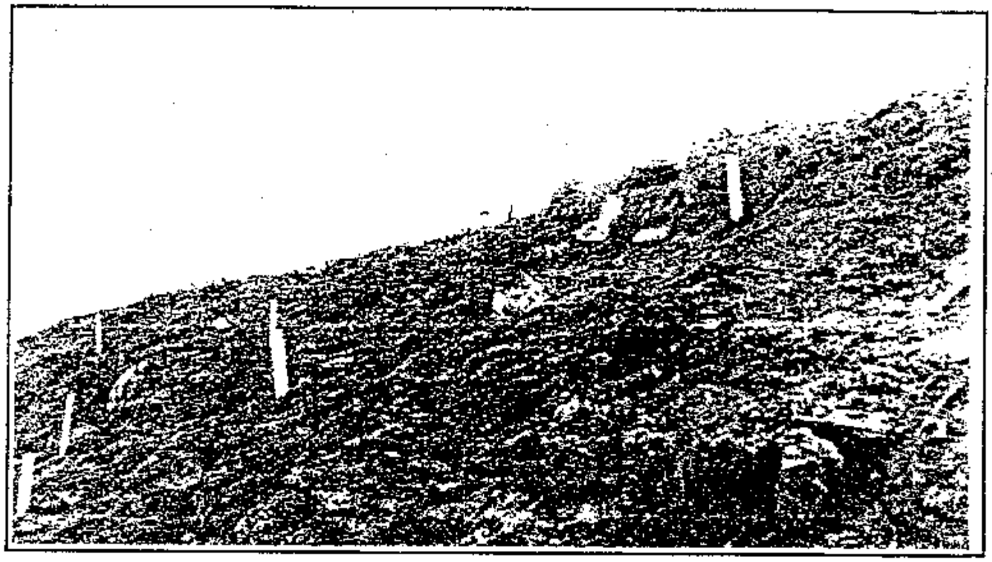
Laguna Beach Fire of 11-2-93

Study Site L-5

Aerially Seeded 11-15-93±

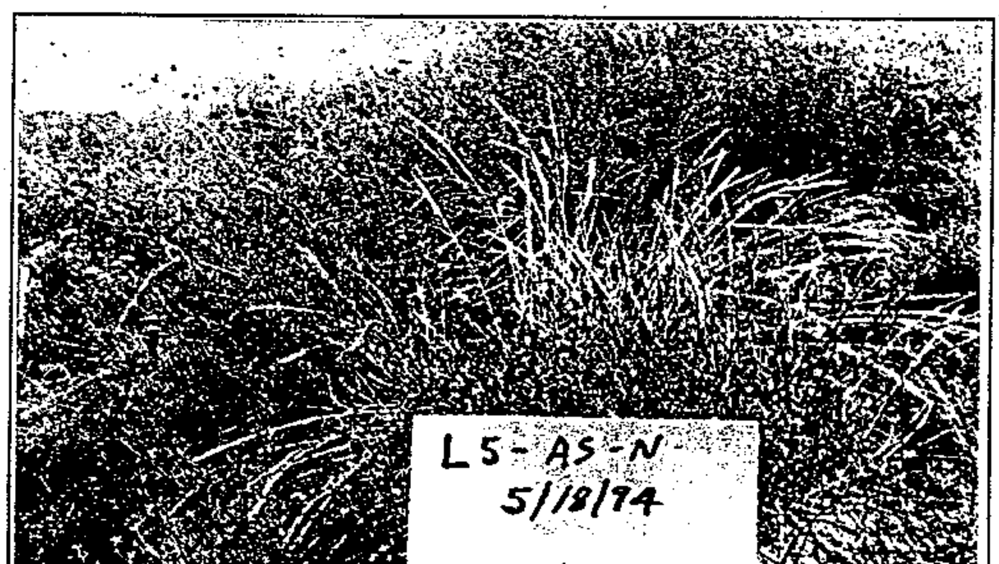
Loc: S 1/2, SE 1/4, Sec 182, near T7S, R9W (Laguna Beach 7.5')
Elev: 300' **Slope:** 42% (variable to 70%)
Aspect: N20W
Geology: On or near landslide in siltstone & sandstones that dip obliquely into slope; Laguna Canyon Fault
Soil Series: Cieneba-Rock Outcrop complex (6)
Vegetation/Habitat: California Sagebrush-California Buckwheat scrub

1-13-94



4-13-94

5-18-94



Laguna Beach Fire of 11-2-93

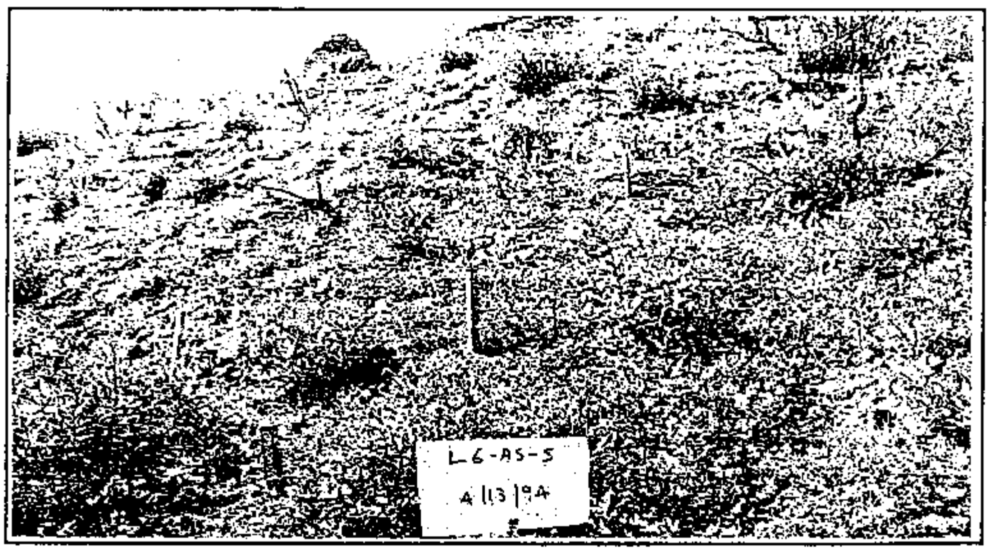
Study Site L-6

Aerially Seeded 11-15-93±

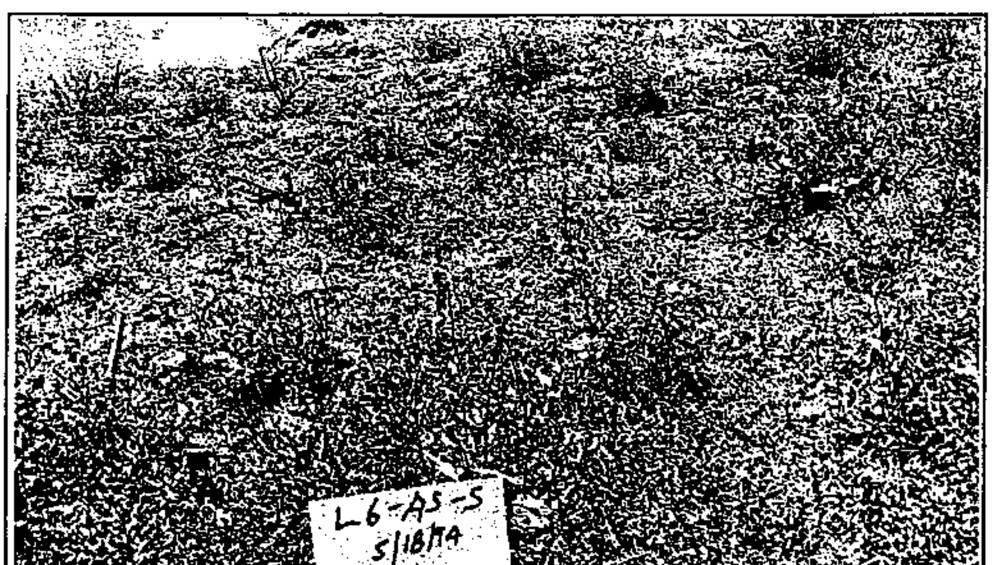
Loc: NE 1/4, SW 1/4, Sec 182, near T7S, R9W
(Laguna Beach 7.5')
Elev: 450' **Slope:** 64% **Aspect:** S45E
Geology: Silty sandstone and siltstone beds dip obliquely into slope
Soil Series: Cieneba-Rock Outcrop complex (6)
Vegetation/Habitat: California Sagebrush-California Buckwheat scrub

1-13-94

4-13-94



5-18-94



Laguna Beach Fire of 11-2-93

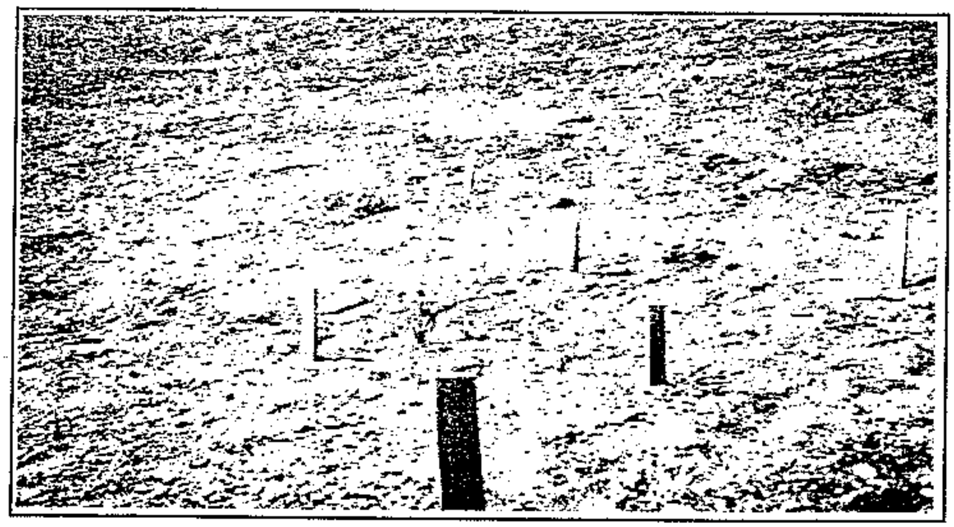
Study Site L-7

Control -
No Seeding or Mulching

Loc: SE 1/4, SE 1/4, Sec 159, near T6S, R9W
(Laguna Beach 7.5')
Elev: 540' **Slope:** 40%
Aspect: N45E
Geology: Sandstone beds; conglomerates exposed nearby
Soil Series: Cieneba-Rock Outcrop complex (6)
Vegetation/Habitat: California Sagebrush-California Buckwheat scrub

1-14-94

4-13-94



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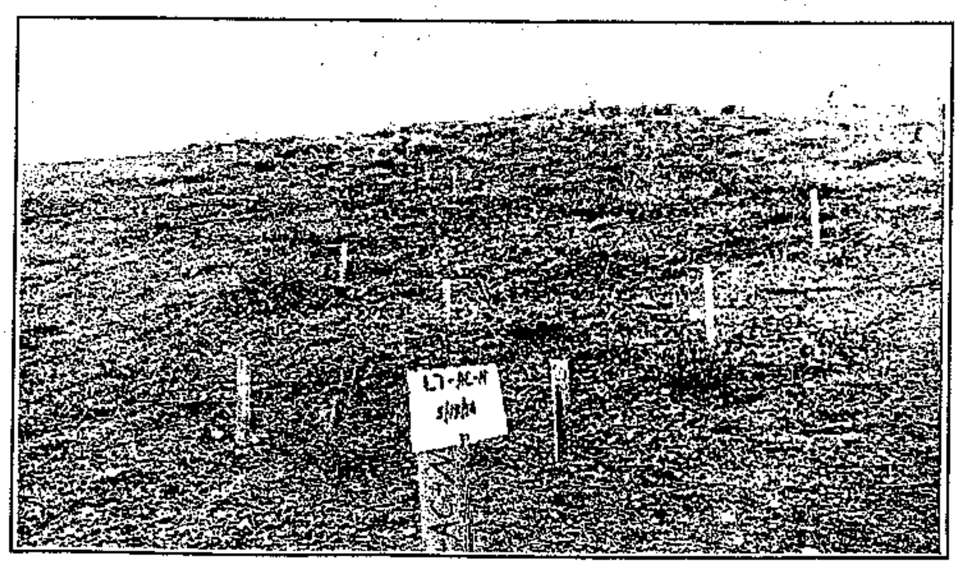


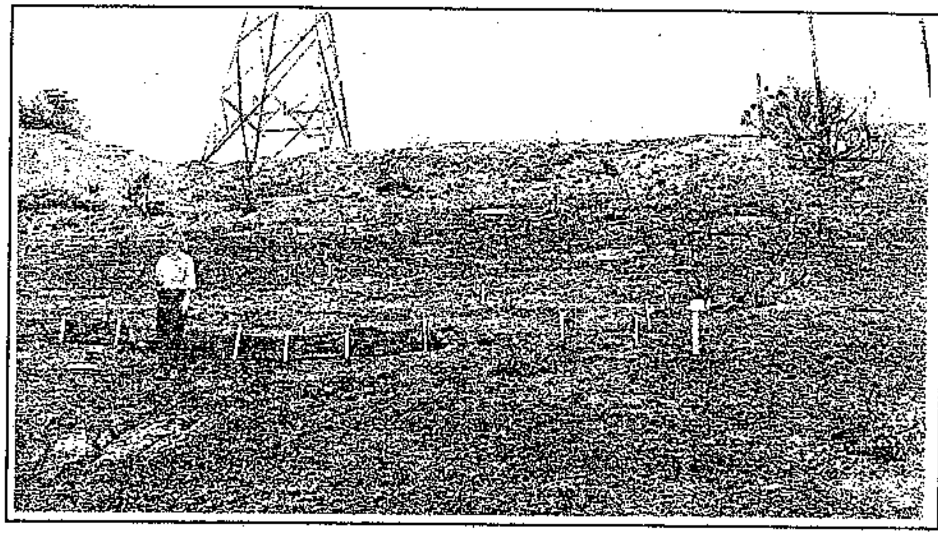
Laguna Beach Fire of 11-2-93

Study Site L-8

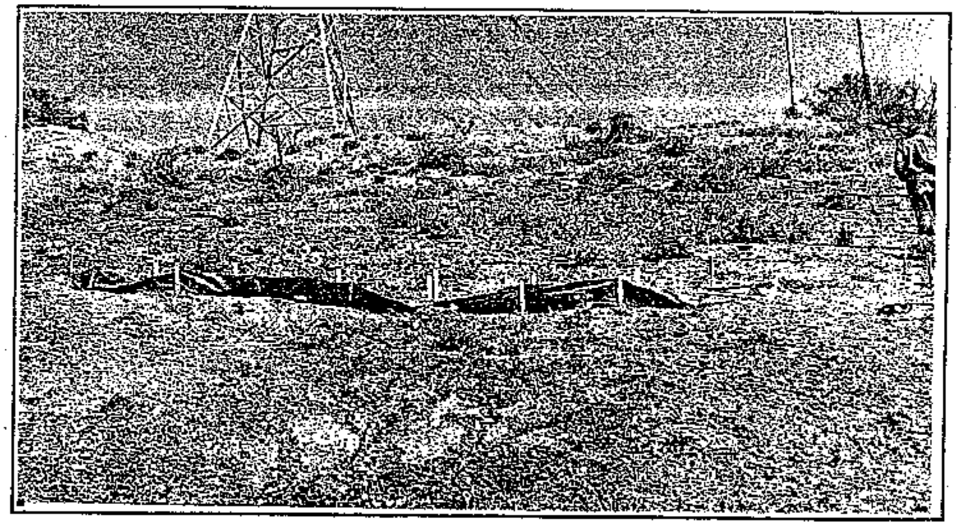
Control -
No Seeding or Mulching

Loc: SE 1/4, SE 1/4, Sec 159, near T6S, R9W
(Laguna Beach 7.5')
Elev: 520' **Slope:** 25%
Aspect: S50E
Geology: Sandstone beds; conglomerates exposed nearby
Soil Series: Cieneba-Rock Outcrop complex (6)
Vegetation/Habitat: California Sagebrush-California Buckwheat scrub

1-14-94



4-13-94



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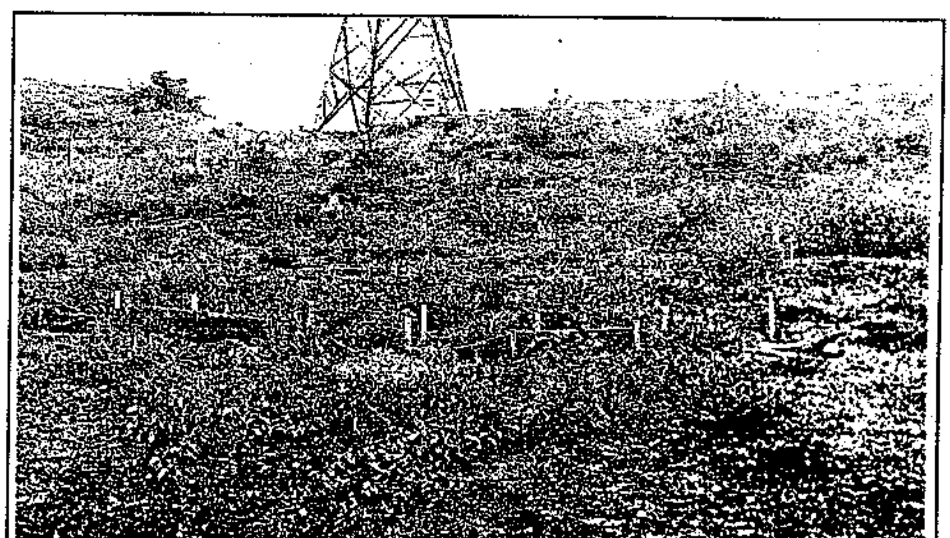


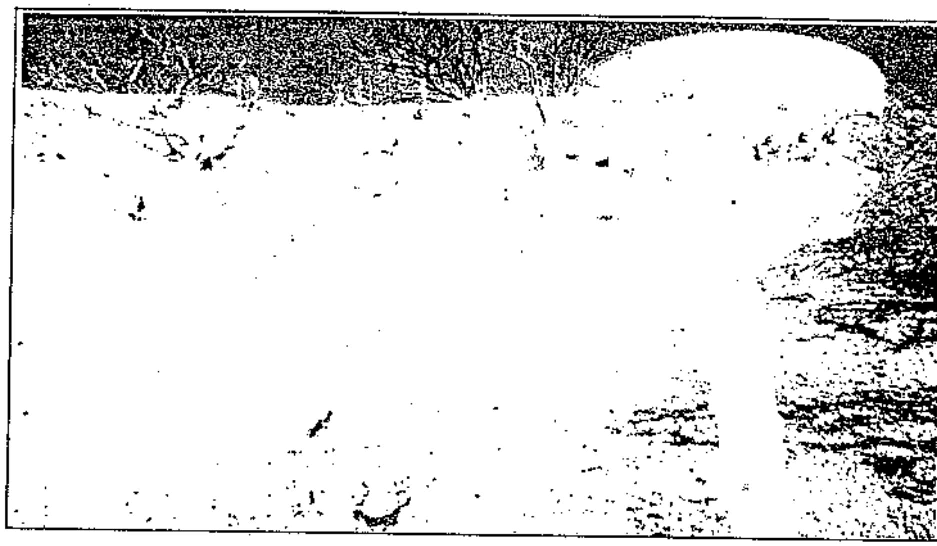
Old Topanga Fire of 11-2-93

Study SiteT-1

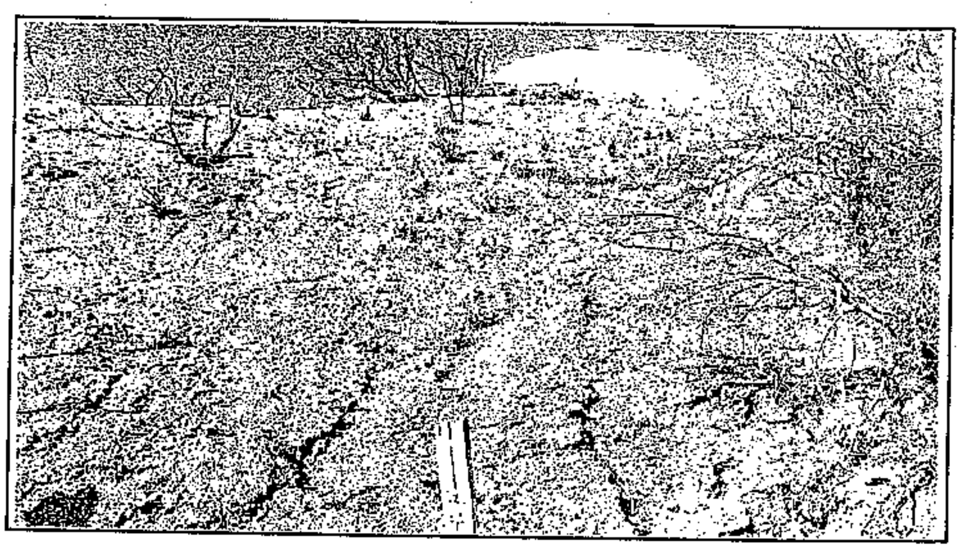
Hydromulched and Seeded 12-21-93

Loc: NE 1/4, SW 1/4, Sec. 34, T1N, R17W (Malibu Beach 7.5')
Elev: 1,640' **Slope:** 55%
Aspect: S15W
Geology: Sandstone, siltstone, and shale beds dip obliquely into slope.
Soil Series: Millsholm (5)
Vegetation: Coastal Scrub (1)

1-11-94



4-11-94



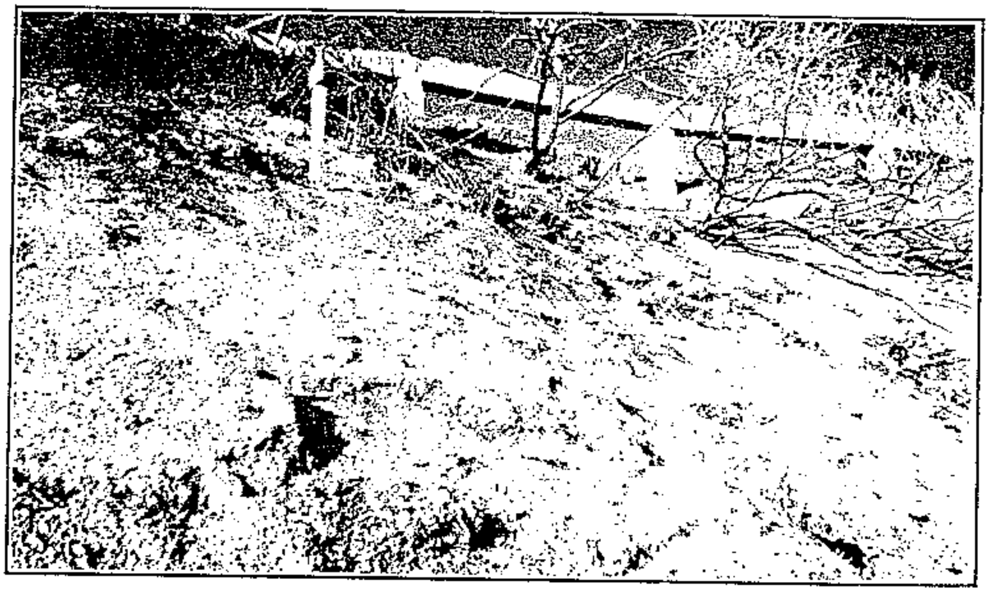
Old Topanga Fire of 11-2-93

Study SiteT-3

Hydromulched and Seeded 12-25-93
(Recycled Fiber; Seed Omitted?)

Loc: Land Grant- W 1/2 Sec. 33, T1S, R17W (Malibu Beach 7.5')
Elev: 325' **Slope:** 75%
Aspect: South
Geology: Fill over volcanics; Malibu Fault Zone.
Soil Series: Millsholm (5)
Vegetation: Coastal Scrub (1)

1-11-94



4-12-94

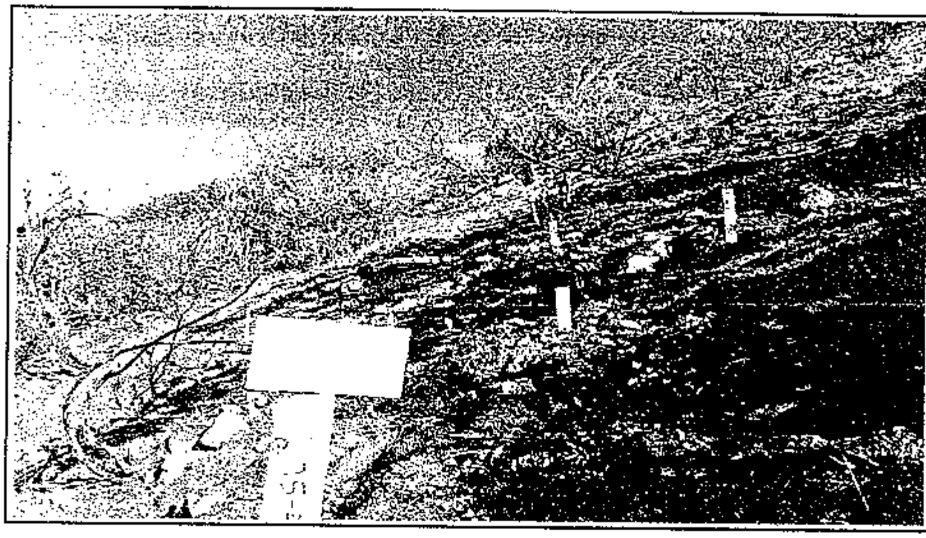
Old Topanga Fire of 11-2-93

Study Site T-5

Control -
No Seeding or Mulching

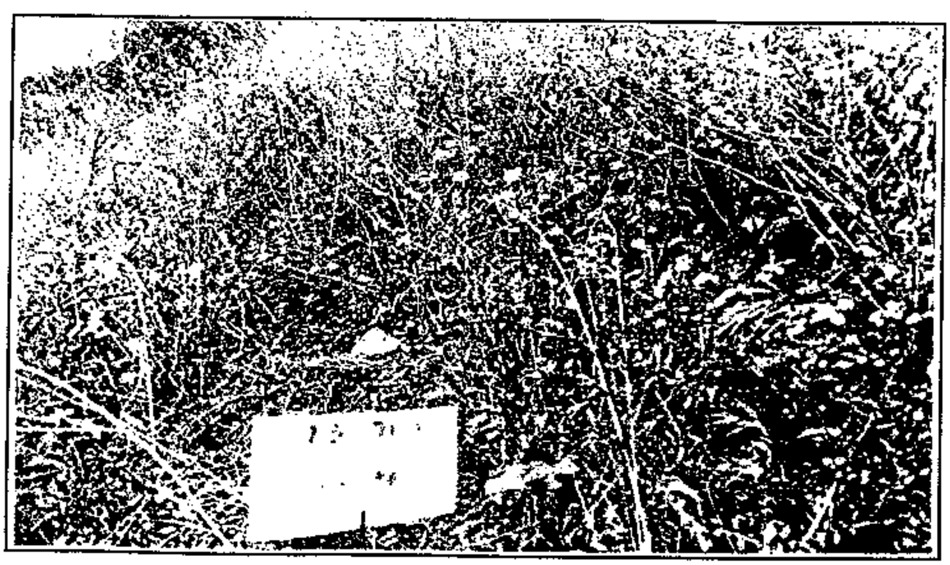
Loc: SW 1/4, NW 1/4, Sec 20, T1S, R17W (Malibu Beach 7.5')
Elev: 1500' **Slope:** 74%
Aspect: S15E
Geology: Sandstone and clayey sandstone beds dip steeply, obliquely into slope.
Soil Series: Millsholm (5)
Vegetation: Coastal Scrub (1)

1-12-94



4-12-94

5-17-94



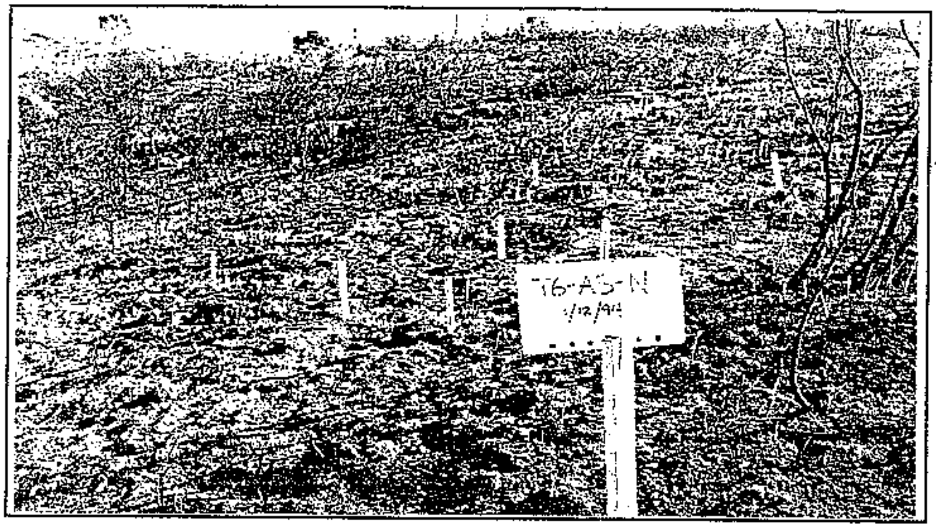
Old Topanga Fire of 11-2-93

Study Site T-6

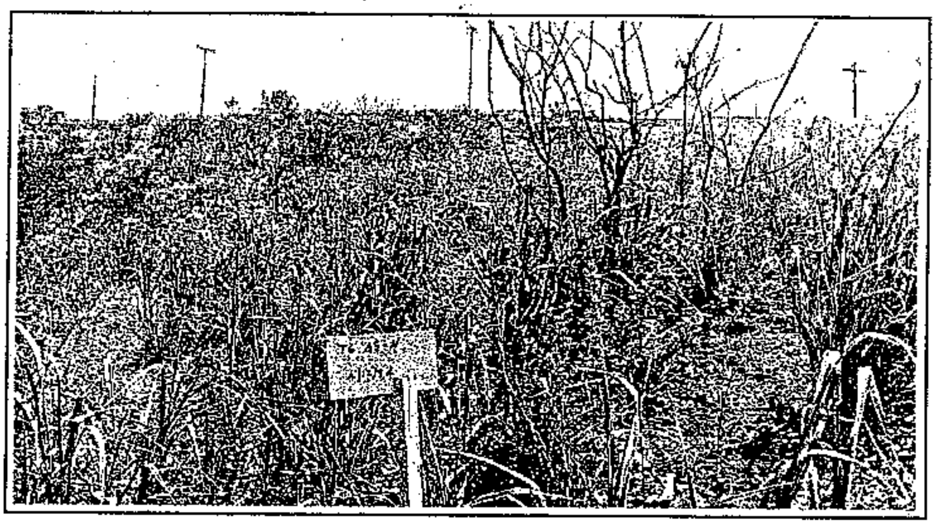
Aerially Seeded 12/4/93±

Loc: SE 1/4, SW 1/4, Sec 22, T1S, R17W (Malibu Beach 7.5')
Elev: 1450' **Slope:** 34%
Aspect: N55W
Geology: Landslide in fractured sedimentary beds that dip steeply, obliquely into slope; Complex structure.
Soil Series: Millsholm (5)
Vegetation: Coastal Scrub (1)

1-12-94



4-11-94



5-17-94

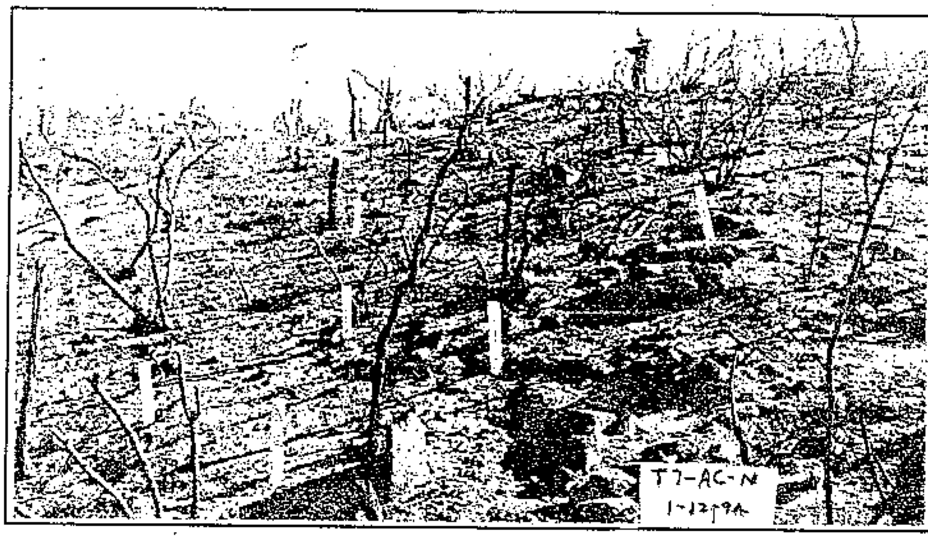
Old Topanga Fire of 11-2-93

Loc: NE 1/4, SW 1/4, Sec 22, T1S, R17W (Malibu Beach 7.5')
Elev: 1600' **Slope:** 38%
Aspect: N55W
Geology: Fine-grained (?) sedimentary beds that generally dip downslopslope at > slope angle? Complex structure.
Soil Series: Millsholm (5)
Vegetation: Coastal Scrub (1)

Study Site T-7

Control -
No Seeding or Mulching

1-12-94



4-12-94

5-17-94

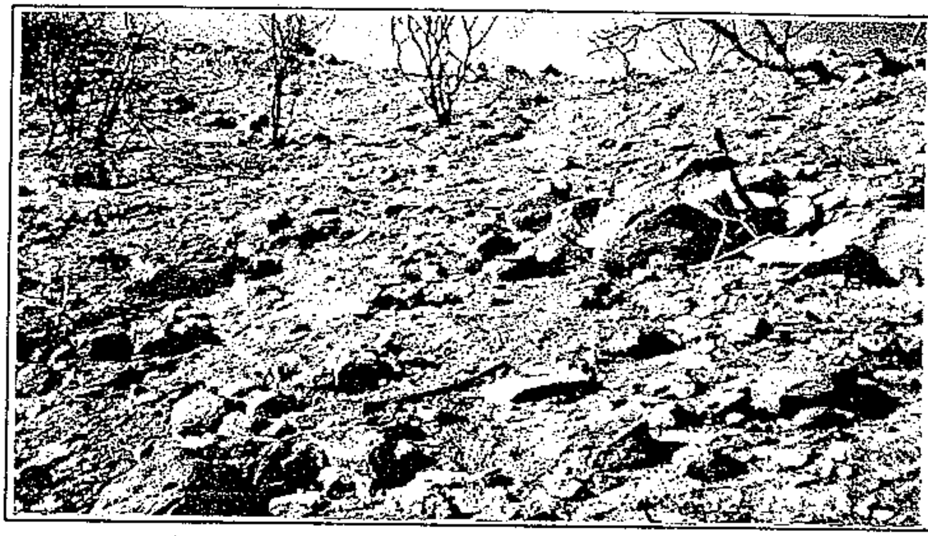
Old Topanga Fire of 11-2-93

Study Site T-8

Aerially Seeded 12/4/93±

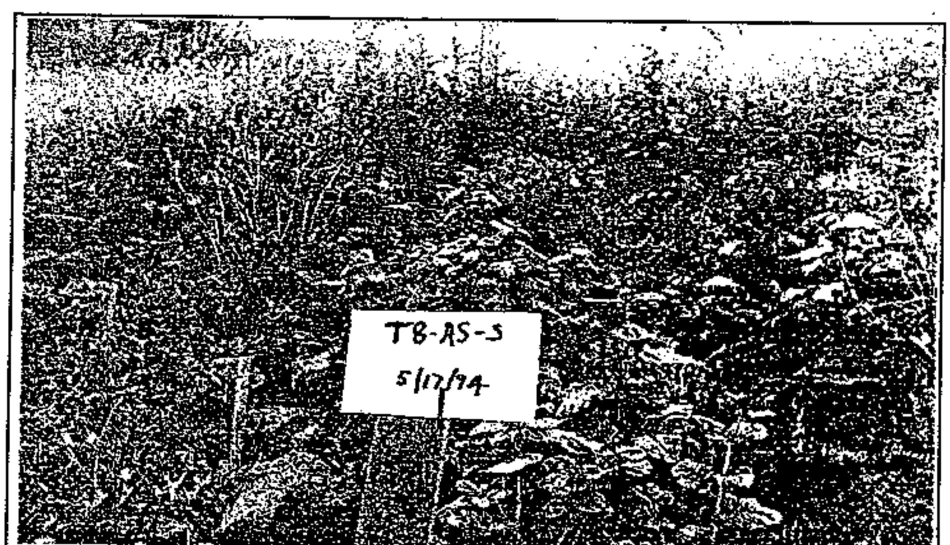
Loc: E 1/2, SE 1/4, Sec 20, T1S, R17W (Malibu Beach 7.5')
Elev: 1850' **Slope:** 60%
Aspect: S65E
Geology: Siltstone beds dip obliquely into slope; boulders and cobbles weathered from upslope sandstone outcrop litter surface.
Soil Series: Sedimentary Rock Land (5)
Vegetation: Coastal Scrub (1)

1-12-94



4-12-94

5-17-94



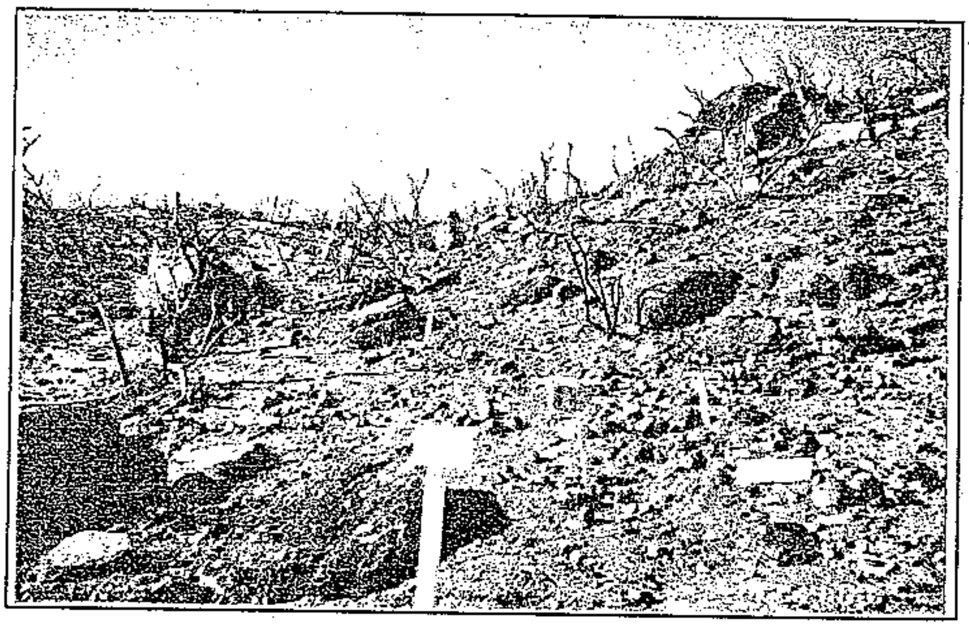
Old Topanga Fire of 11-2-93

Study SiteT-9

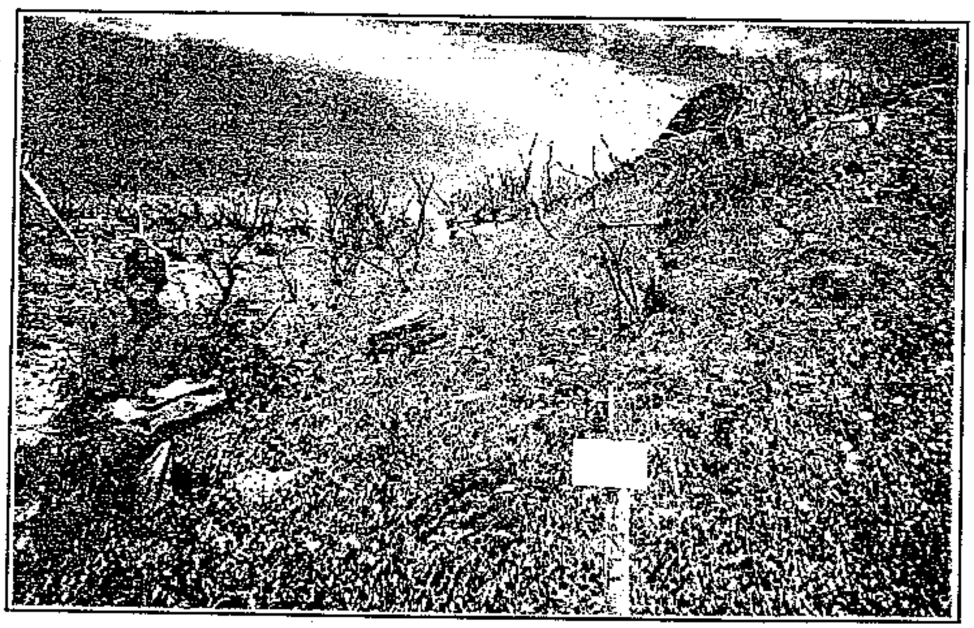
Aerially Seeded 12-4-93

Loc: NW 1/4, 1/4, Sec. 34, T1N, R17W (Malibu Beach 7.5')
Elev: 2,000' **Slope:** 45%
Aspect: S45
Geology: Sandstone beds dip obliquely into slope; boulders and cobbles from upslope sandstone & conglomerate outcrop litter surface; near Zuma Fault.
Soil Series: Sedimentary Rock Land (5)
Vegetation: Coastal Scrub (1)

1-12-94



4-12-94



Kinneloa Fire of 10-27-93

Study Sites K-2

Hydromulched and Seeded 1-7-94±

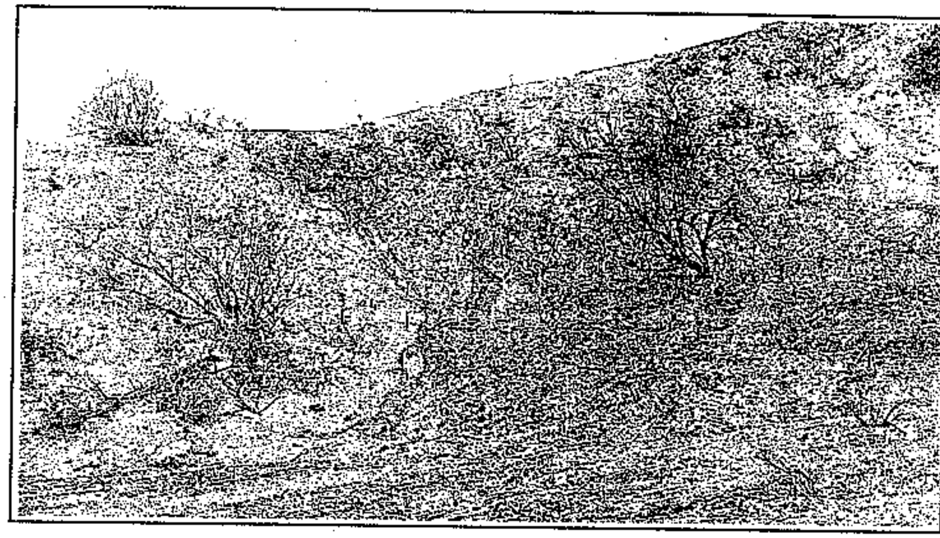
(left side of photos)

K-3 - Control

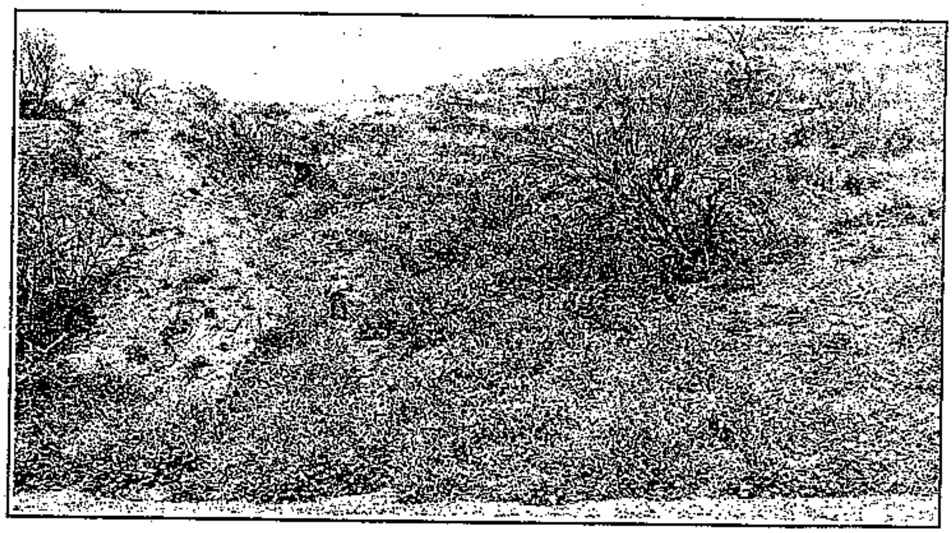
(right side of photos)

Loc: N 1/2, Sec 18, T1N, R11W (Mt Wilson 7.5')
Elev: 1400' **Slope:** 75%
Aspect: S15-20E
Geology: Sheared, fractured metamorphics and granitics; Sierra Madre Fault Zone
Soil Series: Rough Stony Land (2)
Vegetation: Chemise chaparral (1)

1-14-94



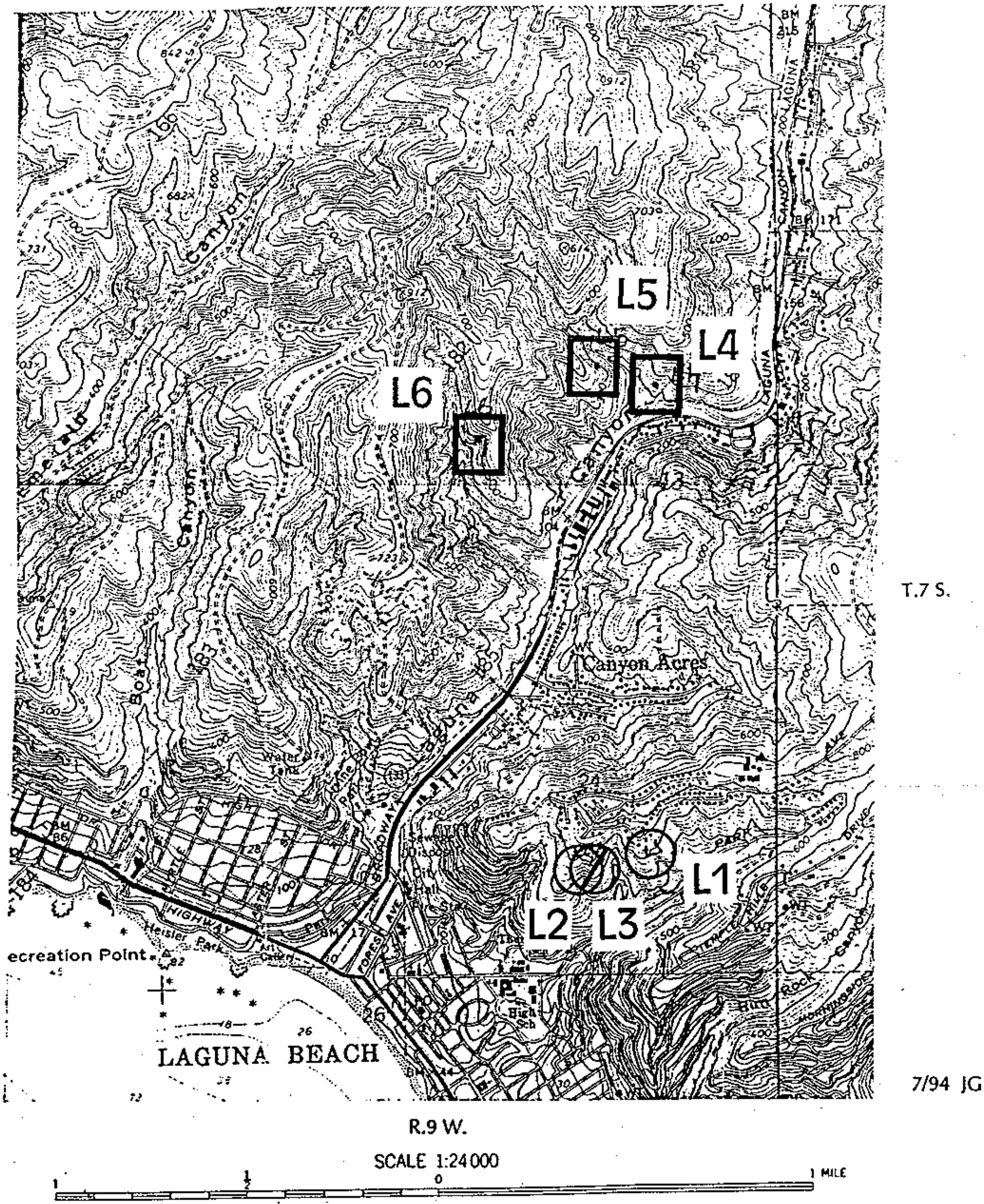
4-14-94



8-11-94

Figure 1 (Appendix B)
EWP Follow-Up Study Plot Locations
Laguna Beach Fire Area

LAGUNA BEACH QUADRANGLE
CALIFORNIA—ORANGE CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

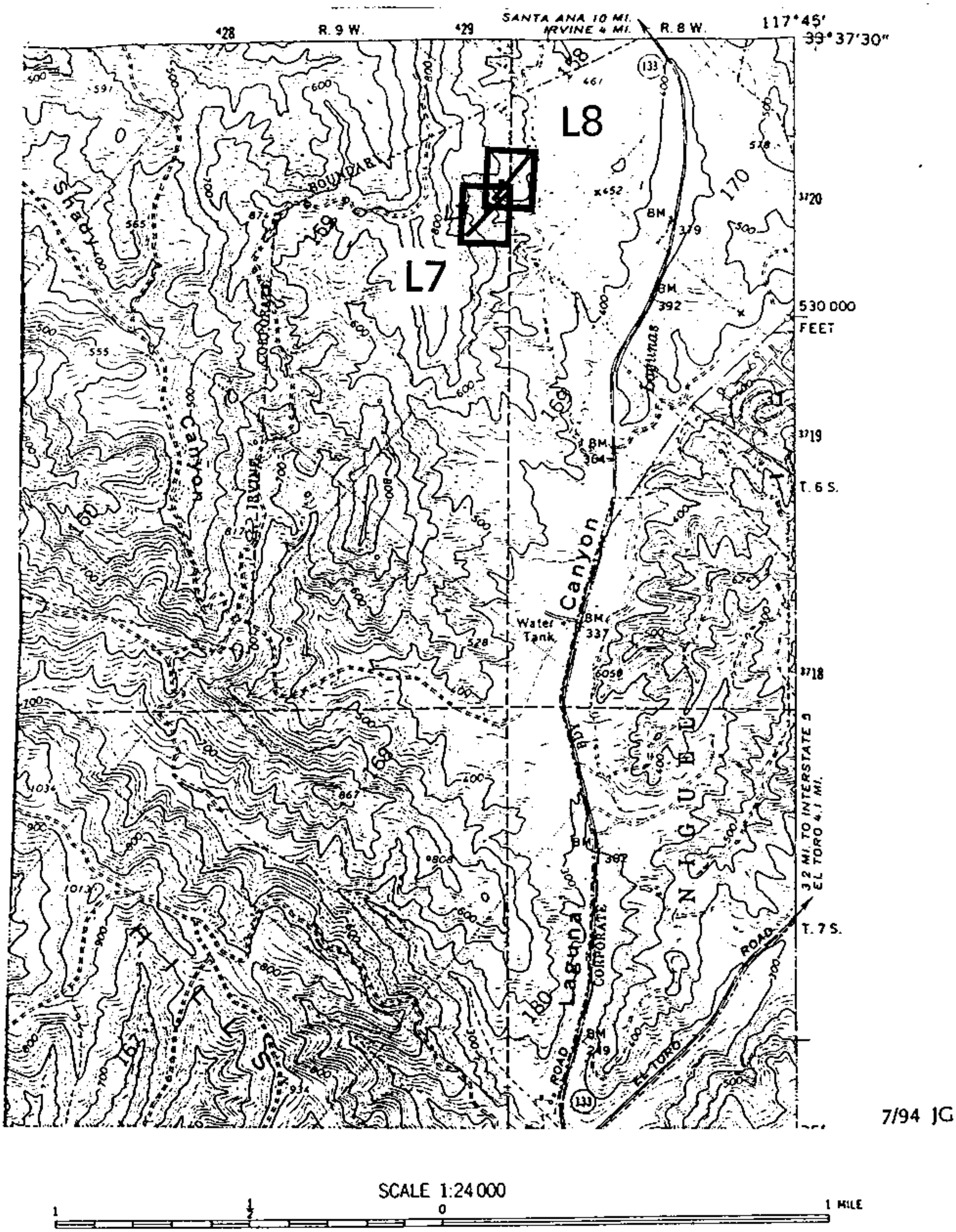


Aerial Seeding
Hydroseeding
Hydroseeding Control

(L2 = Bonded Fiber Matrix)

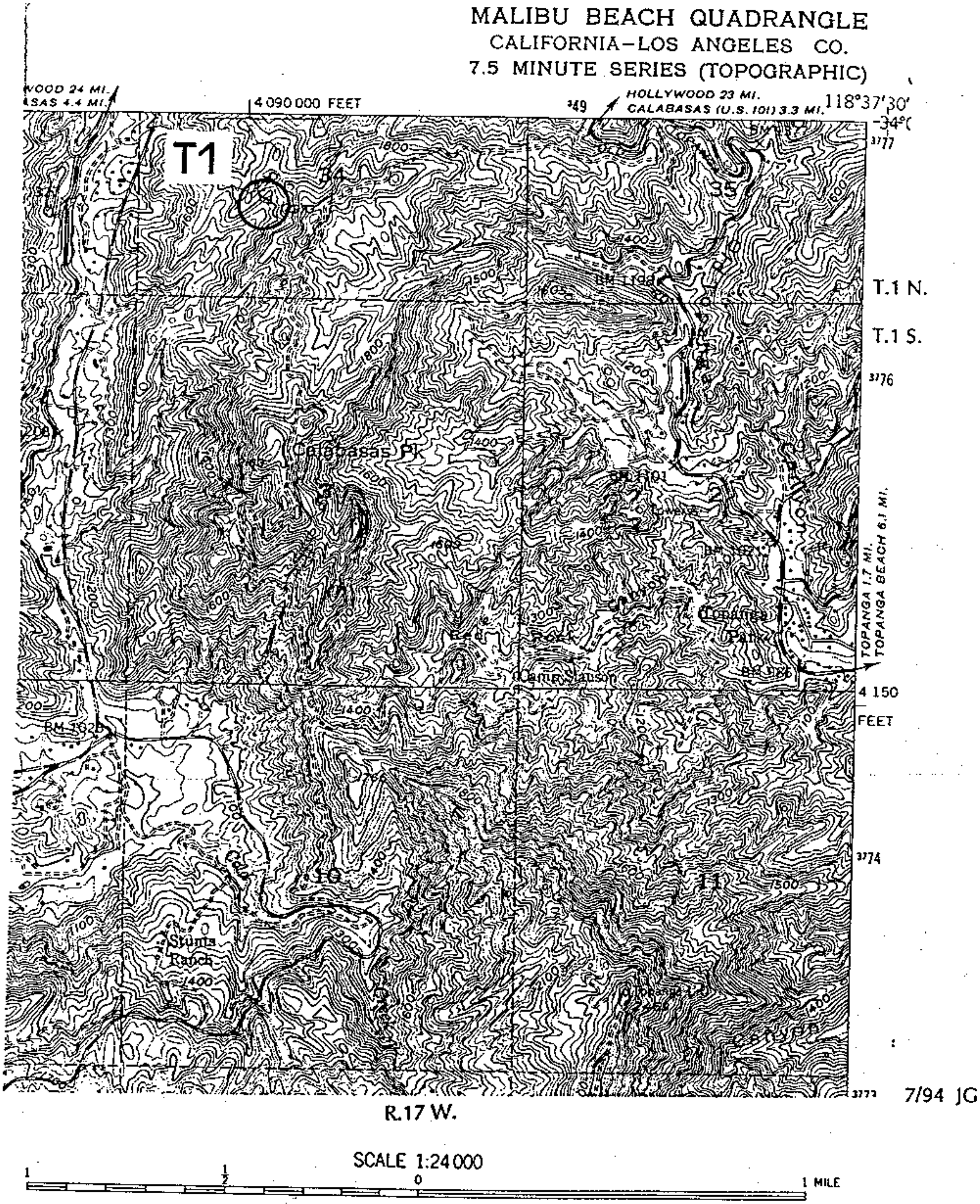
Figure 2 (Appendix IB)
EWP Follow-Up Study Plot Locations
Laguna Beach Fire Area

LAGUNA BEACH QUADRANGLE
CALIFORNIA–ORANGE CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



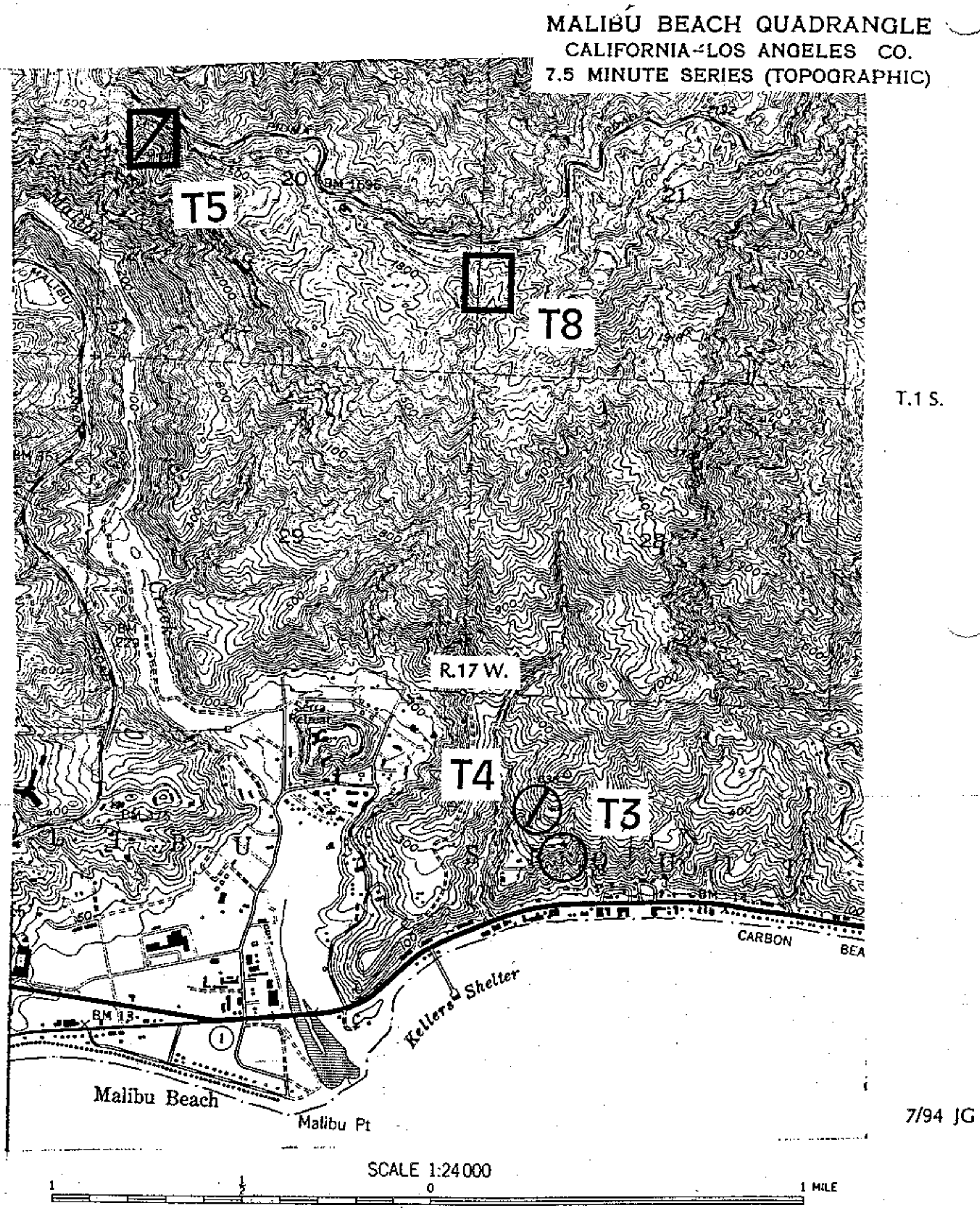
Aerial Seeding Control

Figure 3 (Appendix B)
EWP Follow-Up Study Plot Locations
Old Topanga Fire Area



Hydroseeding

Figure 4 (Appendix B)
EWP Follow-Up Study Plot Locations
Old Topanga Fire Area



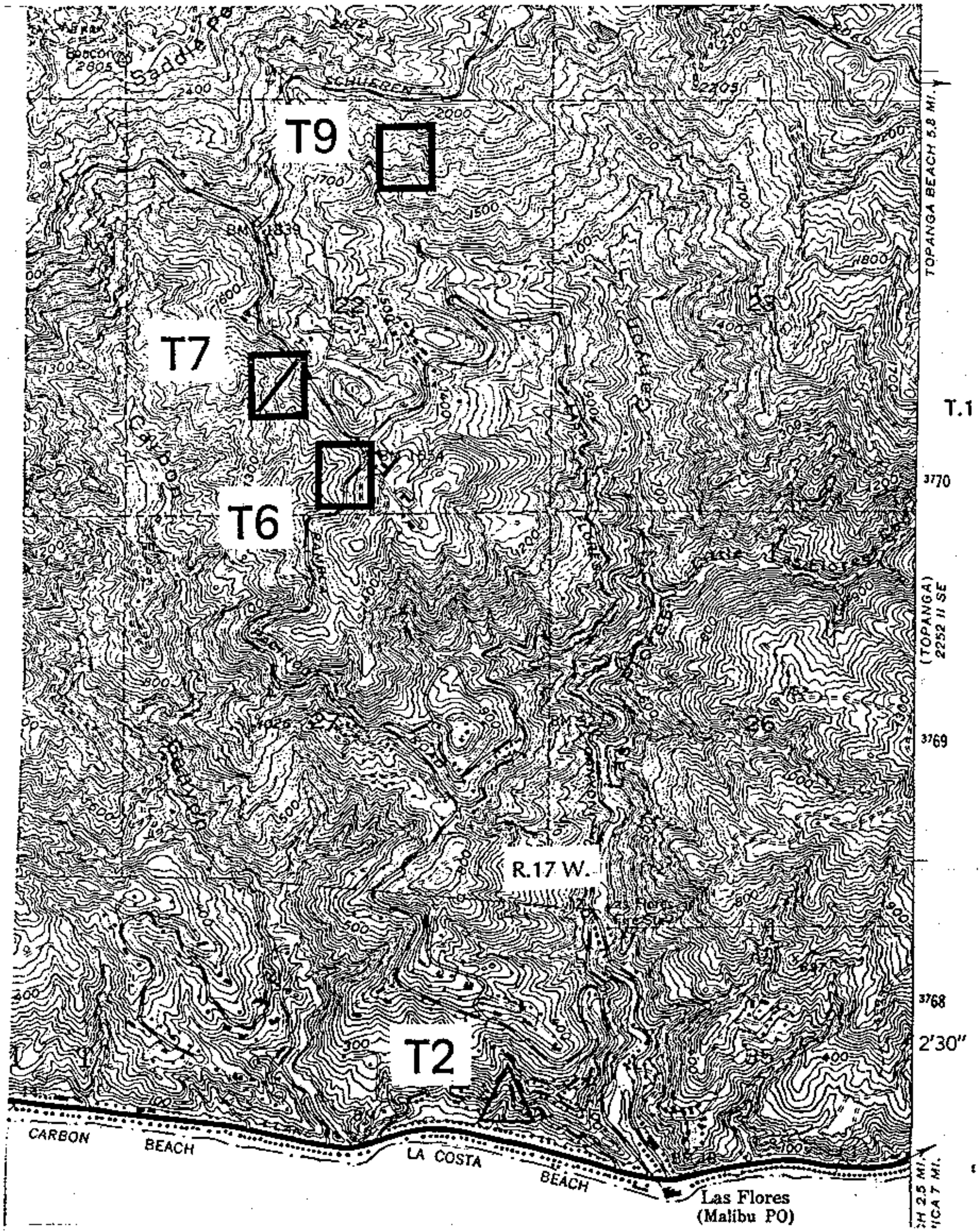
Aerial Seeding

Hydroseeding

(Control where Slashed)

Figure 5 (Appendix B)
EWP Follow-Up Study Plot Locations
Old Topanga Fire Area

MALIBU BEACH QUADRANGLE
CALIFORNIA–LOS ANGELES CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



7/94 JG

SCALE 1:24 000

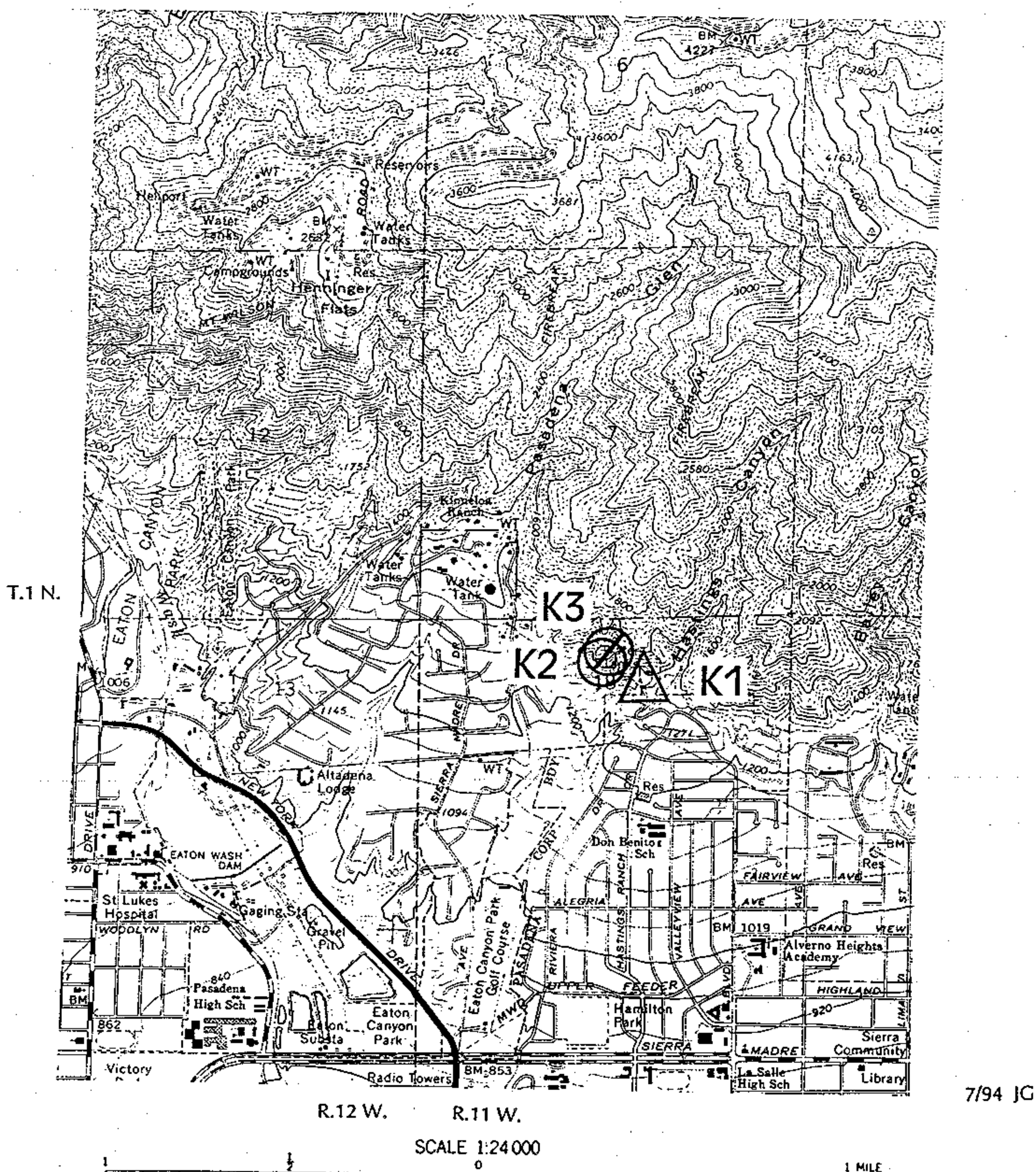
Straw Bale Structures

Aerial Seeding
(Control where Slashed)

Figure 6 (Appendix B)
EWP Follow-Up Study Plot Locations
Kinneloa Fire Area

MT. WILSON, CALIF.
N3407.5—W11800/7.5

1966
PHOTOREVISED 1972
AMS 2352 II NE–SERIES V895



7/94 JG

△ Straw Bale Structures

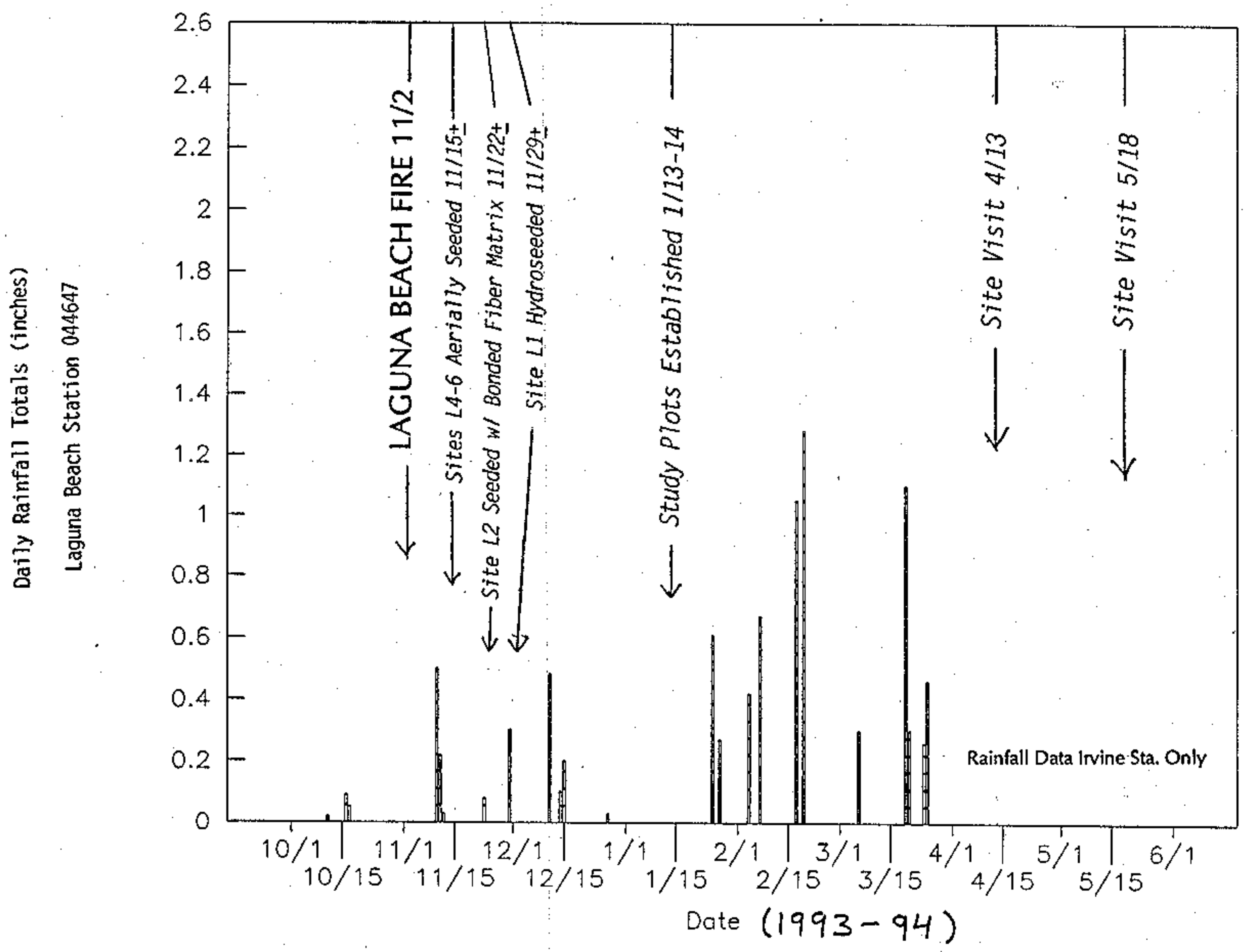
○ Hydroseeding

⊘ Hydroseeding Control

EWP Follow-Up Study

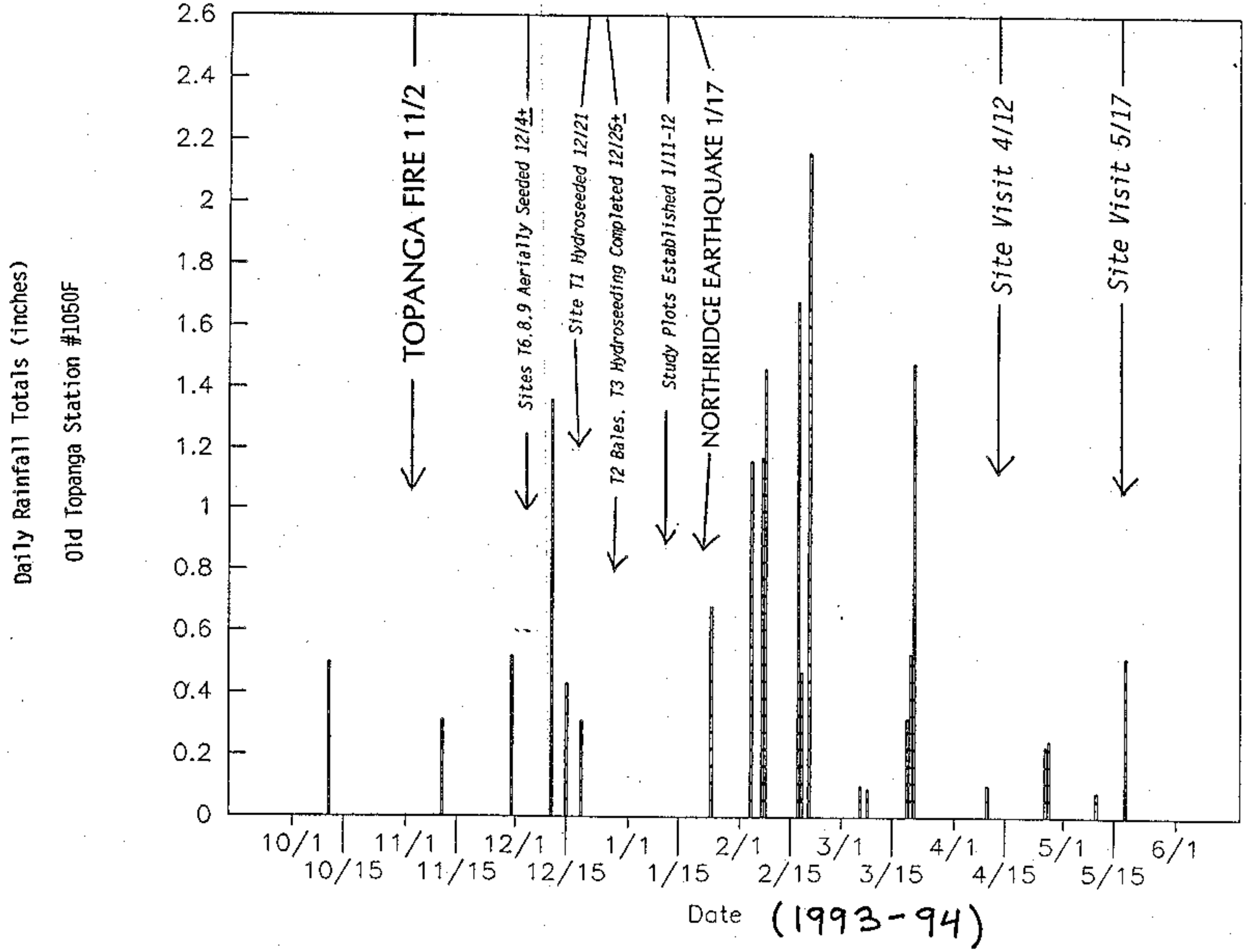
Figure 7 (Appendix B)

Chronology of the Laguna Beach Fire Study Plots



EWP Follow-Up Study
Figure 8 (Appendix B)

Chronology of the Old Topanga Fire Study Plots



EWP Follow-Up Study
Figure 9 (Appendix B)

Chronology of the Kinneloa Fire Study Plots

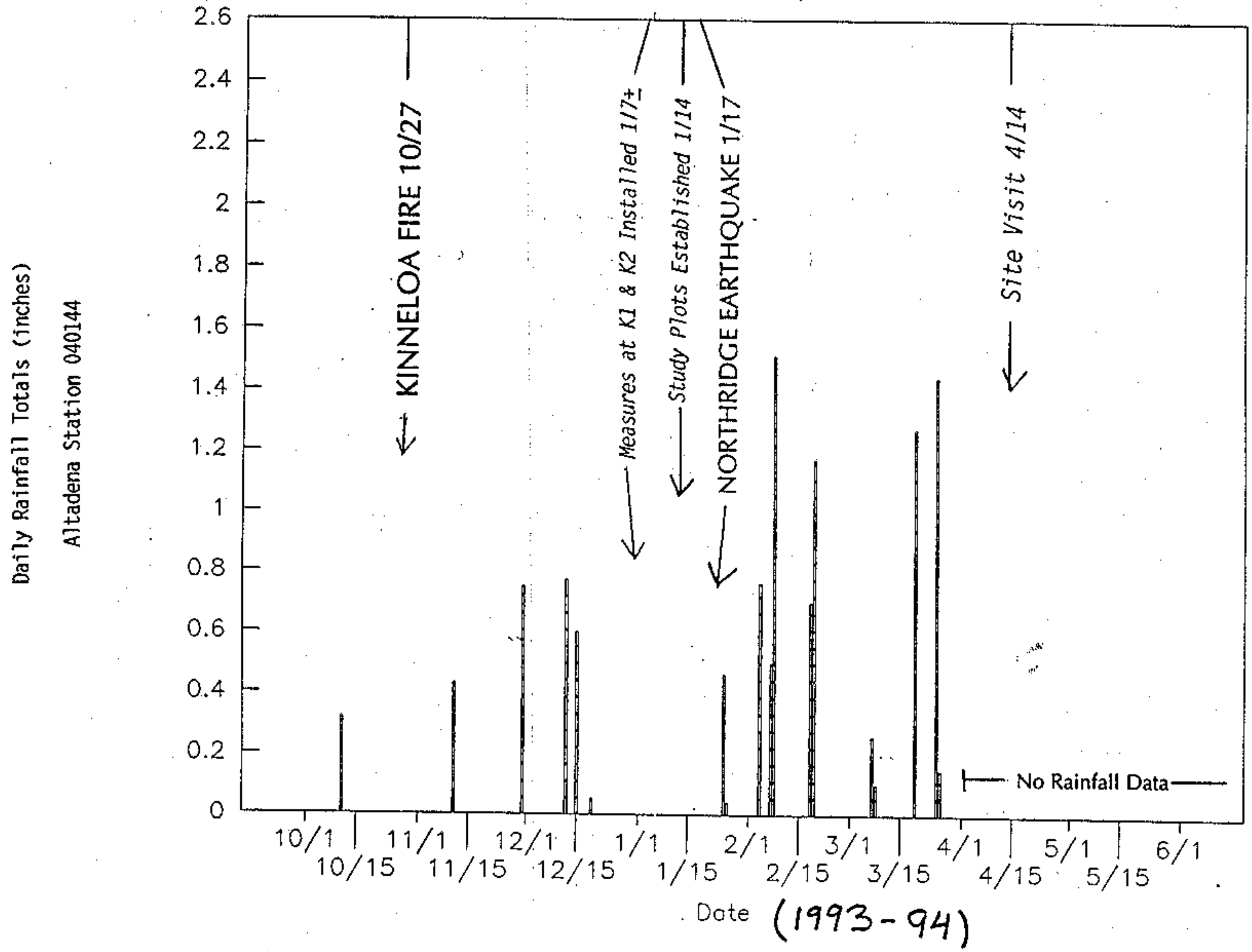
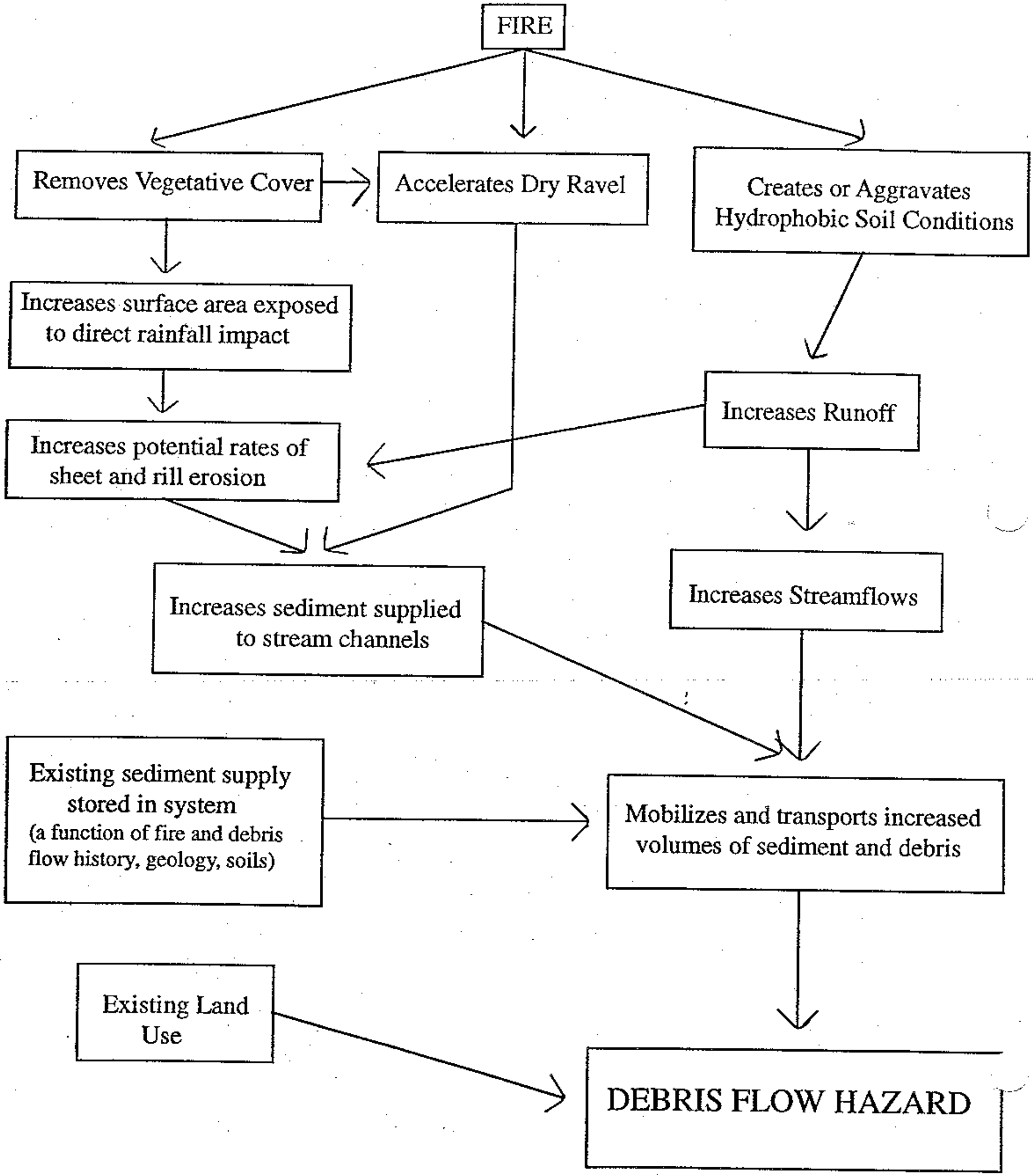


Figure 10

PROCESSES THAT CONTRIBUTE TO INCREASED DEBRIS FLOW HAZARDS FOLLOWING A CHAPARRAL WILDFIRE



EWP Follow–Up
General Geology of Laguna Beach Study Sites
Filename=fy95geol/ewp/lagnageo.wk1
Updated 1/19/95 jkg

TABLE 1 – APPENDIX B

Fire/Area	Site #	% Slope (Aspect)	Formation	Mapped Geology Type/Texture	Structure/Orientation	Field Observations
Laguna Beach	L1–HS	45 (S25E)	Topanga Fm.	Fine silty sandstone, locally conglomeratic, and siltstone interbeds	Approx. 1000' N of Temple Hills Fault Beds dip 25 deg. towards SE	Float of well–graded, medium–to coarse–grained arkosic sandst.
	L2–BFM	32 (S75E)	Topanga Fm.	(see L1)	Approx. 1000' N of Temple Hills Fault Beds dip 25–30 deg. towards SE	Float of poorly–graded, fine–to med–grained sandstone; Exposed on S–facing slope; sed. beds dipping 27 deg. towards E
	L3–HC	34 (S75E)	Topanga Fm.	(see L1)		
	L4–AS–S	38 (S15W)	Vaqueros Fm.	Silty fine– to med–grained arkosic sandstone w/ siltstone and shale interbeds	Approx. 1000' E of Laguna Canyon Fault; beds dip 24–29 deg. towards ESE	Resistant sandstone ledges occur locally
	L5–AS–N	42 (N20E)	Vaqueros Fm. On or near mapped landslide	(see L4)	< 500' E of Laguna Canyon Fault; beds dip 24–30 deg. E to ESE; numerous mapped landslides on N–facing slopes	Massive sandstone exposed just upslope
	L6–AS–S	64 (S45W)	Topanga Fm.	(see L1)	<300' NW of unnamed fault trace; beds dip 25 deg. towards E	Soft sandstone exposed approx. 100' upslope; beds dip E into slope; sediment stored in adjacent channel
	L7–AC–N	40 (N45E)	Sespe Fm.	Nonmarine clayey and silty arkosic sandstone w/ minor beds of conglomeratic sandst., conglomerate, and mudstone	Mapped fault trace follows eastern edge of channel that separates L–7 (south) and L–8 (north)	Nearby roadcut exposes medium–to coarse–grained arkosic sandst. dipping 44 deg. towards SW(?), overlain by poorly–bedded to massive conglomerate (SW side of mapped fault trace)
	L8–AC–S	25 (S50W)	Sespe Fm.			

Reference: Tan, S.S., and Edgington, W.J., 1976, Geology and Engineering Geologic Aspects of the Laguna Beach Quadrange, Orange County, California: California Div. Mines & Geology Special Report 127, 32 p. plus maps, 1:12,000.

EWP Follow–Up
General Geology of Malibu and Kinneloa Study Sites
Filename=fy95geol/ewp/malbugeo.wk1
Updated 1/19/94 jkg

TABLE 2 – APPENDIX B

Fire/Area	Site #	% Slope (Aspect)	Formation	Mapped Geology Type/Texture	Structure/Orientation	Field Observations
Old Topanga	T1–HVF	55 (S15W)	Cold Creek Member Topanga Canyon Fm.	Marine sandstone, siltstone, and pebbly sandstone	Beds dip 48–50 deg. towards NW	Thinly–bedded sandy shale; Med– and coarse–grained sandstone colluvial fragments.
	T3–HRF	75 (S)	Conejo Volcanics near contact w/ coastal nonmarine terrace deposits	Breccia, flow, tuff, volcanic sandstone and siltstone	Malibu Coastal Fault trends NE–SW < 500 map–feet of site; Volcanic sandstone beds to west dip 66 deg. SSW; shale beds south of site and fault dip 20–60 deg. NNE	Site underlain by loose fill material from building pad.
	T4–HC	74 (SW)	Conejo Volcanics	(see T3)		Highly fractured mudstone that readily spalls into 1" fragments observed.
	T5–AC–S	74 (S15E)	Topanga Canyon Fm.	Siltstones and sandstones	West limb of minor north–plunging anticline; beds dip 45–60 deg. NNE to NE	Exposed to west: well–graded qtz. sandstone dipping 42 deg. to vertical towards NW, alternating w/ beds of clayey sandstone.
	T6–AS–N	34 (N55W)	Mapped landslide toe in Coal Canyon Fm.	Marine sandstone, siltstone, pebbly sandstone, and conglomerate	Discontinous high–angle fault traces dipping SE, NNW, etc. mapped on Rambla Pacifico roadcuts in area; orientation of beds also variable, w/ prominent(?) dip dir. towards SW at 30–60 deg.	Exposed across road: alternating beds of fissile shale/shaley sandst. and fractured sandstone that dip gently towards SW.
	T7–AC–N	38 (N55W)	Coal Canyon Fm.	(see T6)	Same general area/structural complexity as T6 – sandstone beds dip 30–50 deg. towards NW to WNW	Nearby sandstone, conglomerate beds dip W to WNW; nearby gully exposes mudstone?
	T8–AS–S	60 (S65E)	Cold Creek Member Topanga Canyon Fm.	(see T1)	Sandstone, siltstone beds dip 20–42 deg. towards N to NW	Exposed 20'W of site: medium–grained fractured sandstone dipping 25 deg. WNW; site underlain by less resistant siltstone?
	T9–AS–S	45 (S45E)	Sespe Fm.	Nonmarine sandstone, pebbly sandst., conglomerate and mudstone (small intrusive bodies in area)	Site ~500' N of Zuma Fault trace/ Coal Canyon Fm contact; area is flanked on E, W, NNE by large ancient landslides; beds dip 13–22 deg. towards N	Sandstone + conglomerate extensively exposed upslope from site; beds dip N
Kinneloa	K2–HS	75 (S20E)	Granitic–Metamorphic Complex	Gneissic granitic rock w/ minor amounts of schist and diorite; abundant cross–cutting granitic dikes; highly sheared and fractured	Located within Sierra Madre Fault Zone; strike of layering generally parallel to front of range	K–2 on relatively resistant ridge of fractured metamorphics; K–3 on eroded swale
	K3–HC	75 (S15E)				

References:

TOPANGA Yerkes, R.F., and Campbell, R.H., 1980, Geologic Map of East–Central Santa Monica Mountains, Los Angeles County, California: U.S. Geological Survey Miscellaneous Map Series I–1146, 1:24,000.

KINNELOA Saul, R.B., 1976, Geology of the West Central Part of the Mount Wilson 7.5' Quadrangle, San Gabriel Mountains, Los Angeles County, California: California Div. Mines & Geology Map Sheet 28, 1:12,000.

Table 3, Appendix B
News Reports of Flooding and Debris Flows in the Laguna Beach Fire Area

11/10-12/93: **0.02" rainfall at Irvine CIMIS**
0.75" rainfall at Laguna Beach

"...as many as 25 homes suffered some damage Thursday morning...and three homes were flooded with muck as deep as five feet in some rooms. Although no one was injured, dozens of people fled their neighborhoods. (A resident) watched as a dozen cars floated down Canyon Acres Drive...In many cases, workers had not yet secured some of the hay bales intended to absorb the rains, and many of them floated down city streets in a torrent of water.". Laguna Canyon Road temporarily closed.

12/11/94: **0.38" rainfall at Irvine CIMIS**
0.48" rainfall at Laguna Beach

Laguna Canyon Road "was shut down due to flooding and authorities called for the voluntary evacuation of hilly areas considered most prone to mudslides...Nevertheless...(their) worst fears...remained unmaterialized."

1/27/94: **0.31" rainfall at Irvine CIMIS**
0.27" rainfall at Laguna Beach

"A quarter-inch to half inch of rain fell in an hour...Six miles of Highway 133 through Laguna Canyon were closed for about four hours because of mud six to 18 inches deep...But most of the debris dams, sandbagging and other diversion techniques implemented after the fires kept water and mud away from homes and diverted flows into culverts or the roadway...None of the canyon's 208 residents were evacuated."

(in-house report): "Some post and wire revetment structures that were about 90% complete sustained minor damage. Some cleanup after the rains in the Irvine Bowl will be necessary. The projects performed as planned."

2/7/94: **0.82" rainfall at Irvine CIMIS**
0.67" rainfall at Laguna Beach

"...the most powerful storm of the winter...tornadolike winds (Newport Beach to Tustin, esp. Irvine)...nearly 2 inches of rain on parts of Orange County."

"(Compared to Topanga and Kinneloa Fire areas) Laguna Beach...had less rain and no mudslides."

2/17-18/94: **1.09" rainfall at Irvine CIMIS**
1.05" rainfall at Laguna Beach

"...except for local flooding the region emerged more weary than wet from Thursday's rainstorms."

2/19-20/94: **0.57" rainfall at Irvine CIMIS**
1.28" rainfall at Laguna Beach

"...Laguna Canyon Road...sustained minor flooding."

3/19-20/94: **0.93" rainfall at Irvine CIMIS**
1.40" rainfall at Laguna Beach

"...flash flood warning was in effect in several areas that were burned...including Laguna Beach...No substantial flooding was reported, however."

Table 4, Appendix B
News Reports of Flooding and Debris Flows in the Topanga Fire Area

11/11/93: **0.40" rainfall at Malibu-Big Rock**
0.31" rainfall at Old Topanga
0.35" rainfall at Calabasas

"In Malibu...a mudslide shut down all but one lane of Pacific Coast Highway, as residents filled sandbags in anticipation...the mud and debris on the highway took work crews about six hours to clear. The damage was produced by relatively little rain - between a quarter-inch and a half-inch in most areas."
(in-house report): One slide yesterday and another one this morning deposited debris along roads in Topanga Canyon and left three feet of sediment in one home.

11/15/93:
"...winds gusted as high as 53 miles per hour in the Santa Monica Mountains.." Concerns expressed about the winds' impacts on recently completed aerial seeding.

12/11-12/93: **0.40" rainfall at Malibu-Big Rock**
1.36" rainfall at Old Topanga
0.84" rainfall at Calabasas

"...intense but mercifully swift-moving winter storm...causing mud and water to ooze down canyon roads, but bringing no major reports of major damages or injuries. In fire-ravaged Malibu...rock and mud slid onto the side of Pacific Coast Highway...mud streaming down Big Rock Canyon..."

1/24-25/94: **0.30" rainfall at Malibu-Big Rock**
0.68" rainfall at Old Topanga
0.61" rainfall at Calabasas

(in-house report): "Last week's rain...caused little sediment damage..."

2/7-8/94: **1.80" rainfall at Malibu-Big Rock**
2.63" rainfall at Old Topanga
1.65" rainfall at Calabasas

"In Malibu, water, mud and rocks coursed down the canyons to the sea, invading homes and blocking portions of Pacific Coast Highway between Topanga Canyon Boulevard and Malibu Canyon Road...A delta of debris washed out of Big Rick Canyon Road and across Pacific Coast Highway, sloshing against about a dozen houses and scattering half a dozen cars and trucks...despite (sandbagging) efforts, mud began seeping into shorefront homes and about 15 houses farther inland at Big Rock and in Las Flores Canyon...More than 30 residents were forced to evacuate. A big Caltrans skip-loader was used to pluck..(about two dozen residents) from their roofs (and/or upper floors).."
"The Malibu Colony...was not affected by the slides (that closed PCH)..."
"Total damage is estimated to be about $1.6 million."
(In-house report): "Las Flores Canyon had to be closed. Pacific Pallisades had heavy mudflows."

Table 4, Appendix B - Cont'd
News Reports of Flooding and Debris Flows in the Topanga Fire Area

2/17-18/94: **1.80" rainfall at Malibu-Big Rock**
2.15" rainfall at Old Topanga
1.09" rainfall at Calabasas

"...except for local flooding the region emerged more weary than wet from Thursday's rainstorms...by 3 p.m...the National Weather Service to cancel flood, storm, and wind warnings for most of the region...Tractors cleared several minor mud and rockslides along the Pacific Coast Highway stretching from...Ventura County...to Santa Monica...Warnings of severe storms prompted several Malibu residents to abandon their homes.."

2/20/94: **2.40" rainfall at Malibu-Big Rock**
2.16" rainfall at Old Topanga
1.52" rainfall at Calabasas

" (In Malibu) rivers of mud cascaded down coastal canyons and onto Pacific Coast Highway...Sunday...A mudslide briefly trapped a handful of Malibu residents inside their homes, and a motorist was rescued from his car in Las Flores Canyon when it became mired in muck...Several homes were damaged...no evacuations were ordered, and no injuries were reported...About 2 inches of rain loosened soil Sunday despite reseeding and sandbagging...mud in front of a few beachfront homes caused portions of asphalt to collapse...In Big Rock, (one resident reported seeing) a 2-foot-deep river of mud and water flowing down the street."

3/6-8/94: **0.00" rainfall at Malibu-Big Rock**
0.19" rainfall at Old Topanga
0.16" rainfall at Calabasas

"Malibu...escaped with minor damage...(and) was getting moderate rain, but was prepared to handle flooding."

3/19-21/94: **0.60" rainfall at Malibu-Big Rock**
2.33" rainfall at Old Topanga
0.74" rainfall at Calabasas

"...flash flood warning was in effect in several areas that were burned...included Malibu...No substantial flooding was reported, however."

Table 5, Appendix B
News Reports of Flooding and Debris Flows in the Kinneloa Fire Area

11/15/93: High winds reported for Los Angeles County

Concerns expressed about the winds' impacts on recently completed aerial seeding.

12/11-12/93: 0.78" rainfall at Mt. Wilson
0.77" rainfall at Altadena

(in-house report): "Saturday's rains produced a total of 4 to 8 feet of sediment deposited in recently completed sediment basins...Debris and mud flowed down a street just an hour after 1,400 feet of SCS-designed K-rails were installed...They functioned as planned."

"Indeed, some relieved residents of Pasadena Glen...said Saturday's rains might prove beneficial by helping newly planted hillside vegetation germinate...Nonetheless, 39 families...voluntarily evacuated their Pasadena Glen homes....Heavy debris...flowed through Pasadena Glen in midafternoon. But, with the roadway closed and houses protected like fortresses behind three foot high stacks of sandbags, no damage was reported."

1/25-26/94: 1.34" rainfall at Mt. Wilson
0.50" rainfall at Altadena

(in-house report): "storm damage from last week's rains...: The Winnifred Canyon project experienced some silt damage, but is back in shape now. The Pasadena Glen trash racks had some sediment wash in where the racks are to be placed, but the sediment has been excavated..."

2/7-8/94: 2.01" rainfall at Mt. Wilson
2.67" rainfall at Altadena

"up to 5 feet of mud smashed through sandbag berms and chased residents from 40 homes. At least 12 people were temporarily stranded and 5 homes sustained water damage..."

(in-house report): "The Winnifred channel in the Pasadena Glen area had a basin behind a structure under construction overflow, washing away steel that had been laid down. The steel was pushed down into the main channel. The lower culvert of Winnifred Canyon plugged up. A lot of debris washed over the road, undermining it so that the road washed away, closing a main exit for the residential area. Holes dug for the Pasadena Glen debris barriers filled up with sediment and debris. Damage to homes was reported in the Oak Grove area. All residents were safely evacuated there. Wilcox Canyon worked well. All of the debris that came down stayed in the channel. The K-rails around the Loma Alta and Glen Ellen areas were topped by the flows, but they did protect the homes."

2/17-20/94: 1.87" rainfall at Mt. Wilson
3.25" rainfall at Altadena

"most residents in (Pasadena Glen Canyon) fled the burgeoning runoff waters...Emergency crews erected steel barriers and flood control walls."

"The Altadena Fire area...escaped flooding Sunday..."

3/6-8/94: 0.36" rainfall at Mt. Wilson
0.66" rainfall at Altadena

"...in the foothills of the San Gabriel Mountains, searchers on Monday found (the shoe of a 9-year old missing from Sierra Madre since Sunday)...in a catch basin that was half-filled with water and mud."

3/19-20/94: 1.27" rainfall at Mt. Wilson
0.87" rainfall at Altadena

"...no substantial flooding reported..."

POST-SCRIPT
Tables 3-5, Appendix B
LA Times News Reports of Flooding and Debris Flows of January 4-11, 1995
-All three fire areas-

Reports dated 1-4-95:
"...(burned) bare hillsides from Malibu to Altadena to Laguna Beach...showed surprising resistance to mudslides..."

"Parts of Orange County were hit hard. Floodwaters clogged streets, forced evacuations, and tore out a 100-foot stretch of boardwalk in Laguna Beach that may cost $300,000 to repair...(the) flood control manager (stated that)...the storm...dumped nearly four inches of rain in some places in a few hours."

Reports dated 1-7-95:
News article notes that the LA County Department of Public Works oversees a sophisticated flood control system that consists of "15 dams, 129 debris basins, 470 miles of open channel, and 2,300 miles of underground storm drains."

The "Los Angeles County fire inspector...said the hillsides stripped of soil-binding vegetation (by the 1993 fires)...were still holding, 'but the ground up there is saturated and if these storms keep up, it's very possible there will be some problems.'"

Report dated 1-9-95:
"Despite warnings of bacterial contamination from storm drains, surfers poured into the water off Topanga State Beach to enjoy the unusually large eight-foot waves..."

Report dated 1-10-95:
"...residents in the Altadena burn area were told to be ready to evacuate."

Reports dated 1-11-95:
"All told, almost three inches of rain fell at the Los Angeles Civic Center by late afternoon...There were widespread variations, however-Pasadena recorded 5.3 inches, El Toro (in Orange County) 2.31 and the Matilija Creek station in Santa Barbara recorded 12.32 inches."

Two local residents..."left their home on Wonderview Drive in Glendale on Tuesday morning, shortly before mud slammed through a retaining wall and into their master bedroom."

"At the beach in Malibu, the hillsides that have somehow stayed together despite a week of debilitating rains began to give way. Rushing brown water and boulders coursed down creeks and roads alike...Thirty homes were ordered evacuated, and into the afternoon the surging Las Flores Creek threatened to wash away homes and swept away much of a local landmark, Cosentino's Nursery."

"In nearby Topanga Canyon, residents compared the storm to a cataclysmic weather system in 1990, when portions of the roads serving the area were washed out."

Summary report for the Civic Center Area in Malibu: PCH closed to general traffic about 7:30 a.m.; closed to residents about 12:30 p.m.; Malibu Lagoon bridge closed at 12:30 because of fear of collapse; classes at Pepperdine University were cancelled; Surfrider Beach cluttered with tree trunks and debris washed down by Malibu Creek; stores in Cross Creek Mall closed.

Summary report for Las Flores Canyon Area in Malibu: PCH closed to general traffic about 7:30 a.m., several mudslides reported, one car trapped; Las Flores Creek overflowing - emergency crews use backhoe to remove debris; floor and creekside walls of Cosentino's Nursery collapse; about 50 people are evacuated; many businesses closed; supports beneath Las Flores Creek bridge erode, resulting in temporary closure.
One article noted the "week's worth of punishing storms in February, 1992, (which) dumped more than 16 inches of rain, caused seven deaths and $88 million in damage."

POST-SCRIPT CONT'D
Tables 3-5, Appendix B

Reports dated 1-11-95 cont'd:

"In...Pasadena Glen, storm waters, carrying boulders so large they sounded like passing aircraft, tumbled by-but not through any homes. New culverts diverted torrents...completed (in October) at a cost of $1.2 million (which came) from the Federal Emergency Management Agency and homeowner assessment fees of $500 per household. The largest culvert (has a capacity) of 2,600 (cfs)..., or about three times the amount coming down Tuesday at midday." "'This much water and rain last year would have been a disaster. It would have taken out homes, said (a local contractor and resident)." "'From our experience, this amount of rain should cause flooding' (said a national Weather Service specialist), 'so the credit ought to go to those people who set up those barriers and sandbags.'"

Reports dated 1-12-95:

Cumulative total rainfall as measured at LA Civic Center January 3 through 11, 1995: 1/3: 0.45"; 1/4: 2.48"; 1/5: 3.69"; 1/7: 4.64"; 1/8: 5.36"; 1/9: 5.51"; 1/10: 8.50"; 1/11: 9.06". Average Annual Rainfall is 15.0".

"Caltrans crews hoped to reopen part of the Malibu Lagoon Bridge by nightfall Wednesday. The bridge, built in 1935, had been scheduled to be replaced in the next year."

"The latest rains sent a river of mud-laden water into downtown businesses in Laguna Beach...(residents) hope to persuade city officials to prevent a similar occurrence in the future, perhaps by cutting a culvert through Laguna's popular Main Beach park to allow floodwaters to reach the Pacific more easily."

As of 1/11, a state of emergency remained in effect, portions of Laguna Canyon Road remained closed by flooding, and PCH was open only during rush hour.

EWP Follow-Up
Erosion and Sedimentation Hazard Summary of Study Sites
Filename=fy95geol/ewp/genhaz.wk1
Updated 1/19/95 jkg

TABLE 6 ~ APPENDIX B

* Informal reports that seed was omitted from hydromulch at T3.
Also at T3, solids content of mulch was below spec.

Fire/Area	Site #	% Slope (Aspect)	Geology Summary	Predicted Sediment Yield ~ Post Fire Conditions (1)	Estimated Erosion/Sedimentation Hazard Ratings: Landslides (2)	Dry Ravel (3)	Sheet and Rill (4): Unburned	Post-burn	4/94	% Cover Obs. 4/94 (5) N=species not in seed mix Y=sp. incl. in seed mix M=est. cover from mulch	Erosion-Related Field Observations 1/94, 4/94
Laguna Beach	L1-HS	45 (S25E)	Sandstone and silty sandstone beds dip downslope, generally parallel to surface; near Temple Hills Fault.	150 cy/acre (182 tons/acre at 90 pcf) Assumed	5	2	1	30	15	N=6 Y=13 M=30	1/94: Patchy though relatively competent mulch layer; rare burrows; 1/2"-deep cracks; no rilling. 4/94: Mulch has decomposed and is thin, discontinuous; numerous burrows or ant hills; rills not obvious; minor pedestaling.
	L2-BFM	32 (S75E)	Fine- and medium-grained sandstone beds dip downslope at or slightly greater than surface slope; near Temple Hills Fault.	150 cy/acre (182 tons/acre at 90 pcf) Assumed	3	1	1	24	7	N=10 Y=30 M=90	1/94: Relatively continuous, thick mulch mat; discontinuous where sprayed over cactus, at microescarpments, and at rare burrows. 4/94: Bonded fiber matrix remains relatively intact, strong; resprouting veg. esp. in swales and on flatter spots; possible correlation between BFM mat thickness and veg. resprout - is there less germination where mat is 1/4" vs. 1/8" thick?
	L3-HC	34 (S75E)			3	1	1	20	4	N=20 – –	1/94: Burn layer essentially intact except where wind erosion has thinned; rilling not obvious. 4/94: Some pedestaling; no obvious rills; some ash remains.
	L4-AS-S	38 (S15W)	Siltstone and sandstone beds dip obliquely into slope; near Laguna Canyon Fault.	150 cy/acre (182 tons/acre at 90 pcf) Assumed	4	2	1	28	4	N=50 Y=0 – (i.e. 0% total veg cover from seeding)	1/94: Ash has blown away; 20-30% patches of burned roots; very minor pre-fire rilling. 4/94: Poorly-defined "levee" of burned debris to 8" high across plot suggests possible sed. transport as small-scale debris flows; sheet erosion; some post-fire rills to 1" deep, esp. where concentrated flow comes off bedrock and at slope break.
	L5-AS-N	42-70 (N20E)	On or near landslide in siltstone and sandstone beds that dip obliquely out of slope; near Laguna Canyon Fault.	150 cy/acre (182 tons/acre at 90 pcf) Assumed	6	4	1	24	4	N=25 Y=20 – (i.e. 0-44% total veg cover from seeding)	1/94: Very steep, irregular surface incl. small escarpments, rare cobble-sized frags; discontinuous ash layer; some pre-fire rills, small slumps. 4/94: Pedestals suggest sheet erosion dominates; rilling not obvious; resprouting veg. confined to flatter areas; debris flows down main channel bet. L4 and L5 have damaged chain-link debris catchments and filled rock gabion structures.
	L6-AS-S	64 (S45W)	Silty sandstone and siltstone beds dip obliquely into slope; near unnamed fault trace.	150 cy/acre (182 tons/acre at 90 pcf) Assumed	5	3	1	11	2	N=44 Y=6 – (i.e. 0-12% total veg cover from seeding)	1/94: Steep, irregular surface w/ loose material, rare cobbles, small slumps and escarpments, very minor rilling. 4/94: Pedestals to 6-8" suggest sheet erosion dominates; shallow, poorly-defined rills, esp. near/around cobbles.
	L7-AC-N	40 (N45E)	Sandstone beds dip obliquely out of slope? conglomerates exposed nearby; near unnamed fault trace.	150 cy/acre (182 tons/acre at 90 pcf) Assumed	4	2	1	19	15	N=5 – –	1/94: Notably bare; some rilling; downslope channel w/ post-fire sediment accumulations from slopes around L7, L8. 4/94: Roughly 1.6 ft3 of fine- to med-grained sand + ash accum. behind silt fence, equiv. to approx. 0.9 tons/ac sed yield from 0.08 ac. drainage area. Assuming 100% sed. delivery and noting that structure neither overtopped nor failed, approx. sheet and rill erosion rate= 1 ton/ac. Major sed. source to downslope channel = gullying to 10' deep up nearby first-order drainage and along roadbanks.
	L8-AC-S	25 (S50W)			3	1	1	11	7	N=15 – –	1/94: Notably bare; some pre-fire shallow to moderately-deep rills; black, some grey ash remains; note sediment accum. in nearby channel as described for L7. 4/94: Roughly 3 ft3 of fine- to med-grained sand + ash accum. behind silt fence, equiv. to 0.5 tons/ac sed. yield, from 0.26 ac drainage area. Erosion rate is higher, citing partial failure of silt fence, minor sed. from upslope road, and < 100% delivery; rills + relatively unchanged pre-fire rills; much ash remains.
Old Topanga	T1-HVF	55 (S15W)	Sandstone, siltstone, and shale beds dip obliquely into slope.	49 cy/acre for 10y event (60 tons/acre at 90 pcf) Using Scott & Williams, 1978	3	3	2	95	36	N=20 Y=10 M=65	1/94: Relatively continuous, competent mulch layer. 4/94: Roughly 210' of rills to 5" deep + sheet erosion has deposited roughly 1.5 tons (33 ft3) of sed at base of slope; assuming 90% delivery, this is equivalent to approx. 2 tons/ac. erosion.
	T3-HRF	75 (S)	Fill over volcanic sed. beds and/or other volcanics; Malibu Coastal Fault Zone.	77 cy/acre for 10y event (93 tons/acre at 90 pcf) Using Scott & Williams, 1978	6	4	2	61	5	N=80 Y=0* M=65	1/94: Very weak, crumbly mulch; ornamental veg. sprouting up through mulch to 3' high; ants helping breaking up mulch. 4/94: Downslope neighbor reports two 10-12 cy flows from hillslope onto his driveway, with mud going over nearby retaining wall; sheet erosion dominates, w/ minor shallow rills; mulch erodes as fragments, esp. from nearby swale/landslide scar.
	T4-HC	74 (SW)	Highly fractured volcanic siltstones and shales.	35 cy/acre for 10y event (43 tons/acre at 90 pcf) Using Scott & Williams, 1978	3	5	5	204	NA	(site dropped)	1/94: Very steep swale w/ loose material, small debris chutes and dry ravel; some rilling; ash layer essentially lost. 4/94: Landowners hydroseeded and installed 3 sandbag dikes before Feb or Mar storm.
	T5-AC-S	74 (S15E)	Sandstone and clayey sandstone beds dip steeply, obliquely into slope.	43 cy/ac for 10y event (52 tons/acre at 90 pcf) Avg. rate per acre of all model results used for est.	4	3	3	122	8	N=80 – –	1/94: Very steep, w/ surprisingly thick soil mantle; rare pre-fire rills; some cobble-sized frags; discontinuous ash layer. 4/94: Evidence of minor rill + sheet erosion; rills typically shallow, w/ 3"-wide scarps 1-2" high; rapidly thinning; dense veg. cover obscures view; ash confined to small areas under shrubs.
	T6-AS-N	34 (N55W)	Landslide in fractured sed. beds that dip obliquely into slope? Complex structure; dry ravel and talus are common. to Coal Canyon Fm.	30 cy/acre for 10y event (36 tons/acre at 90 pcf) Using Scott & Williams, 1978	6	1	1	52	4	N=55 Y=20 – (i.e. 0-27% total veg cover from seeding)	1/94: No observed rilling; common microescarpments; located on landslide toe; discontinuous black ash layer. 4/94: Sheet erosion has created pedestals to 0.5"; rills are more obvious near top of plot; approx. 12 small burrows.
	T7-AC-N	38 (N55W)	Fine-grained (?) sed. beds that generally dip downslope at > slope angle(?); complex structure; dry ravel and talus are common to Coal Canyon Fm.		4	2	2	72	21	N=40 – –	1/94: Very minor rilling; some cobble-sized frags; large gully nearby; rare microescarpments; discontinuous ash layer. 4/94: Very shallow, subtly-expressed rills + sheet erosion.
	T8-AS-S	60 (S65E)	Siltstone beds dip obliquely into slope; boulders and cobbles weathered from upslope outcrop litter surface.	43 cy/ac for 10y event (52 tons/acre at 90 pcf) Avg. rate per acre of all model results used for est.	3	5	1	12	2	N=60 Y=0 – (i.e. 0% total veg cover from seeding)	1/94: Very steep, rocky; small dry ravel cones nearby at sandstone contact; boulders, cobbles, and loose material make walking difficult; discontinuous black ash layer. 4/94: Discontinuous rills to 4" deep where concentrated flow erodes between large surface frags; ~2" of debris accum. onto nearby dry ravel cones since Jan.; resprouted grasses approx. 5' downslope limits sed. delivery from cones to drainage.
	T9-AS-S	45 (S45E)	Sandstone beds dip obliquely into slope; boulders and cobbles weathered from upslope ss and cng outcrop litter surface; near Zuma Fault.	38 cy/acre for 10y event (46 tons/acre at 90 pcf) Using Scott & Williams, 1978	5	2	1	6	1	N=55 Y=10 – (i.e. 0-15% total veg cover from seeding)	1/94: Cobbles and boulders litter surface; very minor rills between large frags; first-order drainage cuts across western edge of plot. 4/94: Rilling confined to small channel where flows run off bedrock; rills 2-10" deep; other rills nearby but not obvious in study plot; sheet erosion.
Kinneloa	K2-HS	75 (S20E)	Sheared, fractured metamorphics and granitics Sierra Madre Fault Zone.	167 cy/acre for 50y event (137 tons/acre at 90 pcf) LA Co. design debris event for Sierra Madre Villa Dam (da=1.46mi2)	3	6	1	21	6	N=10 Y=14 M=60	1/94: Dry ravel dominates; just upslope of filled debris basin; rilling in first-order drainage has eroded thru' mulch; mulch is relatively continuous, competent. 4/94: Barer but rockier than control site; rills, esp. in swale; debris cones downslope w/ veg.
	K3-HC	75 (S15E)			2	6	1	21	1	N=60 – –	1/94: Dry ravel dominates; rills through dry ravel cones. 4/94: Pedestaling, mini-slumps, some rilling observed through dense but patchy cover.

(1) Sediment yield rate estimates for subwatersheds where study plots were located. Different models were used for different burn areas. For the sake of comparison, volumetric estimates reported for Laguna and Kinneloa were converted to tons/ac assuming a dry unit density of 90 pcf.
(2) Landslide hazards at study sites were qualitatively rated based on observations, published information (1=lowest; 6=highest).
(3) Propensity of areas near study sites to produce sediment by dry ravel, based on observations, USFS proposed guidelines (1=lowest; 6=highest).
(4) Potential rates of sheet and rill erosion for unburned, burned, and as observed in April, 5 1/2 months after the fires. The Universal Soil Loss Equation was used to estimate relative potential sheet and rill erosion hazard between sites and over time. Results typically reported in tons/acre-yr, although units have been intentionally omitted to emphasize USLE's use as a comparative tool.
(5) Percent vegetative and mulch cover visually estimated in field. Percent veg. cover from species that were also included in the applied seed mix vs. from species not included in mix are est. based on plant count data and/or visual estimation. Percent cover from species included in seed mix represents maximum possible success rate of applied seed (seeding was done using native species; the proportion of cover from species included in the mix but actually germinated from the resident seed base cannot be determined.)

Planting Evaluation for

Hydro Seeded Blando Brome

Appendix D-13

Characteristics	K2 HMHM	K3 HS-C-	T1 HVF	T3 HRV	L1 H5	L2 BFM	L3 HC
Stand			7	9			
Client Acceptance			8				
Survival							
Competition			5				
Destroyed			N	Y			
Height/Inches			3				
Weed competition			5				
Vigor			2				
Sprouting Res. spp.			1				
Adaptation to site			7				
Plant Injury			1				
Injury type							
Erosion-Sheet rill gully			2				
Erosion-Landslide			9				
Erosion-Debris Flow			6				

Planting Evaluation for

Hydro Seeded Blando Brome

Appendix D-12

Characteristics	K2 HMHM	K3 HS-C-	T1 HVF	T3 HRV	L1 H5	L2 BFM	L3 HC
Stand			7	9			
Client Acceptance			8				
Survival							
Competition			5				
Destroyed			N	Y			
Height/Inches			3				
Weed competition			5				
Vigor			2				
Sprouting Res. spp.			1				
Adaptation to site			7				
Plant Injury			1				
Injury type							
Erosion-Sheet rill gully			2				
Erosion-Landslide			9				
Erosion-Debris Flow			6				

*Control sites were evaluated for native/resident species

Planting Evaluation for

Hydro Seeded Zorro Annual Fescue

Appendix D-11

Characteristics	K2 HMHM	K3 HS-C-	T1 HVF	T3 HRV	L1 H5	L2 BFM	L3 HC
Stand	4	2			8	3	4
Client Acceptance	3	3			3	2	4
Survival							
Competition	1				1	2	
Destroyed	N	N			N	N	N
Height/Inches	12	36			12	12	18
Weed competition	3				2	2	
Vigor	4	2			3	2	3
Sprouting Res. spp.	2	2			2	2	3
Adaptation to site	2	2			3	2	2
Plant Injury							
Injury type							
Erosion-Sheet rill gully	3	2			8	8	6
Erosion-Landslide	8	7			9	9	9
Erosion-Debris Flow	3	2			8	9	8

*Control Sites were evaluated for native/resident species

Planting Evaluation for

Hydro Seeded California Poppy

Appendix D-10

Characteristics	K2 HMHM	K3 HS-C-	T1 HVF	T3 HRV	L1 H5	L2 BFM	L3 HC
Stand	3	2			8	7	4
Client Acceptance	2	3			2	2	4
Survival							
Competition	1				3	2	
Destroyed	N	N			N	N	N
Height/Inches	12"	36"			18"	12"	18"
Weed competition					2	2	
Vigor	2	2			1	2	3
Sprouting Res. spp.	2	2			2	2	3
Adaptation to site	2	2			2	2	2
Plant Injury	1	1			1	1	1
Injury type							
Erosion-Sheet rill gully	3	2			8	8	6
Erosion-Landslide	8	7			9	9	9
Erosion-Debris Flow	3	2			8	9	8

*Control sites were evaluated for nature/resident species.

Planting Evaluation for

Hydro Seeded Hykon rose clover

Appendix D-9

Characteristics	K2 HMHM	K3 HS-C-	T1 HVF	T3 HRV	L1 H5	L2 BFM	L3 HC
Stand	9	2	6	9			
Client Acceptance		3	8				
Survival							
Competition	1		2				
Destroyed	Y	N	N	Y			
Height/Inches		36	1				
Weed competition		2	3				
Vigor		2	1				
Sprouting Res. spp.		2	7				
Adaptation to site		2	7				
Plant Injury		1	1				
Injury type							
Erosion-Sheet rill gully		2	2				
Erosion-Landslide		7	9				
Erosion-Debris Flow		2	6				

*Control sites were evaluated for native/resident species

Planting Evaluation for

Aerial Seeded Blande Brome sites & Control sties

Appendix D-8

Characteristics	L4 AS-5	L6 AS-5	L8 AC-5	L5 AS-N	L7 AC-5	T5 AC-5	T8 AS-5	T9 AS-5	T6 AS-N	T7 AC-N
Stand						4	9	7	9	6
Client Acceptance						2		7		5
Survival								2		
Competition										
Destroyed						N	Y	N	Y	N
Height/Inches						14		5		8
Weed Competition								7		
Vigor						3		7		6
Sprouting Res Spp.						4		2		4
Adaptation to Site						2		7		3
Plant Injury						1		1		1
Injury type										
EROSION										
Sheet rill gully						8		8		7
Landslides						9		9		9
Debris flow						8		7		8

*Control sites were evaluated for native/resident

Planting Evaluation for

Aerial seeded hykon rose clover

Appendix D-7

Characteristics	L4 AS-5	L6 AS-5	L8 AC-5	L5 AS-N	L7 AC-5	T5 AC-5	T8 AS-5	T9 AS-5	T6 AS-N	T7 AC-N
Stand						4	9	6	9	6
Client Acceptance						2		3		5
Survival										
Competition								3		
Destroyed						N	Y	N	Y	N
Height/Inches						14		2		8
Weed Competition								7		
Vigor						3		4		6
Sprouting Res Spp.						4		2		4
Adaptation to Site						2		5		3
Plant Injury						1		1		1
Injury type										
EROSION										
Sheet rill gully						8		8		7
Landslides						9		9		9
Debris flow						8		7		8

*Control sites were evaluated for native/resident species

Planting Evaluation for

Native/resident species

Appendix D-6

Characteristics	L4 AS-5	L6 AS-5	L8 AC-5	L5 AS-N	L7 AC-5	T5 AC-5	T8 AS-5	T9 AS-5	T6 AS-N	T7 AC-N
Stand	4	4	7	6	8	4	3	4	2	6
Client Acceptance	2	2	8	2	8	2	4	4	2	5
Survival										
Competition										
Destroyed	N	N	N	N	N	N	N	N	N	N
Height/Inches	24	12	14	24	10	14	18	18	24	8
Weed Competition										
Vigor	2	2	3	2	3	3	3	3	2	6
Sprouting Res Spp.	7	5	9	9	9	4	3	2	3	4
Adaptation to Site	2	2	5	4	5	2	2	2	2	3
Plant Injury										
Injury type										
EROSION										
Sheet rill gully	8	5	5	5	4	8	4	8	8	7
Landslides	8	8	9	7	9	9	8	9	9	9
Debris flow	2	7	8	6	6	8	4		9	8

*Control sites evaluated for native/resident species

Planting Evaluation For

Aerial Séeded Zorro Fescue

Appendix D-5

Characteristics	L4 AS-5	L6 AS-5	L8 AC-5	L5 AS-N	L7 AC-5	T5 AC-5	T8 AS-5	T9 AS-5	T6 AS-N	T7 AC-N
Stand	4	9	7	3	8	4	9	7	3	6
Client Acceptance	3		8	2	8	2		7	2	5
Survival										
Competition	2			2				2	2	
Destroyed	N	Y	N	N	N	N	Y	N	N	N
Height/Inches	10		14	18	10	14		6	12	8
Weed Competition	5			4				7	6	
Vigor	3		3	1	3	3		5	2	6
Sprouting Res Spp.	7		9	9	9	4		2	3	4
Adaptation to Site	2		5	1	5	2		6	2	3
Plant Injury	1		1	1	1	1		1	1	1
Injury type										
EROSION										
Sheet rill gully	8		5	5	4	8		8	8	7
Landslides	8		9	7	9	9		9	9	9
Debris flow	2		8	6	6	8		7	9	8

*Control sites were evaluated for native/resident species.

PLANTING EVALUATION

Characteristics Legend for Appendix-D-5 through D-13

Stand:

Relative value of stand of species planted (1 excellent, 9 none).

Client Acceptance:

Rating (1 best, 9 worst)-is the user satisfied with performance of this plant.

Competition:

How does the plant compete with native species. Rating: (1 none, 9 severe).

Destroyed:

Answer yes if the planting was destroyed, or no if it still exists.

Height:

Inches- height recorded to the nearest inch.

Weed Competition:

Rating (1 none, 9 severe).

Vigor:

Rating (1 excellent, 9 poor).

Sprouting of Resident Species:

Relative vigor and size of sprouting regrowth. Rating (1 excellent, 9 none).

Adaptation to Site:

Rating (1 best, 9 worst) - Will the plant perform adequately on this site give proper management?

Plant Injury:

Rating (1 none, 9 severe)

Appendix D-4

SPECIES FOUND AT OR NEAR SITE	K2 HMHM	K3 HS-C	T1 HVF	T3 HRV	L1 HS	L2 BFM	L3 HC
Annual fescue	X	--	--	--	X	X	X
Foothill stipa	--	--	X	--	X	X	X
Nodding stipa	--	--	--	--	X	X	X
Brodea	--	--	X	--	--	X	X
California poppy	X	X	X	--	X	X	X
Red brome	--	X	X	--	X	X	X
Lemmonade berry	--	--	--	--	X	X	X
Prickely pear	--	--	--	--	--	X	X
Chamise	--	--	X	--	--	X	--
California encelia	--	--	--	X	X	X	--
Lotus	X	--	X	--	X	X	X
Spiny lupine	--	X	--	--	--	X	--
Softchess	--	--	X	--	X	X	--
Mariposa lilly	--	--	--	--	X	X	--
Wild oats	--	--	X	--	X	--	--
Black mustard	X	X	X	X	X	--	--
Black nightshade	--	X	X	--	--	--	--
Rose clover	--	X	X	--	--	--	--
Yucca spp.	X	--	X	--	--	--	--
Morning glory	--	X	X	--	--	--	--
Arroyo lupine	--	--	X	--	--	--	--
Tobacco tree	--	--	--	X	--	--	--
Man-root	X	--	--	--	--	--	--
Common mallow	X	--	--	--	--	--	--
Laurel sumac	--	X	--	--	--	--	--
Poison oak	--	X	--	--	--	--	--
California sage	--	X	--	--	--	--	--
Perennial rye	--	X	--	--	--	--	--
Black sage	--	--	--	--	X	--	--

Species in bold print were hydroseeded. Refer to Appendix D-2.

Appendix D-3

SPECIES FOUND AT OR NEAR SITE	L4 AS-S	L6 AS-S	L8 AC-S	L5 AS-N	L7 AC-N	T5 AC-S	T8 AS-S	T9 AS-S	T6 AS-N	T7 AC-N
Arroyo lupine	--	--	--	X	--	--	X	--	--	--
Black sage	--	--	--	X	--	X	X	--	--	--
California encelia	X	--	--	--	--	--	--	--	X	--
Brodea	X	X	--	--	--	--	--	--	X	X
Man-root	X	--	X	--	X	X	--	X	X	X
California brome	X	--	--	--	--	--	--	--	--	--
Spiny lupine	--	X	X	--	--	--	X	--	--	--
Red brome	--	X	X	--	X	--	X	--	X	X
Foxtail barley	--	--	X	--	--	--	--	--	--	--
Greenbark ceanothus	--	--	--	--	--	X	--	--	X	--
California sage	X	--	--	--	--	X	--	--	--	--
California poppy	--	--	--	--	--	X	--	--	--	--
Sugar bush	--	--	--	--	--	X	--	--	--	--
Phacelia	--	--	--	--	--	X	X	--	--	--
Poison oak	--	--	--	--	--	--	--	--	X	--
Wild oats	--	--	--	--	--	--	--	--	X	X
Night shade	--	--	--	--	--	--	X	--	X	--
Brome spp.	--	--	--	--	--	--	X	--	X	--
Manzanita spp.	--	--	--	--	--	--	--	--	--	X
Black mustard	--	--	--	--	--	--	X	X	--	X
Softchess	--	--	--	--	--	--	--	X	--	X
Rose clover	--	--	--	--	--	--	--	--	--	X
Fire poppy	--	--	--	--	--	--	--	--	--	X
Yarrow	--	--	--	--	--	--	--	X	--	--
Lotus spp.	--	--	--	X	--	--	--	X	--	--
Perennial ryegras s	--	--	--	--	X	--	--	--	--	--
Nodding stipa	--	--	--	--	X	--	--	X	--	--
Chamise	--	--	--	--	--	--	--	X	--	X
Rip-gut brome	--	X	X	--	--	--	--	--	X	--
Hedge nettle	--	X	--	--	--	--	--	--	--	--
Annual fescue	--	--	X	--	X	--	X	X	--	--
Morning glory	--	--	--	--	X	--	--	--	--	--
Toyon	--	--	--	--	--	X	--	--	--	--

Species in bold print were aerial seeded. Refer to Appendix D-2 for seeding data.

Appendix D-3

SPECIES FOUND AT SITES	L4 AS-S	L6 AS-S	L8 AC-S	L5 AS-N	L7 AC-N	T5 AC-S	T8 AS-S	T9 AS-S	T6 AS-N	T7 AC-N
1 Square Meter										
Annual fescue	7	--	--	8	--	--	--	--	30	--
Lotus	6	7	7	--	7	--	1	--	--	6
Black sage	5	--	3	--	--	--	--	--	--	--
Spiny lupine	1	--	--	--	--	--	--	--	--	--
California encelia	--	6	1	--	--	--	--	--	--	--
Forbs	--	--	--	27	--	5	2	3	30	46
Brodea	--	--	--	9	4	--	--	3	--	--
Laurel sumac	--	--	4	--	2	--	--	--	--	--
Morning glory	--	--	3	--	--	--	3	20	--	11
Black Mustard	--	--	--	--	--	5	--	--	3	--
Red brome	--	--	--	--	--	24	--	1	--	--
Ripgut brome	--	--	--	--	--	4	--	--	--	--
Wild oats	--	--	--	--	--	7	--	--	--	--
Man-root	--	--	--	--	--	--	1	--	--	--
Sugar bush	--	--	--	--	--	--	10	--	--	--
Rose clover	--	--	--	--	--	--	--	21	--	--
Giant wildrye	--	--	--	--	--	--	--	--	11	--
10 Square Meter										
Black sage	27	--	3	--	3	--	--	--	--	--
Chamise	5	--	--	--	--	--	--	--	--	--
California sage	--	1	--	--	--	--	--	--	--	--
Laurel sumac	--	--	10	--	10	--	--	--	--	--
Shrub spp	--	--	--	--	--	--	13	--	--	2
100 Square Meter										
Dead shrubs	27	8	20	5	30	5	--	1	--	16
Resprouting Shrubs	--	--	--	--	--	5	--	--	8	35
Lemmonade berry	2	7		--	--	--	--	--	--	--
Laurel sumac	--	--	1	--	--	--	17	3	--	--
Chamise	--	--	--	--	--	--	--	8	--	--
Species at or Near Site										
Foothill stipa	X	X	--	X	X	--	X	--	--	X
Bur clover	--	--	--	X	--	--	--	--	--	--
Yerba Santa	--	--	--	X	--	--	--	--	--	--
Laurel sumac	X	--	--	X	--	--	--	X	--	--
California melic	--	--	--	X	X	--	--	--	--	--
Giant wildrye	--	--	--	X	--	--	--	--	--	--
Monkey flower	--	--	--	X	X	--	--	--	--	--

Species in bold print were aerial seeded. Refer to appendix D-2

Appendix D-2

SITE LOCATION AND SPECIES USED	SEEDING RATE lb/ac	FERTILIZER AND RATE	SEED SQ. FT	METHOD OF APPLICATION
Laguna Beach Area				
L2-BFM				
'Zorro' annual fescue	8.00		157	Hydroseeding
California poppy	0.50		3	Bonded fiber
Arroyo lupine	1.00	NA	0.3	matrix
Purple needlegrass	4.00		11	
L3-HC		NA		Control
L4-AS-S				Aerial seeding
'Zorro' annual fescue	7.00		138	
Nodding stipa	1.10	NA	7	
Purple stipa	0.50		1	
Foothill stipa	0.50		5	
L5-AS-N				
'Zorro' annual fescue	7.00		138	Aerial seeding
Nodding stipa	1.10		7	
Purple stipa	0.50	NA	1	
Foothill stipa	0.50		5	
L6-AS-S				Aerial seeding
'Zorro' annual fescue	7.00		138	
Nodding stipa	1.10	NA	7	
Purple stipa	0.50		1	
Foothill stipa	0.50		5	
L7-AC-N		NA		Control
L8-AC-S		NA		Control
Kinneloa Area				
K1-SB		NA		Straw bales
K2-HS				Hydroseeding
'Zorro' annual fescue	4.0	16-20-0	79	66%Americanfiber
'Hykon' rose clover	13.0	250 lb/a	49	33% United fiber
California brome	6.0		19	Ecology M-Binder
California poppy	1.0		6	
K3-HS-C		NA		Control

Appendix D-2

SITE LOCATION AND SPECIES USED	SEEDING RATE lb/ac	FERTILIZER AND RATE	SEED SQ. FT	METHOD OF APPLICATION
TOPANGA AREA				
T1-HVF (T 1N R 17W Sec. 34) 'Blando' brome 'Hykon' rose clover	 12 6	 16-20-0 250 lb/ac	 70 23	Hydroseeding 50% fiberwood 50% ECO fiber Sentinaltackifier
T2-SB (T 1S R 17W Sec. 34)		NA		Straw bales in channel.
T3-HRF (T 1S R 17W Sec. 33) 'Blando' brome 'Hykon' rose clover	 12 6	 16-20-0 250 lb/ac	 70 23	Hydroseeding 66% Americanfiber 33% United fiber Ecology M-Binder
T4-HC (T 1S R 17W Sec. 33)		NA		Control Site
T5-AC-S		NA		Control Site
T6-AS-N 'Hykon' rose clover California brome 'Blando' brome 'Zorro' annual fescue	 3.98 1.07 1.00 2.14	NA	 15 3 6 42	Aerial Seeding
T7-AC-N		NA		Control Site
T8-AS-S 'Hykon' rose clover California brome 'Blando' brome 'Zorro' annual fescue	 3.98 1.07 1.00 2.14	NA	 15 3 6 42	Aerial Seeding
T9-AS-S 'Hykon' rose clover California brome 'Blando' brome 'Zorro' annual fescue	 3.98 1.07 1.00 2.14	NA	 15 3 6 42	Aerial Seeding
Laguna Beach Area				
L1-HS 'Zorro' annual fescue California poppy Arroyo lupine Purple needlegrass	 8.00 0.50 1.00 4.00	NA	 157 3 0.3 11	Hydroseeding Terratack 50 lb Ecology control M-binder 100lb Styrene butadine copolymer emulsion (SBR) 60lb Polyvinylacetate (PVA) 100 lb Copolymer of and acrylates 100 lb

Appendix D-1

T9-AS-S 05/19/94

1 sq meter of plants	**Number**	
Rose clover	21	Trifolium hirtum
Forbs	3	

10 sq meters (Seedlings)

None

100 sq meter (sprouts)

Dead 1		
Sprouts	8	Adenostoma fescicuatum
3	Rhus laurina	

Plants in the area

Annual fescue	Vulipa myuros
Softchess	Bromus mollis
Nodding needlegrass	Stipa cernua
Chamise	Adenostoma fesciculatum
Laurel sumac	Rhus laurina
Man-root	Marah macrocarpus
Lotus	Lotus spp.
Black mustard	Brassica nigra
Yarrow	Achillea spp.

Appendix D-1

T-7-AC-N

05/19/94

Plants in the area	
Brodea	Dichelostemma capitatum
Softchess	Bromus hordeaceus hordeaceus
Man-root	Marah macrocarpus
Foothill stipa	Stipa lepida
Rose clover	Trifolium hirtum
Red brome	Bromus rubens
Wild oats	Avena fatua
Fire Poppy	Papaver californicum

T8-AS-S

05/19/94

1 sq meter of plants	Number	
Morning glory	3	Calystegia macrostegia
Sugar bush	10	Rhus ovata
Lotus	1	Lotus spp.
Man-root	1	Marah macrocarpus
Forbs	2	
10 sq meters (seedlings)		
Shrubs	13	
100 sq meters (Sprouts)		
Dead 0		
Sprouts	17	Rhus laurina

Plants in the area	
Black mustard	Brassica nigra
Night shade	Solanum xantii
Lupine	Lupinus succulentus
Spiny lupine	Lupinus hirsutissimus
brome	bromus spp.
Red brome	Bromus rubens
Annual fescue	Vulipa myuros (1 plant)
Black sage	Saliva mellifera
Foothill stipa	Stipa lepida
Phacelia	Phacelia grandiflora

T9-AS-S

05/19/94

1 sq meter of plants	Number	
Morning glory	20	Calystegia macrostegia
Brodea	3	Dichelostemma capitatum
Red brome	1	Bromus rubens

Appendix D-1

T6-AS-N 05/19/94

1 sq meter of plants	**Number**	
Giant wildrye	11	Eylmus condensatus
annual fescue	30	Vulipa myuros
Black mustard	3	Brassica nigra
Forbs	30	

10 sq meters (seedlings)
None

100 sq meters (sprouts)

Dead 0		
sprouts	8	

Plants in the area

Poison oak	Rhus diversiloba
wild oats	Avena fatua
Night shade	Solanum xantii
Brome	Bromus spp.
Red brome	Bromus rubens
Brodea	Dichelostemma capitatum
Ripgut brome	Bromus rigidus
Man-root	Marah macrocarpus
California encelia	Encelia californica
Ceanothus	Ceanothus spinosus

T-7-AC-N 05/19/94

1 sq meter of plants	**Number**	
Morning glory	11	Calystegia macrostegia
Lotus	6	lotus spp.
Forbs	46	

10 sq meters (seedlings)

seedlings	2

100 sq meters (sprouts)

Dead 16	
Sprouts	35

Plants in the area

Manzanita	Arctostaphylos spp.
Black mustard	Brassicia nigra
Chamise	Adenostoma fesciculatum

Appendix D-1

T1-HVF 05/19/94

Plants in the area

Brodea	Dichelostemma capitatum
morning glory	Calystegia macrostegia
Lupine	Lupinus succulentus
Brachypodium	Brachypodium distachyon

T3- HRF (fireplace & pool) 05/19/94

Pants in the area

Black mustard	Brassica nigria
Tobacco tree	Nicotiana glauca
California encelia	Encelia californica

T5-AC-S 05/19/94

1 sq meter of plants	Number	
Black mustard	5	Brassica nigra
Red brome	24	Bromus rubens
Ripgut brome	4	Bromus rigidus
Wild oats	7	Avena fatua
Forb spp.	5	

10 sq meter (sprouts)
None

100 sq meter (sprouts)
Dead 5
Sprouts 5

Plants in the area

Toyon	Heteromeles arbutifolia
Black sage	Saliva mellifera
Ceanothus	Ceanothus spinosus
California sage	Artemisia californica
California poppy	Eschscholtzia californica
Man-root	Marah macrocarpus
Sugar bush	Rhus ovata
Phacelia	Phacelia grandiflora

Appendix D-1

L7-AC-N

05/19/94

Plants in the area	
Nodding stipa	Stipa cernua
Foothhill stipa	Stipa lepida
Monkey flower	Mimulus aurantiacus
California melic	Melica imperfecta

L8-AC-S

05/19/94

1 sq meter of plants	**number**	
Lotus	7	Lotus spp.
Morning glory	3	Calystegia macrostegia
Black sage	3	Saliva mellifera
Laurel sumac	4	Rhus laurina
California encella	1	Encella californica

10 sq meter (Seedlings)		
Laurel sumac	10	Rhus laurina
Black sage	3	Saliva mellifera

100 sq meter (sprouts)		
Dead 20		Artemisia californica
Laurel sumac	1	Rhus laurina

Plants in the area	
Red brome	Bromus rubens
Spiny lupine	Lupinus hirsutissimus
Ripgut Brome	Bromus rigidus
Annual fescue	Vulipa myuros
Man-root	Marah macrocarpus
Foxtail	Hordeum spp.

T1-HVF

05/19/94

Plants in the area	
Red brome	Bromus rubens
Soft chess	Bromus hordeaceus hordeacus
Wild oats	Avena fatua
Foothill stipa	Stipa lepida
Black mustard	Brassica nigra
Black night shade	Solanum xantii
Rose clover	Trifolium hirtum
Lotus	Lotus spp.
California poppy	Eschscholtzia californica
Yucca	Yucca baccata or whipplei
Chamise	Adenostoma fesciculatum

Appendix D-1

L6-AS-S 05/19/94

1 sq meter OF PLANTS	NUMBER	
Lotus	7	Lotus spp.
California encelia	6	Encelia californica
10 sq meters (seedlings)		
California sage	1	Artemisia californica
100 sq meters (sprouts)		
Dead 8		
Lemmonade berry	7	
Rhus integrifoliia		
Plants in the area		
Foothill stipa		Stipa lepida
Spiny Lupine		Lupinus hirsutissimus
Red brome		Bromus rubens
Rip-gut brome		Bromus rigidus
Brodea		Dichelostemma capitatum
Hedge nettle		Stachy bullata

L7-AC-N 05/19/94

1 sq meter of plant	Number	
Lotus	7	Lotus spp.
Brodea	4	Dichelostemma capitatum
laurel sumac	2	Rhus laurina
10 sq meters (seedlings)		
Black sage	3	Saliva mellifera
Laurel sumac	10	Rhus laurina
100 sq meters (sprouts)		
Dead 30		
Sprouts	00	
Plant in the area		
Clover		Trifolium spp.
Annual fescue		Vulipa myuros
Perennial ryegrass		lolium perenne
Morning glory		Calystegia macrostegia
Red brome		Bromus rubens
Man-root		Marah macrocarpus

Appendix D-1

L2-BFM 05/19/94

Plants in the area

Annual Fescue	Vulipa myuros
Foothill stipa	Stipa lepida
Nodding stipa	Stipa cernua
Red brome	Bromus rubens
Lemmonade berry	Rhus integrifoliia
Prickely pear	Opuntia spp.
Chamise	Adenostoma fasciculatum
California encelia	Encelia californica
Lotus	Lotus spp.
Lupine	Lupinus hirsutissimus
Softchess	Bromus hordeaceus hordeaceus
California poppy	Eschscholtzia californica
Mariposa lilly	Calochortus spendens
Brodea	Dichelostemma capitatum

North slope near site: Annual fescue is a thick stand of 24 to 30 inches tall. Did not find california sage at this site, but did not find much california sage at L1, L2, or L3.

Most of the growth at this site was limited to draws and terraces.

L3-HC 05/19/94

Plants in the area

Annual fescue	Vulpia myuros
California poppy	Eschscholtzia californica
Brodea	Dichelostemma capitatum
Foothill stipa	Stipa lepida
Nodding stipa	Stipa cernua
Mariposa poppy	Calochortus spendens
Lemmonade berry	Rhus integrifoliia
Lotus	Lotus spp.
Red brome	Bromus rubens

L4-AS-S 05/19/94

1 sq meter of plants	Number	
Lotus	6	Lotus spp.
Black sage	5	Salvia mellifera
Spiny lupine	1	Lupinus hirsutissimus
Annual fescue	7	Vulipa myuros

Appendix D-1

K2-HS 5/19/94

Plants in the area

Man-root	Marah macrocarpus
Black Mustard	Brassica nigria
California Poppy	Eschscholtzia californica
Annual fescue	Vulipa myuros
Common Mallow	Maliva borealis
Lotus spp	lotus spp.
Yucca	Yucca baccata or whipplei

K3-HC

05/19/94

Plants in the area

Rose clover	Trifolium hirtum
California poppy	Eschscholtzia californica
Spiny lupine	Lupinus hirsutissimus
Laurel sumac	Rhus laurina
Black mustard	Brassica nigria
Poison oak	Rhus diversiloba
California sage	Artemisia californica
Night shade	Solanum xantii
Red brome	Bromus rubens
Perennial rye	Lolium perenne
Morning glory	Calystegia macrostegia

L1-HS 05/19/94

Plants in the area

Lotus	Lotus spp.
Foothill stipa	Stipa lepida
California encelia	Encelia californica
Lemmonade berry	Rhus integrifoliia
Black mustard	Brassica nigra
Black sage	Salvia mellifera
Lotus	Lotus spp.
Brodea	Dichelostemma capitatum
Wild oats	Avena fatua
Maripoas lilly	Calochortus spendens
Red brome	Bromus rubens
Annual fescue	Vulpia myuros
Soft chess	Bromus hordeaceus hordeceus
California poppy	Eschscholtzia californica

Coastal sage was found in thick stand of wild oats, only place found.

Appendix C-2 Erosion Evaluation

	Erosion Potential USLE				Erosion Index	
	R	K	LS	A	T	EI
T1-HVF	90	0.28	10.0	210	2	105
T2-SB	60	0.20	12.5	150	2	75
T3-HRF	60	0.24	12.5	180	5	36
T4-HC	60	0.49	15.4	453	1	453
T5-AC-S	90	0.17	17.7	271	2	135
T6-AS-N	85	0.20	6.8	116	2	58
T7-AC-N	85	0.24	7.9	160	2	80
T8-AS-S	85	0.02	15.4	26	2	13
T9-AS-S	90	0.02	9.4	17	1	17
L1-HS	35	0.20	9.4	66	3	22
L2-BFM	35	0.17	9.0	53	2	27
L3-HC	35	0.15	8.4	44	2	22
L4-AS-S	40	0.20	7.8	62	2	31
L5-AS-N	40	0.15	8.9	53	2	27
L6-AS-S	40	0.05	12.5	25	1	25
L7-AC-N	40	0.15	7.2	43	2	22
L8-AC-S	40	0.15	4.0	24	3	8
K1-SB	75	0.20	12.5	188	2	94
K2-HS	75	0.05	12.5	47	2	23
K3-HS-C	75	0.05	12.5	47	2	23

Appendix C-1 Soils Information For Each Site

Site	Soil Symbol	Map Unit Name	Normal pH of surface
T1-HVC	MrG	Millsholm rocky loam, 50 to 75 percent slopes	6.6-7.3
T2-SB	LoF	Los Osos clay loam, 30 to 50 percent slopes	6.1-6.5
T3-HRF	MrG	Millsholm rocky loam, 50 to 75 percent slopes	6.6-7.3
T4-HC	MrG	Millsholm rocky loam, 50 to 75 percent slopes	6.6-7.3
T5-AC-S	MrG	Millsholm rocky loam, 50 to 75 percent slopes	6.6-7.3
T6-AS-N	MhF	Millsholm loam, 15 to 50 percent slopes	6.6-7.3
T7-AC-N	MhF	Millsholm loam, 15 to 50 percent slopes	6.6-7.3
T8-AS-S	SR	Sedimentary rock land	---
T9-AS-S	SR	Sedimentary rock land	---
L1-HS	145	Cieneba-Rock outcrop complex, 30 to 75 percent slopes	5.6-6.0
L2-BFM	145	Cieneba-Rock outcrop complex, 30 to 75 percent slopes	5.6-6.0
L3-HC	145	Cieneba-Rock outcrop complex, 30 to 75 percent slopes	5.6-6.0
L4-AS-S	145	Cieneba-Rock outcrop complex, 30 to 75 percent slopes	5.6-6.0
L5-AS-N	145	Cieneba-Rock outcrop complex, 30 to 75 percent slopes	5.6-6.0
L6-AS-S	145	Cieneba-Rock outcrop complex, 30 to 75 percent slopes	5.6-6.0
L7-AC-N	145	Cieneba-Rock outcrop complex, 30 to 75 percent slopes	5.6-6.0
L8-AC-S	145	Cieneba-Rock outcrop complex, 30 to 75 percent slopes	5.6-6.0
K1-SB	R	Rough broken land	---
K2-HS	R	Rough broken land	---
K3-HS-C	R	Rough broken land	---