# Fertility Element Storage in Chaparral Vegetation, Leaf Litter, and Soil[1]

Paul J. Zinke[2]

Abstract: This study was conducted on various chaparral sites sampled throughout California in the range of the following species: chamise, Adenostoma fasiculatum; scruboak, Quercus dumosa; and Ceanothus cuneatus, & C. crassifolius. Data for elemental composition, total vegetation and leaf litter weights, and elemental storage weights for each of these species were determined. These data are aggregated and presented as tables of cumulative probability values for composition and storage weight of nitrogen, phosphorus, calcium, magnesium, potassium, sodium, iron, manganese, and zinc in chaparral. These tables can be used by the land manager to give a percentile rank to any values for vegetation analyses or to assess probable values to expect for fertility storage in the soil or vegetation of chaparral stands.

Knowledge of the total storage of material in chaparral stands is of interest to land managers because of its utility in solving a variety of problems. The total weight of the stand is related to fuel content and thus to relative fire hazard of the stand. The elemental content of the chaparral vegetation and total site fertility are affected by brush removal, as for example, where harvest is planned for fuel utilization. Chaparral species vary in their elemental content and it is wise to favor species which enhance site fertility. Ashing vegetation by burning returns elements to the site in soluble form. These elements are subject to immediate use by herbaceous vegetation. In addition, the elemental composition of the surface litter and soil relates to these total site fertility problems. Knowledge of these factors may increase management options, and offer a more sound basis for decisions.

This paper reports results of a study in which data have been gathered on vegetal and litter weights and elemental compositions and storages from various chaparral sites. These were sampled throughout the range of the following species in California: chamise, Adenostoma fasiculatum; scrub oak, Quercus dumosa; and the Ceanothi, Ceanothus cuneatus and C. crassifolius.

The data from the various sampling sites will be aggregated into probability distributions for total weights of constituents, and their elemental compositions and storages. This will allow the manager to determine the probable variation in chaparral properties, as well as to rank any data at hand as a site specific application of the data.

## LITERATURE

Chaparral literature concerned with weights, areal extent, and fertility has been mainly in the context of forestry and range management applications. These came about because of the practical necessity of conducting surveys of areal extent, assessing fire hazards and watershed influences of chaparral cover; and determining the relation of chaparral as browse to range carrying capacity for domestic and game animals.

The extent of chaparral vegetation types was assessed by Wieslander (1935) who began an early map of the vegetation of California in which the chaparral vegetation types were mapped over the entire state. The vegetation survey has since been expanded to include relevant soil information as part of the California Soil-Vegetation survey. The areal extent of chamise chaparral is 3,099,300ha (9,866,000 acres). Various measures have been made of total weight of chaparral in relation to fuel assessment. Specht (1969), determined weights of chaparral and elemental contents at various time intervals following fire on the San Dimas Experimental forest. Trabaud (1977) published data for litter and biomass for garrique in France composed mainly of Quercus coccifera, similar to Q. dumosa in California chaparral. Kittredge (1955) published a thorough study of litter weights and rates of accumulation under various chaparral species on the San Dimas Experimental Forest. The probability tables that will be presented in this paper allow a percentile ranking of any of these data within the range of weights, nutrient compositions, and total nutrient storage found in California chaparral.

## METHOD OF STUDY

### Site Selection

In this study, the sampling sites were chosen to represent the range of conditions over which three representative California chaparral species;

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[2] Assoc. Prof. of Forestry, University of California, Berkeley.

chamise, scrub oak, and Ceanothus grow. Sampling sites were selected over gradients of annual rainfall, in mountain areas of similar geologic soil parent material in San Diego, Los Angeles, and Glenn Counties. Other sites were chosen to represent additional conditions of soil parent material conditions, and annual rainfall extremes in Lake, Mariposa, Tehama, and Shasta Counties.

Sample sites and their characteristics are listed in table 1.

Table 1-- Sample site locations

| Location | Species | Age (yr) | Precip. (mm) |
|---|---|---|---|
| San Diego Co. | | | |
| nr San Marcos | Af,Qd | 15 | 305 |
| Descanso | Af,Cc,Qd | 20 | 635 |
| Sunrise | Af,Cc,Qd | 25 | 965 |
| Scissors Jct. | Af,Qd | 50 | 229 |
| Los Angeles Co. | | | |
| Griffith Pk. | Af,Qd | 25 | 356 |
| El Prieto Can. | Af,Qd | 25 | 635 |
| Tanbark Fl. | Af,Ccr,Qd | 39 | 990 |
| Glenn Co. | | | |
| Elk Cr. | Af,Cc | 17 | 356 |
| Sanhedrin Rd | Af | 20 | 457 |
| Sanhedrin Rd | Af | 20 | 889 |
| Sanhedrin Rd | Af | 20 | 1520 |
| Miscellaneous | | | |
| Bear Val. Marip. Co. | Af,Cc | 23 | 500 |
| Kiethly Rch. Lake Co. | Af,Cc,Qd | 30 | 500 |
| Pattymocus Bt. Tehama Co. | Af,Cc | 15 | 1520 |
| Delta Pt. Lkt. Shasta Co. | Af | 20 | 1650 |
| Tanbark Fl. Lysimeters | Af,Ccr,Qd | 20 | 990 |

Af, Adenostoma fasiculatum; Cc, Ceanothus cuneatus; Ccr, Ceanothus crassifolius; Qd, Quercus dumosa.

### Vegetation Sampling

Dominant shrubs of the desired species were selected for sampling at each site. Either a single large shrub, or a rectangular area of 2.22m$^2$ (4' x 6') was chosen, marked by stakes, and the shrubs cut at ground level. When a single large shrub was chosen, the crown projectional area was used to relate the subsequent weight measurements to an areal basis. Vegetation weights and elemental storage were calculated on a square meter basis.

Age was determined at the time of cutting the shrubs by counting annual rings. It was recognized that this represented age since sprouting or growth following fire.

### Vegetation Weights

The cut shrubs were further sectioned into 38 cm (one ft) height increments, and fresh field weights obtained for each. These were taken to the laboratory to dry and separate oven dry weights of foliage and stems were obtained on each sample. For some sites with very large shrubs or dense growth, the drying was done on subsamples of known field weight. Moisture contents were determined by oven drying at 80°C.

### Leaf Litter and Soil Sampling

Leaf litter, and soil samples were obtained directly beneath the center of the canopy radius of the shrub. The leaf litter and organic detritus was sampled from a unit area, usually 0.1 square meter.

Soil samples were taken from a pit dug to rock bottom; sampling at uniform depth intervals at each site of 0-2.5 in.(6.4 cm), 2.5-6 in.(15.2 cm), 6-12 in. (30.4 cm), 12-24 in.(61 cm.), and 24-48 in.(121.9 cm). The calculations of storage of soil elemental composition were made on the basis of the square meter area to the depth of rock, or to one meter depth if no rock bottom was encountered.

### Soil Preparation

Soil samples of known volume were obtained in the field, and bulk densities determined. Samples were oven dried, and the oven dry weight divided by volume of the sample was used as a bulk density figure. Also; roots were sieved from this known volume sample to obtain root weights by volume. The soil coarse fraction greater than 2 mm was sieved out, and percent by weight calculated. A bulk sample of soil for chemical analysis was collected uniformly through each depth increment. These roots were weighed and saved for subsequent chemical analysis. Coarse mineral fragments remaining were considered devoid of available fertility element storage, and their weights were deducted from the calculated storage for the square meter soil volume.

### Chemical Analyses

Vegetation and litter samples were analyzed after grinding in a wiley mill through a 50 mesh stainless steel sieve. Nitrogen was determined on this material by microKjeldahl method. Perchloric acid digestates were used for the remaining elements analysed. Phosphorus was analysed by molybdenum blue method, and the remaining elements; calcium, potassium, sodium, iron, manganese, and zinc were determined by atomic absorption spectrometry, methods described by Johnson and Ulrich (1959). Elemental contents were calculated on a weight percent basis for nitrogen, calcium, potassium, sodium; and weight per million basis for phosphorus, iron, manganese and zinc.

Soils analyses were conducted on the fine earth fraction (less than 2 mm) soil material. Total organic nitrogen content was determined by macro-Kjeldahl analyses; phosphorus was determined in a water extract; exchangeable cations were determined in 1 N ammonium acetate extracts buffered to pH 7.0; and exchange capacity was determined by the total ammonium remaining on the soil after such extraction and rinsing with methyl alcohol. These standard methods of soil analysis reported in Black (1965). Nitrogen was calculated on a weight percent basis, phosphorus on a weight per million basis, and exchangeable cation data on a milliequivalent per hundred grams basis. These data are the basis for the intensity factor of soil storage, which when multiplied by the capacity factors of bulk density, volume of the square meter depth increment minus coarse fragments, determines total soil fertility storage.

These composition and storage values were arrayed in order of magnitude and fitted to the cumulative probability function described by Weibull (1949) in application to variation in organism properties. A modification developed by Bailey and Dell (1973) was used in this study. An application to foliar analysis is described by Zinke and Stangenberger (1981).

The form of the Weibull cumulative probability distribution used in this paper is as follows:

$$F(x) = 1 - e^{-\left(\frac{x-A}{B}\right)^{C}} \qquad (1)$$

This function is determined by factor A, which is a threshold value related to the lowest value obtained; B, which is a scale value related to the magnitude of the units used in describing the respective property of the vegetation, litter or soil; and C, which is a shape factor. C ranges from values of one or lower for exponential distributions with data peaking at low values skewed toward high values, to 3.25 for normal bell shaped distributions about a central value. The flexibility of the Weibull function allows the fitting of diverse data with the same computer program developed by Dr. Alan Stangenberger. The fitted probability functions were then used to develop tables of probable values to be expected for cumulative percentiles of the field population of chaparral sites for each property. These can be considered to be preliminary rating tables for chaparral sites, their vegetation weights, elemental compositions, and total elemental storages.

The results will be presented as capacity and intensity factors evaluated for elemental storage for each species at each sampling site. The capacity factor for vegetation is the oven dry weight of vegetation per unit area of horizontally projected land surface, with the vegetation subdivided into categories of foliage, stems, and roots, and surface litter and detritus. The intensity factor is the weight fraction elemental composition. The total elemental storage in the vegetation is the sum of the products of the capacity and the elemental intensity factors for each vegetation subdivision.

Similarly, for the soil, the intensity factors will be the respective available elemental weight fractions for each element of concern, multiplied by capacity factors derived from bulk density, coarse fraction percent, and volume of each sampling depth increment.

## RESULTS and DISCUSSION

### Foliage & Stem Weights (table 2)

The capacity factor (weight per unit area) for the individual shrubs or stands were determined at each sampling site for foliage, stems, leaf litter, and roots. These form the storage capacity for the retention of elements, and are a measure of the fuel content of the stand.

Data on the foliage, stem, and foliage plus stem weights were determined for each site. These individual site data were arrayed by the Weibull equation in probability functions, and the data tables are developed from this function. The data in table 2 are presented as equal to or less than values of weight for each cumulative percentile class of the population. This allows the manager to rank any data within the range of values in these tables. Thus a determination of 180 $gm/m^2$ for chamise foliage would be in the lower 1% of the range of that species according to this table. Likewise, a value of 3 $kg/m^2$ for foliage plus stems of mixed chaparral would be in the 40% class of these data.

These data indicate that foliage weights range from a low 9f 0.15 kg per square meter to more than 2 $kg/m^2$, with a 50% value of 474 $gm/m^2$. Generally, chamise has the least foliage weight and Ceanothus the most per unit area; with scrub oak intermediate.

Table 2— Chaparral foliage and stem weight cumulative probabilities (oven dry $grams/m^2$).

| Component | Foliage | | | | Stems | | | | Foliage +Stems | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | All | Af | Qd | Cc | All | AF | Qd | Cc | All | Af | Qd | Cc |
| Cumul. Pct. | | | | | | | | | | | | |
| ≤1 | 156 | 185 | 175 | 151 | 823 | 734 | 962 | 1556 | 1065 | 965 | 1021 | 1636 |
| 5 | 178 | 192 | 186 | 186 | 1085 | 870 | 1130 | 2052 | 1374 | 1137 | 1303 | 2244 |
| 20 | 262 | 235 | 244 | 244 | 1739 | 1312 | 1698 | 2817 | 2132 | 1665 | 2097 | 3212 |
| 40 | 394 | 322 | 365 | 382 | 2507 | 1935 | 2525 | 3455 | 3009 | 2382 | 3110 | 4039 |
| 50 | 474 | 383 | 449 | 490 | 2914 | 2299 | 3013 | 3741 | 3472 | 2792 | 3383 | 4413 |
| 60 | 570 | 462 | 558 | 632 | 3366 | 2722 | 3587 | 4030 | 3983 | 3265 | 4306 | 4795 |
| 80 | 861 | 729 | 928 | 1125 | 4576 | 3947 | 5267 | 4707 | 5345 | 4610 | 6069 | 5695 |
| 95 | 1420 | 1323 | 1760 | 2268 | 6555 | 6170 | 8365 | 5624 | 7554 | 6997 | 9090 | 6931 |
| 99 | 2047 | 2108 | 2826 | 3773 | 8488 | 8544 | 11700 | 6385 | 9699 | 9499 | 12200 | 7969 |
| Sample n | 32 | 16 | 8 | 8 | 32 | 16 | 8 | 8 | 32 | 16 | 8 | 8 |

[1] Af, Adenostoma fasiculatum; Qd, Quercus dumosa; Cc, Ceanothus cuneatus and C. crassifolius. (Divide by 100 for metric tons/ha; multi-ply by .00446 for tons/acre)

Stem weights are 7 to 8 times the foliage weights. Stem weights range from 0.7 to 11.7 kg/$m^2$, with 50% 2f the population having approximately 3000 gm/$m^2$ or less. Stem weights are highest for Ceanothus at 3.7 kg/$m^2$, lowest for chamise with 2.2 kg/m2.

Combining the foliage and stem weights accentuates the relative ranking of the species at the 50% level. Ceanothus has the greater weigh at 4.4 kg/$m^2$, and chamise is low with 2.8 kg/$m^2$.

## Leaf Litter Weights (table 3)

Leaf litter weights obtained in this study were also fitted to cumulative probability functions. The derived data are presented in table 3. These data indicate that litter weights can be almost as great as the vegetation weights in the stand. Thus they will be an important storage component for nutrient elements, as well as an important fuel component of stands. Typical values for all species sampled indicate 50% of the population weigh 2.0 kg or less per square meter. This is in contrast to the 3.5 kg/$m^2$ for foliage and stems recorded in the previous table.

Table 3—Leaf litter weight probabilities in chaparral stands (oven dry gms/$m^2$).

| Cumul. Pct. | All | Af | Qd | Cc |
|---|---|---|---|---|
| <1 | 156 | 279 | 954 | 306 |
| 5 | 419 | 316 | 1025 | 674 |
| 10 | 648 | 375 | 1119 | 956 |
| 20 | 1021 | 523 | 1328 | 1377 |
| 30 | 1356 | 710 | 1566 | 1728 |
| 40 | 1685 | 944 | 1847 | 2058 |
| 50 | 2026 | 1239 | 2179 | 2386 |
| 60 | 2399 | 1621 | 2588 | 2732 |
| 70 | 2830 | 2140 | 3118 | 3120 |
| 80 | 3373 | 2914 | 3869 | 3591 |
| 90 | 4190 | 4322 | 5163 | 4273 |
| 95 | 4913 | 5816 | 6464 | 4855 |
| 99 | 6373 | 9532 | 9508 | 5982 |
| Sample n | 75 | 30 | 13 | 22 |

Af, *Adenostoma fasiculatum*; Qd, *Quercus dumosa*; Cc, *Ceanothus cuneatus* and *C. crassifolius.* (Divide weights by 100 for metric t/ha; multiply by .00446 for tons per acre)

As with the other probability tables in this paper, the manager can use table 3 to rank litter weight data at hand. For example, Kittredge (1955) found that the weight of litter of *Quercus dumosa* litter in Bell Canyon on the San Dimas Experimental forest to be 17.7 metric tons per acre, or 43.7 metric tons per hectare. This value would rate between 80-90% on the cumulative probability presented in table 3. The value of 4.7 metric tons per acre for chamise chaparral obtained by Kittredge for Fern Canyon on the same forest was 1160 gm/$m^2$, ranking at approximately the 50% level for chamise in table 3.

## Elemental Composition

To determine total elemental storage on the site, the capacity factor of weight and the elemental composition as an intensity factor are needed. In addition to their use as intensity factors elemental composition values may be used in rating the fertility of a site by foliar analysis, and for assessing possible elemental deficiencies. The data obtained for elemental composition of foliage, stems, litter, and roots for the various sampling sites and chaparral species were also fitted to cumulative probability functions, and probability tables derived for weight fractions of each element analysed.

## Foliage Analyses (table 4)

The cumulative probability percentile ranking of foliage analyses by order of magnitude for chaparral species studied are presented in table 4.

Nitrogen contents of chamise foliage are generally lower than for scrub oak or Ceanothus. The higher nitrogen content of the scrub oak foliage in general is a surprise because of the demonstrated nitrogen fixation ability of the Ceanothi (Delwiche, *et al*. 1965). However, as will be seen later, this added nitrogen is stored in stem storage in the Ceanothi.

Phosphorus, iron, and zinc contents in contrast to nitrogen are much higher at the 50% level in chamise than in scrub oak, and Ceanothus. Calcium contents in scrub oak foliage are lower than in either chamise or Ceanothus foliage. Magnesium amounts are higher in Ceanothus than in chamise or scrub oak.

These tables may be used to rank foliar analyses which may be at hand. Thus, if a foliar analysis has been made for a chamise sample which shows 0.7% calcium, the table indicates that this is a very low value, found in the lower 5% of the population.

## Stem Analyses (table 5)

The data for cumulative probability percentiles of the population of stem analyses for the same elements are presented in table 5. These data are for stemwood plus bark. Most of the composition values are much lower for stems than for foliage. Exceptions are sodium in Ceanothus, and calcium in scrub oak stemwoods.

Nitrogen values are highest for Ceanothus stems. This indicates that lower values in scrub oak and chamise stems. This indicates that much of the nitrogen fixed by Ceanothus is stored in high nitrogen content stems.

Table 4-Elemental composition of chaparral foliage. (oven dry basis)

| Probability Cumul. Pct. | N Pct. | P ppm | Ca Pct. | Mg Pct. | K Pct. | Na Pct. | Mn ppm | Fe ppm | Zn ppm |
|---|---|---|---|---|---|---|---|---|---|
| Chamise | | | | | | | | | |
| ≤5 | .397 | 673 | .715 | .079 | .184 | .011 | 42 | 168 | 26 |
| 20 | .627 | 1102 | .844 | .096 | .277 | .019 | 85 | 210 | 34 |
| 40 | .810 | 1455 | .980 | .127 | .371 | .025 | 125 | 279 | 49 |
| 50 | .891 | 1611 | 1.049 | .146 | .417 | .028 | 145 | 324 | 58 |
| 60 | .971 | 1769 | 1.123 | .171 | .466 | .031 | 165 | 379 | 71 |
| 80 | 1.156 | 2137 | 1.314 | .247 | .591 | .038 | 216 | 550 | 113 |
| 95 | 1.402 | 2632 | 1.609 | .403 | .778 | .047 | 289 | 896 | 205 |
| Sample n | 20 | 20 | 20 | 20 | 20 | 16 | 20 | 20 | 20 |
| Scrub oak | | | | | | | | | |
| ≤5 | 1.007 | 1010 | .569 | .085 | .283 | .020 | 121 | 112 | 20 |
| 20 | 1.240 | 1186 | .671 | .096 | .362 | .021 | 133 | 129 | 21 |
| 40 | 1.394 | 1351 | .765 | .109 | .417 | .023 | 166 | 164 | 23 |
| 50 | 1.455 | 1429 | .810 | .115 | .439 | .024 | 194 | 189 | 25 |
| 60 | 1.514 | 1510 | .856 | .123 | .460 | .027 | 233 | 221 | 27 |
| 80 | 1.639 | 1709 | .970 | .142 | .505 | .037 | 389 | 331 | 37 |
| 95 | 1.789 | 1996 | 1.132 | .173 | .561 | .068 | 820 | 579 | 63 |
| Sample n | 8 | 8 | 8 | 8 | 8 | 7 | 8 | 8 | 8 |
| Ceanothus | | | | | | | | | |
| ≤5 | 1.038 | 538 | .850 | .106 | .248 | .006 | 27 | 93 | 17 |
| 20 | 1.110 | 975 | 1.044 | .130 | .326 | .007 | 41 | 105 | 19 |
| 40 | 1.213 | 1363 | 1.173 | .159 | .412 | .009 | 54 | 140 | 21 |
| 50 | 1.273 | 1542 | 1.224 | .174 | .457 | .011 | 60 | 168 | 21 |
| 60 | 1.343 | 1727 | 1.273 | .192 | .506 | .014 | 67 | 208 | 22 |
| 80 | 1.546 | 2169 | 1.378 | .239 | .634 | .028 | 82 | 364 | 25 |
| 95 | 1.916 | 2789 | 1.503 | .318 | .837 | .067 | 105 | 782 | 28 |
| Sample n | 12 | 11 | 11 | 11 | 11 | 8 | 12 | 12 | 12 |

Table 5--Elemental composition of chaparral stems (oven dry).

| Probability Cumul. Pct. | N Pct. | P ppm | Ca Pct. | Mg Pct. | K Pct. | Na Pct | Mn ppm | Fe ppm | Zn ppm |
|---|---|---|---|---|---|---|---|---|---|
| Chamise | | | | | | | | | |
| ≤5 | .119 | 110 | .288 | .023 | .084 | .009 | 11 | 48 | 16 |
| 20 | .179 | 191 | .385 | .028 | .101 | .015 | 20 | 84 | 22 |
| 40 | .240 | 288 | .471 | .035 | .127 | .022 | 29 | 144 | 34 |
| 50 | .270 | 340 | .510 | .039 | .143 | .026 | 33 | 182 | 43 |
| 60 | .302 | 398 | .551 | .044 | .162 | .030 | 38 | 229 | 55 |
| 80 | .384 | 554 | .646 | .058 | .218 | .040 | 51 | 373 | 95 |
| 95 | .506 | 811 | .780 | .085 | .323 | .056 | 70 | 661 | 188 |
| Sample n | 72 | 72 | 72 | 72 | 72 | 67 | 72 | 71 | 72 |
| Scrub oak | | | | | | | | | |
| ≤5 | .195 | 43 | .573 | .030 | .072 | .013 | 26 | 39 | 8 |
| 20 | .267 | 92 | .801 | .039 | .087 | .019 | 35 | 53 | 13 |
| 40 | .332 | 178 | .968 | .051 | .110 | .026 | 49 | 75 | 17 |
| 50 | .363 | 232 | 1.037 | .057 | .122 | .030 | 57 | 90 | 18 |
| 60 | .395 | 300 | 1.105 | .064 | .137 | .034 | 66 | 107 | 20 |
| 80 | .473 | 514 | 1.257 | .085 | .181 | .044 | 93 | 160 | 24 |
| 95 | .584 | 951 | 1.448 | .120 | .260 | .061 | 142 | 264 | 30 |
| Sample n | 36 | 36 | 35 | 35 | 35 | 32 | 36 | 36 | 36 |
| Ceanothus | | | | | | | | | |
| ≤5 | .277 | 40 | .488 | .026 | .054 | .015 | 9 | 36 | 41 |
| 20 | .328 | 86 | .603 | .031 | .072 | .018 | 11 | 58 | 5 |
| 40 | .389 | 172 | .725 | .040 | .107 | .022 | 14 | 80 | 8 |
| 50 | .422 | 230 | .787 | .046 | .131 | .025 | 16 | 91 | 10 |
| 60 | .459 | 304 | .854 | .053 | .162 | .028 | 18 | 103 | 12 |
| 80 | .558 | 546 | 1.026 | .075 | .266 | .039 | 27 | 132 | 17 |
| 95 | .724 | 1068 | 1.292 | .121 | .495 | .061 | 46 | 177 | 26 |
| Sample n | 39 | 39 | 38 | 39 | 39 | 26 | 38 | 37 | 37 |

Table 6: Elemental composition of chaparral roots (oven dry).

| Probability Cumul.Pct. | N Pct. | P ppm | Ca Pct. | Mg Pct. | K Pct. | Na Pct. | Mn ppm | Fe ppm | Zn ppm |
|---|---|---|---|---|---|---|---|---|---|
| Chamise | | | | | | | | | |
| ≤5 | .299 | 222 | .297 | .044 | .039 | -- | 25 | 718 | 12 |
| 20 | .432 | 358 | .604 | .076 | .068 | -- | 46 | 1317 | 15 |
| 40 | .583 | 485 | 1.012 | .114 | .110 | -- | 87 | 2128 | 24 |
| 50 | .662 | 545 | 1.241 | .135 | .134 | -- | 115 | 2591 | 34 |
| 60 | .748 | 608 | 1.505 | .158 | .163 | -- | 152 | 3125 | 48 |
| 80 | .978 | 762 | 2.248 | .221 | .246 | -- | 277 | 4642 | 115 |
| 95 | 1.348 | 984 | 3.549 | .324 | .397 | -- | 553 | 7332 | 335 |
| 99 | 1.704 | 1178 | 4.897 | .426 | .559 | -- | 905 | 10147 | 724 |
| Sample n | 57 | 38 | 45 | 46 | 46 | -- | 38 | 39 | 38 |
| Scrub oak | | | | | | | | | |
| ≤5 | .345 | 180 | .514 | .050 | .031 | -- | 23 | 454 | 9 |
| 20 | .501 | 312 | 1.068 | .100 | .067 | -- | 42 | 1158 | 13 |
| 40 | .677 | 486 | 1.611 | .147 | .107 | -- | 79 | 1961 | 23 |
| 50 | .769 | 583 | 1.875 | .170 | .128 | -- | 104 | 2381 | 31 |
| 60 | .869 | 695 | 2.154 | .194 | .150 | -- | 135 | 2844 | 42 |
| 80 | 1.133 | 1006 | 2.849 | .253 | .209 | -- | 238 | 4070 | 84 |
| 95 | 1.554 | 1548 | 3.879 | .340 | .301 | -- | 456 | 6043 | 195 |
| Sample n | 41 | 28 | 37 | 37 | 37 | -- | 28 | 27 | 28 |
| Ceanothus | | | | | | | | | |
| ≤5 | .306 | 605 | .794 | .063 | .062 | -- | 72 | 662 | 26 |
| 20 | .598 | 638 | 1.025 | .098 | .077 | -- | 77 | 919 | 29 |
| 40 | .871 | 793 | 1.328 | .142 | .112 | -- | 96 | 1711 | 37 |
| 50 | 1.001 | 955 | 1.498 | .166 | .138 | -- | 115 | 2394 | 43 |
| 60 | 1.136 | 1293 | 1.692 | .193 | .173 | -- | 145 | 3390 | 51 |
| 80 | 1.468 | 2545 | 2.235 | .267 | .298 | -- | 279 | 7454 | 80 |
| 95 | 1.947 | 7440 | 3.180 | .392 | .601 | -- | 721 | 19166 | 153 |
| Sample n | 22 | 9 | 12 | 12 | 12 | -- | 8 | 9 | 8 |

Table 7--Elemental composition of chaparral litter (oven dry).

| Probability Cumul. Pct. | N Pct. | P ppm | Ca Pct | Mg Pct. | K Pct. | Na Pct, | Mn ppm | Fe ppm | Zn ppm |
|---|---|---|---|---|---|---|---|---|---|
| Chamise | | | | | | | | | |
| ≤5 | .372 | 495 | .842 | .079 | .106 | .007 | 206 | 1359 | 44 |
| 20 | .543 | 629 | 1.056 | .164 | .124 | .015 | 289 | 3192 | 76 |
| 40 | .697 | 755 | 1.278 | .263 | .157 | .024 | 377 | 5407 | 131 |
| 50 | .769 | 816 | 1.388 | .316 | .179 | .029 | 421 | 6599 | 165 |
| 60 | .843 | 878 | 1.507 | .374 | .206 | .036 | 468 | 7932 | 208 |
| 80 | 1.023 | 1032 | 1.811 | .530 | .293 | .046 | 590 | 11545 | 340 |
| 95 | 1.276 | 1255 | 2.275 | .786 | .474 | .067 | 778 | 17547 | 606 |
| Sample n | 30 | 30 | 29 | 29 | 29 | 25 | 29 | 29 | 29 |
| Scrub oak | | | | | | | | | |
| ≤5 | .685 | 375 | .954 | .123 | .073 | .013 | 228 | 3377 | 39 |
| 20 | .741 | 448 | 1.156 | .182 | .101 | .021 | 301 | 4428 | 52 |
| 40 | .826 | 551 | 1.299 | .244 | .137 | .028 | 397 | 5158 | 76 |
| 50 | .877 | 611 | 1.357 | .275 | .156 | .031 | 451 | 5456 | 91 |
| 60 | .937 | 681 | 1.414 | .309 | .178 | .034 | 514 | 5744 | 110 |
| 80 | 1.117 | 884 | 1.539 | .395 | .239 | .041 | 689 | 6372 | 169 |
| 95 | 1.456 | 1252 | 1.694 | .528 | .343 | .051 | 995 | 7145 | 291 |
| Sample n | 13 | 13 | 13 | 13 | 13 | 8 | 13 | 13 | 13 |
| Ceanothus | | | | | | | | | |
| ≤5 | .671 | 312 | 1.044 | .163 | .077 | .014 | 136 | 2868 | 41 |
| 20 | .877 | 526 | 1.261 | .217 | .127 | .016 | 187 | 3583 | 72 |
| 40 | 1.029 | 707 | 1.478 | .281 | .180 | .020 | 235 | 5063 | 111 |
| 50 | 1.094 | 788 | 1.585 | .315 | .206 | .023 | 258 | 6107 | 132 |
| 60 | 1.158 | 870 | 1.698 | .354 | .235 | .027 | 282 | 7464 | 156 |
| 80 | 1.300 | 1063 | 1.984 | .457 | .307 | .038 | 342 | 12087 | 223 |
| 95 | 1.482 | 1327 | 2.412 | .627 | .417 | .062 | 429 | 22559 | 337 |
| Sample n | 22 | 22 | 22 | 22 | 21 | 16 | 21 | 21 | 21 |

Phosphorus contents are much higher in chamise stems than in Ceanothus or scrub oak. This is coupled with higher phosphorus contents in chamise foliage.

Calcium, magnesium, and manganese contents are highest in scrub oak stemwood, while in contrast, potassium, iron, and zinc are lowest; while the reverse is true for chamise stemwood contents. The reader can make similar comparisons at the 50% level in table 5.

## Root Composition (table 6)

Cumulative probability values derived from the root analyses are presented in table 6. These values are for roots sieved from the soil samples, and cleaned by blowing air, but not washed. Most

Table 8--Chaparral soil surface properties (in top 31n., 7.6 cm.).

| Property | Bd g/cc | pH | C Pct. | N Pct, | C/N | P ppm | CEC | $Ca^{++}$ | $Mg^{++}$ | $K^{+}$ | Na | $M^{++}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | milliequivs./100grams | | | | |
| Chamise | | | | | | | | | | | | |
| ≤5 | .90 | 5.2 | .49 | .036 | 10.7 | .07 | 5.5 | 4.6 | .6 | .1 | .0 | .0 |
| 20 | 1.04 | 5.6 | .95 | .063 | 14.3 | .19 | 7.3 | 6.5 | 1.0 | .2 | .0 | .1 |
| 40 | 1.15 | 5.9 | 1.69 | .099 | 17.3 | .46 | 9.5 | 8.4 | 1.7 | .3 | .0 | .1 |
| 50 | 1.20 | 6.0 | 2.15 | .120 | 18.5 | .67 | 10.7 | 9.2 | 2.1 | .4 | .1 | .1 |
| 60 | 1.26 | 6.1 | 2.70 | .144 | 19.8 | .96 | 12.0 | 10.1 | 2.6 | .4 | .1 | .2 |
| 80 | 1.38 | 6.3 | 4.40 | .213 | 22.8 | 2.01 | 15.7 | 12.2 | 4.1 | .5 | .1 | .3 |
| 95 | 1.56 | 6.6 | 7.71 | .337 | 26.7 | 4.61 | 22.0 | 15.2 | 7.1 | .7 | .3 | .6 |
| Sample n | 70 | 71 | 71 | 71 | 71 | 71 | 70 | 70 | 65 | 70 | 70 | 70 |
| Scrub oak | | | | | | | | | | | | |
| ≤5 | .74 | 5.2 | .60 | .050 | 11.6 | .12 | 6.1 | 5.1 | 1.0 | .1 | .0 | .0 |
| 20 | .88 | 5.5 | 1.13 | .078 | 13.9 | .22 | 8.0 | 6.9 | 1.4 | .2 | .0 | .1 |
| 40 | 1.00 | 5.8 | 1.84 | .113 | 15.7 | .56 | 10.2 | 8.6 | 2.0 | .4 | .1 | .1 |
| 50 | 1.05 | 5.9 | 2.23 | .133 | 16.5 | .84 | 11.3 | 9.5 | 2.3 | .5 | .1 | .1 |
| 60 | 1.11 | 6.1 | 2.69 | .155 | 17.2 | 1.26 | 12.5 | 10.5 | 2.7 | .6 | .1 | .2 |
| 80 | 1.24 | 6.4 | 3.95 | .217 | 19.0 | 2.96 | 15.9 | 12.9 | 4.0 | .8 | .2 | .3 |
| 95 | 1.42 | 6.9 | 6.16 | .324 | 21.3 | 7.86 | 121.2 | 16.6 | 6.3 | 1.3 | .6 | .6 |
| Sample n | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 47 | 48 | 48 | 47 |
| Ceanothus | | | | | | | | | | | | |
| ≤5 | .98 | 5.5 | .36 | .031 | 10.2 | .18 | 7.1 | 9.8 | 1.8 | .1 | .0 | .1 |
| 20 | 1.03 | 5.7 | .67 | .048 | 12.1 | .26 | 11.6 | 8.2 | 2.3 | .2 | .0 | .1 |
| 40 | 1.12 | 5.8 | 1.35 | .086 | 14.0 | .62 | 13.9 | 9.6 | 3.2 | .3 | .0 | .2 |
| 50 | 1.17 | 5.9 | 1.83 | .114 | 14.9 | .97 | 15.2 | 10.4 | 3.8 | .4 | .1 | .2 |
| 60 | 1.24 | 6.0 | 2.47 | .153 | 15.8 | 1.52 | 16.7 | 11.4 | 4.6 | .5 | .1 | .3 |
| 80 | 1.44 | 6.2 | 4.66 | .289 | 18.2 | 4.08 | 121.0 | 14.1 | 7.0 | .8 | .1 | .4 |
| 95 | 1.83 | 6.5 | 9.73 | .620 | 21.7 | 12.77 | 28.6 | 19.0 | 12.0 | 1.8 | .3 | .6 |
| Sample n | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 20 | 25 | 25 | 24 |

(Bd . bulk density)

Table 10 -- Root weights and elemental storage contents (gm/m$^2$).

All Species: Chamise. Scruboak, Ceanothus.

| | Weight | N | P | Ca | Mg | K | Mn | Fe | Zn |
|---|---|---|---|---|---|---|---|---|---|
| Cumul. | | | | | | | | | |
| ≤5 | 18 | .1 | .008 | .11 | .02 | .02 | .001 | .04 | .0001 |
| 20 | 54 | .3 | .03 | .58 | .06 | .08 | .003 | .1 | .001 |
| 40 | 126 | .8 | .07 | 1.67 | .16 | .17 | .009 | .3 | .004 |
| 50 | 177 | 1.1 | .10 | 2.55 | .24 | .23 | .010 | .4 | .006 |
| 60 | 241 | 1.6 | .14 | 3.77 | .34 | .31 | .022 | .6 | .009 |
| 80 | 460 | 3.2 | .29 | 8.43 | .72 | .58 | .054 | 1.2 | .020 |
| 95 | 948 | 7.2 | .68 | 20.70 | 1.64 | 1.17 | .140 | 2.9 | .048 |
| Sample n | 27 | 27 | 22 | 26 | 26 | 26 | 22 | 22 | 22 |

Table 12-Total elemental storage in top 5 cm of chaparral soils

| Probability Cumul. Pct. | C Kg/m$^2$ | N g/m$^2$ | P mg/m$^2$ | CEC | $Ca^{++}$ | $Mg^{++}$ | $K^{+}$ | $N^{+}$ | $Mn^{++}$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | gram-equivalent wts./m$^2$ | | | | |
| Chamise | | | | | | | | | |
| ≤5 | .5 | 29 | 3 | 3.28 | 2.37 | .43 | .09 | .00 | .07 |
| 20 | 1 | 50 | 7 | 4.24 | 2.81 | .49 | .13 | .00 | .09 |
| 40 | 1.4 | 67 | 11 | 5.46 | 3.56 | .70 | .17 | .01 | .11 |
| 50 | 1.6 | 75 | 13 | 6.13 | 4.05 | .88 | .19 | .01 | .13 |
| 60 | 1.7 | 84 | 15 | 6.90 | 4.65 | 1.14 | .21 | .02 | .14 |
| 80 | 2.2 | 103 | 20 | 9.02 | 6.53 | 2.22 | .26 | .04 | .20 |
| 95 | 2.8 | 130 | 30 | 12.66 | 10.34 | 5.36 | .33 | .11 | .31 |
| Scrub oak | | | | | | | | | |
| ≤5 | .2 | 24 | 6 | 2.76 | 2.34 | .64 | .09 | .01 | .06 |
| 20 | .5 | 37 | 6 | 3.05 | 3.28 | .66 | .11 | .01 | .08 |
| 40 | .9 | 53 | 8 | 3.74 | 3.96 | .75 | .15 | .01 | .10 |
| 50 | 1.1 | 61 | 9 | 4.26 | 4.24 | .85 | .18 | .01 | .12 |
| 60 | 1.3 | 71 | 10 | 4.96 | 4.52 | 1.01 | .22 | .01 | .14 |
| 80 | 1.8 | 97 | 15 | 7.48 | 5.14 | 1.81 | .36 | .04 | .19 |
| 95 | 2.6 | 140 | 27 | 13.65 | 5.92 | 4.79 | .66 | .26 | .29 |
| ALL SPECIES | | | | | | | | | |
| ≤5 | .3 | 21 | 3 | 3.13 | 2.49 | .44 | .08 | .00 | .07 |
| 20 | .6 | 41 | 6 | 4.26 | 3.25 | .59 | .11 | .01 | .09 |
| 40 | 1.0 | 59 | 8 | 5.58 | 4.15 | .93 | .16 | .01 | .12 |
| 50 | 1.2 | 67 | 10 | 6.27 | 4.62 | 1.18 | .18 | .02 | .13 |
| 60 | 1.4 | 76 | 12 | 7.05 | 5.14 | 1.53 | .22 | .03 | .15 |
| 80 | 1.9 | 98 | 17 | 9.12 | 6.54 | 2.80 | .31 | .07 | .19 |
| 95 | 2.7 | 129 | 27 | 12.51 | 8.81 | 5.91 | .50 | .26 | .26 |

(For gram weights of exchangeable cations multiply by equivalent weights: Ca, 20; Mg, 12; K, 39; Na, 23; Mn, 27.4.)

Table 9-- Total elemental storage in chaparral foliage plus stems (gm/m$^2$).

| Probability Cumul. | N | P | Ca | Mg | K | Na | Mn | Fe | In |
|---|---|---|---|---|---|---|---|---|---|
| Chamise | | | | | | | | | |
| ≤5 | 5.6 | 0.7 | 9.7 | 1.0 | 1.8 | .4 | .05 | .23 | .06 |
| 20 | 6.9 | 0.8 | 11.2 | 1.0 | 2.9 | .5 | .06 | .35 | .08 |
| 40 | 9.1 | 1.2 | 14.0 | 1.3 | 4.5 | .6 | .10 | .59 | .12 |
| 50 | 10.5 | 1.4 | 16.0 | 1.5 | 5.4 | .7 | .13 | .74 | .15 |
| 60 | 12.2 | 1.7 | 18.5 | 1.8 | 6.5 | .8 | .16 | .93 | .20 |
| 80 | 17.5 | 2.7 | 26.8 | 3.0 | 9.6 | 1.2 | .28 | 1.56 | .37 |
| 95 | 28.0 | 5.0 | 44.8 | 6.6 | 15.1 | 1.9 | .58 | 2.86 | .79 |
| Scrub oak | | | | | | | | | |
| ≤5 | 7.2 | 1.0 | 14.5 | 1.2 | 1.5 | 0.7 | .12 | .14 | .03 |
| 20 | 11.3 | 1.1 | 22.3 | 1.5 | 2.5 | 1.0 | .16 | .20 | .04 |
| 40 | 16.5 | 1.3 | 31.0 | 2.1 | 4.3 | 1.2 | .23 | .32 | .05 |
| 50 | 19.4 | 1.5 | 35.6 | 2.4 | 5.6 | 1.3 | .29 | .40 | .07 |
| 60 | 22.7 | 1.8 | 40.6 | 2.8 | 7.2 | 1.4 | .36 | .50 | .08 |
| 80 | 31.8 | 2.8 | 53.8 | 4.1 | 12.5 | 1.7 | .62 | .84 | .12 |
| 95 | 47.4 | 5.5 | 75.0 | 6.5 | 24.1 | 2.1 | 1.22 | 1.56 | .20 |
| Ceanothus | | | | | | | | | |
| ≤5 | 14.5 | .5 | 20.2 | 1.0 | 2.5 | .4 | .05 | .23 | .02 |
| 20 | 18.4 | .6 | 26.1 | 1.3 | 3.4 | .5 | .06 | .28 | .03 |
| 40 | 22.4 | .9 | 32.4 | 1.9 | 5.3 | .6 | .08 | .41 | .03 |
| 50 | 24.3 | 1.2 | 35.5 | 2.4 | 6.7 | .8 | .09 | .50 | .04 |
| 60 | 26.4 | 1.7 | 38.8 | 3.0 | 8.6 | .9 | .11 | .61 | .06 |
| 80 | 31.6 | 3.7 | 47.5 | 5.2 | 15.1 | 1.4 | .17 | 1.03 | .31 |
| 95 | 39.4 | 9.8 | 60.7 | 10.5 | 30.4 | 2.5 | .31 | 2.01 | .54 |

Table 11-Total elemental storage in chaparral litter (gm/m$^2$).

| Probability Cumul. Pct. | N | P | Ca | Mg | K | Na | Mn | Fe | Zn |
|---|---|---|---|---|---|---|---|---|---|
| Chamise | | | | | | | | | |
| ≤5 | 2.1 | .2 | 4.4 | .5 | .4 | .2 | .12 | .9 | .03 |
| 20 | 3.5 | .4 | 7.6 | 1.3 | .8 | .3 | .22 | 2.5 | .06 |
| 40 | 6.8 | .8 | 13.8 | 3.1 | 1.9 | .4 | .43 | 6.2 | .14 |
| 50 | 9.2 | 1.1 | 18.0 | 4.4 | 2.7 | .5 | .56 | 8.9 | .22 |
| 60 | 12.5 | 1.4 | 23.2 | 6.1 | 3.7 | .6 | .74 | 12.6 | .33 |
| 80 | 24.4 | 2.6 | 40.5 | 12.0 | 7.5 | .9 | 1.31 | 25.3 | .81 |
| 95 | 53.6 | 5.1 | 77.4 | 25.8 | 16.9 | 1.6 | 2.54 | 55.8 | 2.24 |
| Scrub oak | | | | | | | | | |
| ≤5 | 10.0 | 0.9 | 13.5 | 2.3 | 1.3 | .2 | .58 | 5.9 | 0.7 |
| 20 | 11.6 | 1.1 | 18.0 | 4.5 | 2.0 | .3 | .70 | 8.3 | .10 |
| 40 | 15.3 | 1.5 | 25.2 | 6.7 | 3.2 | .5 | .92 | 11.5 | .18 |
| 50 | 18.1 | 1.7 | 29.6 | 7.9 | 3.8 | .7 | 1.07 | 13.4 | .25 |
| 60 | 21.9 | 1.9 | 35.0 | 9.1 | 4.7 | .9 | 1.26 | 15.6 | .33 |
| 80 | 35.6 | 2.6 | 51.5 | 12.1 | 7.2 | 1.5 | 1.88 | 21.8 | .62 |
| 95 | 69.5 | 4.0 | 83.8 | 16.7 | 12.1 | 2.7 | 3.20 | 33.0 | 1.32 |
| Ceanothus | | | | | | | | | |
| ≤5 | 6.2 | .3 | 7.7 | 1.5 | .6 | .1 | .13 | .9 | .03 |
| 20 | 13.9 | .8 | 19.2 | 3.8 | 1.9 | .2 | .32 | 3.7 | .11 |
| 40 | 21.9 | 1.4 | 32.1 | 6.4 | 3.8 | .4 | .53 | 9.7 | .24 |
| 50 | 25.9 | 1.8 | 38.8 | 7.9 | 4.9 | .5 | .64 | 14.0 | .32 |
| 60 | 30.2 | 2.3 | 46.1 | 9.4 | 6.2 | .6 | .76 | 19.6 | .41 |
| 80 | 41.2 | 3.5 | 65.4 | 13.5 | 10.0 | 1.0 | 1.08 | 38.7 | .70 |
| 95 | 57.9 | 5.6 | 96.1 | 20.0 | 16.8 | 1.5 | 1.59 | 82.5 | 1.25 |

Table 13-Summary of 50 Pct, probability values for nutrient storage (gm/m$^2$) in chaparral stands.

| | N | P | Ca | Mg | K | Na | Mn | Fe | Zn |
|---|---|---|---|---|---|---|---|---|---|
| Chamise | | | | | | | | | |
| Fol.+stems | 10.5 | 1.4 | 16.0 | 1.5 | 5.4 | 0.7 | 0.13 | 0.74 | 0.15 |
| Roots | 1.1 | 0.1 | 2.6 | 0.2 | 0.2 | -- | 0.01 | 0.4 | 0.01 |
| Litter | 9.2 | 1.1 | 18.0 | 4.4 | 2.7 | 0.5 | 0.56 | 8.9 | 0.22 |
| Total | 20.8 | 2.6 | 36.6 | 6.1 | 8.3 | 1.2 | 0.7 | 10.0 | 0.38 |
| Soil/5 cm | 75 | 0.013 | 81 | 11 | 7 | 0.2 | 3.6 | | |
| Scrub oak | | | | | | | | | |
| Fol.+stems | 19.4 | 1.5 | 35.6 | 2.4 | 5.6 | 1.3 | 0.29 | 0.40 | 0.07 |
| Roots | 1.1 | 0.1 | 2.6 | 0.2 | 0.2 | -- | 0.01 | 0.4 | 0.01 |
| Litter | 18.1 | 1.7 | 29.6 | 7.9 | 3.8 | 0.7 | 1.07 | 13.4 | 0.25 |
| Total | 38.6 | 3.3 | 67.8 | 10.5 | 9.6 | 2.0 | 1.4 | 14.2 | 0.33 |
| Soil/5 cm | 61 | .009 | 85 | 10 | 7 | 0.2 | 3.3 | -- | |
| Ceanothus | | | | | | | | | |
| Fol.+stems | 24.3 | 1.2 | 35.5 | 2.4 | 6.7 | 0.8 | 0.09 | 0.50 | 0.04 |
| Roots | 1.1 | 0.1 | 2.6 | 0.2 | 0.2 | -- | 0.01 | 0.4 | 0.01 |
| Litter | 25.9 | 1.8 | 38.8 | 7.9 | 4.9 | 0.5 | 0.64 | 14.0 | 0.32 |
| Total | 51.3 | 3.1 | 71.9 | 10.5 | 11.8 | 1.3 | 0.7 | 14.9 | 0.37 |
| Soil/5 cm | 67 | .010 | 92 | 14 | 7 | 0.4 | 3.6 | -- | |

•(All chaparral soils values used for Ceanothus) likely this definition entails some rhizosphere material.

Nitrogen contents of chaparral roots were highest for Ceanothus roots, although at the lower ranges all species were similar. Phosphorus values are also higher in association with Ceanothus roots, being nearly double those of the other species. Magnesium values are slightly higher in chamise roots than in other species, a contrast with the lower magnesium contents in chamise stems and foliage.

Root manganese contents are similar at the 50% level for all species. Iron contents of roots are much higher for all the species than for any other plant component analyzed.

Zinc contents for roots are in the range of other plant parts analyzed. The much higher foliage and stem values for chamise do not carry through to the roots except in the extreme values in the upper 30% of the population.

## Chaparral litter composition (table 7)

The litter analyses were fitted to probability functions for each species and element and the data in table 7 derived from this function.

The litter accumulated under the various chaparral species reflects some of the compositional differences previously observed in stem and foliage.

Iron and zinc contents as weight per million are highest in chamise litter. However as will be seen later, this does not necessarily mean higher total storage amounts on the site since total litter weights may have different rankings between species.

## Soil Surface Properties (table 8)

The basic laboratory weight composition data for surface soils were also arrayed in probability tables for each property by species as shown in table 8 to show expected ranges. Thus in general, pH has a similar 50% value of 6.0. The percent carbon content is highest under scrub oak, although, it reaches higher extremes under Ceanothus. Nitrogen values also reach greater extremes under Ceanothus, but are generally higher over the population of samples under scrub oak. Ceanothus tends to maintain lower C/M ratios in the surface soil, and higher water soluble phosphorus contents. In general the cation exchange capacity is higher in soils under Ceanothus, as well as having higher amounts of exchangeable calcium and magnesium on that exchange complex.

## TOTAL ELEMENTAL OTORAGF

The values for elemental storage for each component of chaparral stands were obtained by multiplying the intensity factor of elemental composition by the capacity factor of total weight. These individual component storage values for each species and sampling site were fitted to cumulative probability functions and the data derived for elemental storage are presented in tables 9-12.

## Foliage and Stem Elemental Storage (table 9)

Nitrogen storage quantities for various percentiles of the expected field population are shown in table 9. The nitrogen quantities stored in stands of Ceanothus are highest. Scruboak stands have nearly as much stored nitrogen, while chamise stands have half these amounts.

Phosphorus storage values are similar for all three species. Although chamise vegetation had greater phosphorus weight composition, the greater weights of vegetation in Quercus and Ceanothus stands resulted in equivalent stand weights of phosphorus present.

The data in table 9 can be used to rank any calculation on total elemental storage which the forester or manager of chaparral may have at hand. Comparisons between species are also apparent in the data.

## Root Elemental Storage (table 10)

Root storage contents are grouped for all species because of gaps in the data. The quantities are presented in table 10 as cumulative probability values for all chaparral species.

All the storage amounts are about one tenth the corresponding elemental storage in the tops, except for iron which has a high root storage quantity related to the high intensity of storage as shown in table 6. The generally low storage values are due to the low root weights per unit area, since, most elements are high in weight percent in roots.

## Leaf Litter Elemental Storage (table 11)

Elemental storage quantities in leaf litter may be as great as those in the foliage and stem storage because of high litter weights coupled with high weight percent compositions. Table 11 presents the data obtained from the cumulative probability functions fitted to the sample site data for the litter storage of nine elements.

The nitrogen storage values of 25.9 gm/m$^2$ in Ceanothus are the highest of the three species. These are comparable to the quantities stored in vegetation reported in table P. The litter storage of phosphorus is similar for all the species compared. Calcium storage in litter is similar in quantity to that stored in the vegetation storage in foliage plus stems. However magnesium storage amounts in litter are much higher than the foliage plus stem storage. These values are roughly four times vegetation storage, indicating that magnesiumis being accumulated in the litter.

Potassium storage in litter is highest under Ceanothus at 5 gm/m$^2$, least under chamise at 2.7 gm/m$^2$, half the amount in the vegetation, attesting to the ready leaching of potassium. Sodium storage amounts are the same in the hitter of all the species. The values of 0.5 gm/m$^2$ are half the content of vegetation storage indicating ready leaching as in the case of potassium.

Manganese and iron contents are definitely enriched in litter. Manganese contents are highest in oak litter, and second highest in that of Ceanothus litter. Iron storage quantities are generally highest in the Ceanothus, and the scrub oak litters, and least in the chamise litter.

Zinc quantities are generally 0.2 to 0.3 gm/m$^2$ in all the litters without wide differences, although there is a tendency to higher extremes in chamise litter.

## Elemental Storage in Surface Soil Layers (table 12)

The calculated data for elemental storage quantities in the top 5 cm layer of the soil were arrayed and fitted to cumulative probability functions to derive the data in table 12. Elemental storage in the surface soils tend to have less variation related to species influences than the vegetation and litter values. Nitrogen storage in the top 5 cm of soil whether associated with chamise or Ceanothus is very nearly 60-75 gm/m$^2$, despite a much wider variation in the associated litter and vegetation. Available phosphorus storage in soil (water soluble) is much lower than the total storage in litter and vegetation. Calcium storage amounts are nearly the same, at the 50% level from 4.0-4.6 equivalents per square meter (multiply by 40 for grams). Thus, the soil storage quantities in the top 5 cm alone are four times those in the vegetation and liter. Manganese storage of the soil at 50 gm/m$^2$ in the top 5 cm of soil is nearly fifty times that contained in the vegetation and the litter above. No iron or zinc analyses were made of the soil. The data indicate that for many of the elements in the chaparral stand the soil has the major storage amount.

## Elemental Storage Distribution Between Stand Components (table 13)

The total elemental storage on a chaparral site will be distributed variously between the vegetation, leaf litter, and the soil. This partly depends upon the age of the stand of course, but since these were all stands of about 20-25 years of age, they will be considered to be mature stands of chaparral. The data for the fifty percentile class of total storage amounts have been collected in table 13.

At a glance one finds that storage values in the leaf litter are frequently as much or more than the storage in the live vegetation. Some elements such as magnesium have much greater quantities in litter storage. Leachable elements such as potassium and sodium have much less storage in the litter. Manganese, iron, and zinc are present at orders of magnitude greater in litter storage.

Soil storage values in the top 5 cm of the soil alone are much greater than most of the storage quantities in vegetation, indicating the importance of even the loss of a small portion of top soil in erosion associated with brush removal as a major process of nutrient loss from chaparral stands. This is particularly the case in chamise stands where nitrogen storage amounts in the top 5 cm of the soil are more than three times the storage amounts in vegetation and leaf litter combined. Vegetation storage quantities of phosphorus represent a large proportion of the readily available phosphorus in the stand and its associated soil, and the processes involved upon liberation of this phosphorus back to the soil may be important in determining its availability. Magnesium and potassium storage quantities in vegetation are also a substantial proportion of total storage on the site including the surface soil.

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