The study of modern pollen is a critical component of paleoecological research. The relationship between the spatial distribution of modern pollen and its representative vegetation has been demonstrated by many studies (e.g., Jackson 1991, Fall 1992, Jackson & Smith 1994). These relationships may be complicated in areas of high elevational relief by differential pollen production and atmospheric mixing due to in situ air mass movements (Markgraf 1989, Spaulding et al. 1994, Gaudesius et al. 1989). In California, where few such studies have been undertaken, Johnson & Stullworth's (1986) study revealed that yearly pollen distribution in the Owens Valley from distant vegetation communities was low but uniform at sites outside the same vegetation community. Though overprediction by the numerous species of Pinus (pine) in the west provide a complicating factor, both Adam (1967) and Andrews & Davis (1988) demonstrated a strong relationship between modern pollen and vegetation composition within the central Sierra Nevada, a region of high elevational relief. Andrews (1990) demonstrated a similar relationship for the montane conifer forest, particularly in stands where Sequoia sempervirens (sp. sempervirens) is prominent. The modern pollen - vegetation relationship can be determined from collection of the upwind sediments from lakes and wetlands, contemporary wetland samples, a variety of active and stationary pollen traps, and moss spores. While considerable debate exists regarding the use of modern pollen from lakes and wetlands versus moss spores for comparison to sedimentary pollen (Fall 1992), many regions within and outside of North America do not have lakes and wetlands over the entire elevation gradients common to the region. Moss spores, however, are common at elevations from sea level to above tree line throughout the region; and are consequent to the most common depositional site for the study of modern pollen for many regions. Very few modern pollen rain studies exist (for California, with some published for southern California Web 2003) reported on work in progress for the region. Davis (1995) compiled a list of modern pollen transects and isolated sites for much of the western United States, including southern California. In this study we examine modern pollen spectra from a series of moss pollen collected using two elevational transects in the Transverse and Peninsular ranges of southern California. We use cluster analysis to compare the modern pollen rain with its associated plant communities.

STUDY AREA AND CLIMATE

The San Bernardino and San Jacinto Mountains of southern California (Fig 1) are located within the Transverse and Peninsular Ranges, respectively (Norris & Webb 1974). These ranges result from fault-block activity of the San Andreas and San Jacinto faults, and their peaks are the highest in southern California (Mt. San Gorgonio at 3305 m,
Fig. 1. Location map of the Transverse and Peninsular Ranges of southern California. Crosshatching in central panel is the San Bernardino (upper) and San Jacinto (lower) National Forests. Dotted areas of the modern pollen transects in the San Bernardino and San Jacinto ranges are also shown. Numbers are keyed to locations in Tables I and II.

and Mt. San Jacinto at 2334 m, respectively. These ranges consist of quartz monzonite basement rock that has intruded and caused meta-sedimentary and volcanic rocks to outcrop along their lower edges. Evidence of limited glaciers has been noted from Mt. San Gorgonio, where at least two cirques are located (Sharp et al. 1939).

The climate of southern California is zonally subtropical and is classified as Mediterranean, with hot, arid summers and cool, frontal winters. While the growing season is limited by the cooler temperatures of the winter and by drought in the summer, snow accumulation at the highest elevations provides sufficient soil moisture to support coniferous forest through the dry summer season.

Three important gradients exist within the study region.
modifying this general precipitation pattern (Major 1988, Mock 1996). Annual precipitation generally increases from the coast (ca. 210 to 375 mm) northward towards the higher elevations of the San Jacinto and San Bernardino Mountains (ca. 226 to 1940 mm; Fig. 2).

A second gradient of annual precipitation occurs to the east and northeast of the two ranges (Fig. 2). The primary source of precipitation for the region comes from frontal storms originating in the Pacific Ocean during the winter. The San Bernardino- and San Jacinto ranges act as a partial barrier to regional airflow, creating a rain shadow to the east with less than half that of the west and southwest.

A third gradient reflects the seasonal distribution of precipitation (Fig. 3). Summer precipitation west of the crests of the San Bernardino- and San Jacinto ranges is generally <10% of the annual total, whereas more immediately east of the crests receive up to 35% of their annual precipitation during July through September. The crest of the range thus separates areas with significant summer monsoon storms (important to the east).

**Modern vegetation**


**San Jacinto Mountain**

Agricultural fields, orchards and remnant grasslands occur at lowest elevations in valley bottoms to the west of the range today, while elements of the coastal, sage scrub community occur on adobeclays (Vogel 1976). Arctostaphylos xeropholophylla (chamise)-dominated chaparral occurs from the mountain base up to ca. 1225 m, with Eriogonum fasciculatum (blackbush). Rhus ovata (oakleaf sumac), Clethra arborea (California box), Corocorys pendula (mountain mahogany) and Quercus oblongata (buckeye). In the south, A. fasciculata is replaced by A. rigida (redshank). Arctostaphylos spp. (manzanita) sometimes dominate between ca. 1335 and 1545 m elevation, along with Clethra arborea, Rhus ovata (blackbush), and Quercus dumosa var. francisci (interior live oak) or Q. kellogii (black oak). The chaparral-scrub-eucalyptus conifer complex consists of Quercus kelloggi, grasses or Pino cariboj (coast live oak), and Juniperus deppeana (deppe’s juniper), with Usnea cladoniae (California bay). Clethra arborea, Arctostaphylos and Q. widdeni, or Q. chrysolepis (tanoak live oak) are on sandy soils (Vogel 1976).

Between ca. 1545 and 2160 m occurs the mixed conifer forest, including oak (Q. kellogii, Q. widdeni, Q. chrysolepis) with pines (P. ponderosa, P. lambertiana (eugra), P. jeffreyi (jeffrey)), P. ponderosa (ponderosa), Cupressus deodara (incense cedar) and Abies concolor (white fir). However, above ca. 2100 m, P. jeffreyi dominates, with Abies concolor. Forest openings have several mesic chaparral shrubs - Arctostaphylos parryana var. planifolia, Coosia obtusifolia (spiny snowberry) and Chrysolepis sempervirens (chinquapin). At the highest elevations are P. engelmannii (bogpole pine) and occasional P. flexilis (limber pine).

On the south and southwest flanks of the mountains are the P. monticola (single needle pine) and Juniperus californica (California juniper) woodland between ca. 1235 and 1545 m, along with a variety of shrubs, including Q. tremuloides, Q. imbricata, Quercus falcata (faba teak), Corocorys spp., Pisonia glauca (kelpbrush), Adenostoma fasciculatum, Arctostaphylos turbinata (Great Basin manzanita).
San Bernardino Mountains

Califomia sage scrub [Artemisia californica (California sagebrush), Joshua juniperus (bottlebrush), Nutria sparsa (white sage) and Eriogonum spp.] occurs below about 775 m elevation on the southwest flank of the range (Mitchell 1976). Chaparral carpets slope up to 1,345 m (Mitchell 1976) with local dominants Adenostoma fasciculatum, Q. dumosa, Q. viridgigantea, Q. rhamnoides, Ceanothus greggi, Ceanothus spp., Arctostaphylos spp. and Peyotlodon catlinii,fremontii), among many other perennials.

Locally, oak woodlands and oak-fescue species dominate (Mitchell 1976). Quercus agrifolia (most live oak) and Q. Chrysolepis are found in canyons bottoms and on north-facing slopes with P. sparsifolia, Plantago lanceolata, Vicia sativa and Vicia segetalis (white clover) and many others. The Chrysolepis are exposed in canyon bottoms and on north-facing slopes with P. sparsifolia, Plantago lanceolata, Vicia sativa and Vicia segetalis (white clover) and many others.

Methods
Mass plotter samples were collected from reclamation sites at 36 locations, 30 plots were not identified to species, but were consistent with growth form. The presence of major higher plant species within 30 m of the collection site was noted.

RESULTS AND DISCUSSION

Elevation distribution of modern pollen and vegetation

Forty-eight pollen types were encountered in the 36 pollen samples taken along the two transects. However, only 18 of these pollen types either occurred regularly in pollen samples or are diagnostic of vegetation types encountered in the study areas. All voucher specimens and corresponding electron micrographs can be accessed from http://pollen.museum.msu.edu/PollenData/Published.html.

Abies. A single species, Abies concolor, occurs in the two range. In both transects, A. concolor is concentrated in the lower montane Picea-abies zone, but also occurs in the Quercus-Pinus zone. For both transects, the pollen percentages mirror this distribution. Pollen percentages are highest in the Picea-abies zone, with somewhat lower percentages in the Quercus-Pinus zone at both locations. At the 2460 m site in the SB range where the tree is absent, Abies pollen is 5.8% of the sum, comparable to percentages reached in the Picea-abies zone (5.5-7.5%) where trees are present.

Six species of Picea were recorded near the most pollinator collection sites, including P. engelmannii, P. glauca, P. jeffreyi, P. lutea, P. pungens, and P. engelmannii (Pine). These species could not be reliably separated using the subgenus due to inadequate preservation of the hyphae.

Though Picea pollen is a dominant type in both ranges,
Table 1. Pollen abundance, elevations, vegetation types and principal species from sites along the San Bernardino Mountains transect.

<table>
<thead>
<tr>
<th>Site</th>
<th>Elevation (m)</th>
<th>Location</th>
<th>Vegetation Type</th>
<th>Principle Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS-1</td>
<td>1780</td>
<td>Hoy St Mill Creek</td>
<td>Chaparral, Raven's</td>
<td>ADFA, ERO, QDCU, QUCI, PISA, PHE.</td>
</tr>
<tr>
<td>SS-2</td>
<td>1480</td>
<td>New Arroyo Wash Club</td>
<td>Chaparral</td>
<td>ADFA, ERO, QDCU, PISA, PHE.</td>
</tr>
<tr>
<td>SS-3</td>
<td>1575</td>
<td>Hoy St</td>
<td>Chaparral</td>
<td>QUCI, PISA, ERO, ARDI, SALX, PHE.</td>
</tr>
<tr>
<td>SS-4</td>
<td>1630</td>
<td>New Arroyo Wash Club</td>
<td>Chaparral</td>
<td>QUCI, PISA, ERO, ARDI, PAIR, PISA, PHE.</td>
</tr>
<tr>
<td>SS-5</td>
<td>1755</td>
<td>New Arroyo Wash Club</td>
<td>Chaparral</td>
<td>QUCI, ERO, ARDI, PAIR, PISA, PHE.</td>
</tr>
<tr>
<td>SS-6</td>
<td>1775</td>
<td>New Arroyo Wash Club</td>
<td>Chaparral</td>
<td>QUCI, ERO, ARDI, PAIR, PISA, PHE.</td>
</tr>
<tr>
<td>SS-7</td>
<td>1835</td>
<td>New Arroyo Wash Club</td>
<td>Chaparral</td>
<td>QUCI, ERO, ARDI, PAIR, PISA, PHE.</td>
</tr>
<tr>
<td>SS-8</td>
<td>1865</td>
<td>Hoy St</td>
<td>Chaparral</td>
<td>QUCI, ERO, ARDI, PAIR, PISA, PHE.</td>
</tr>
<tr>
<td>SS-9</td>
<td>2120</td>
<td>Poonspur Hill Trail</td>
<td>Chaparral</td>
<td>QUCI, ERO, ARDI, PAIR, PISA, PHE.</td>
</tr>
<tr>
<td>SS-10</td>
<td>2220</td>
<td>South Fork Trail</td>
<td>Chaparral</td>
<td>QUCI, ERO, PAIR, PISA, SALX, PHE.</td>
</tr>
<tr>
<td>SS-11</td>
<td>2277</td>
<td>South Fork Trail</td>
<td>Chaparral</td>
<td>QUCI, ERO, PAIR, PISA, SALX, PHE.</td>
</tr>
<tr>
<td>SS-12</td>
<td>2333</td>
<td>South Fork Trail</td>
<td>Chaparral</td>
<td>QUCI, ERO, PAIR, PISA, SALX, PHE.</td>
</tr>
<tr>
<td>SS-13</td>
<td>2675</td>
<td>South Fork Trail</td>
<td>Chaparral</td>
<td>QUCI, ERO, PAIR, PISA, SALX, PHE.</td>
</tr>
<tr>
<td>SS-14</td>
<td>2285</td>
<td>Dry Lake</td>
<td>Upper montane</td>
<td>PHE, PISA, ERO, PHE, ARTO, ASE, ARDI, PHE.</td>
</tr>
<tr>
<td>SS-15</td>
<td>2810</td>
<td>Dry Lake</td>
<td>Upper montane</td>
<td>PHE, PISA, ERO, PHE, ARTO, ASE, ARDI, PHE.</td>
</tr>
<tr>
<td>SS-16</td>
<td>3460</td>
<td>Sun Gorgona summit</td>
<td>Subalpine</td>
<td>ONSI, POA, RIMO, POLE, ERO, Bras, PHE.</td>
</tr>
<tr>
<td>SS-17</td>
<td>3065</td>
<td>Sun Gorgona summit</td>
<td>Subalpine</td>
<td>ONSI, POA, RIMO, POLE, ERO, Bras, PHE.</td>
</tr>
</tbody>
</table>

**Different sites may contribute to the pollen at different elevations. Where Pinus trees are absent, such as in the lower elevations and lower chaparral of the SJ transect, Pinus pollen percentages are 1.2 - 4.8%. Pinus trees are absent at SS-3, 5, 6, 7, 8, and 9, where the pollen percentage is 2.4%. At locations where trees are present, Pinus pollen varies from 19.0 - 42.8% (SS-6, 7, 8, 9, 10, 11). Pinus pollen is found in the SJ transect from SS-6 to 34.4% in SS-7 and 20.7 - 41.4% (SS-10) to 34.4% in SS-11 and 1.0% - 91.2% in upper montane and subalpine forests. Although clear patterns exist along the transect gradient, our data are not able to elucidate the relationship between the occurrence of Pinus pollen and individual species.**

**Quercus:** Five species of Quercus were identified on the two transects, including Q. wislizenii, Q. dumosa, Q. kelloggii, Q. pubescens and Q. vaccinifolia (huckleberry oak). In our study area, Q. dumosa was found along the SJ transect in the chaparral, while Q. kelloggii occurred on both transects in the chaparral and lower montane zones. Q. kelloggii was found in the lower montane Quercus-Pinus woodland in both the SJ and SB ranges, but Q. vaccinifolia occurred in the montane above 2220 m (SJ) and the upper montane above 2810 m (SB). Q. pubescens was recorded only in the SB range (SS-17) in the pinyon-juniper woodland.

Consistently high Quercus pollen percentages occur in the lower montane Quercus-Pinus forest communities of both ranges (SB: 19.5 - 76.5%; SJ: 23.4 - 59.9%). High values in the SJ transect sites from SB (19.7 - 55.8%) correspond exactly to the current pollen occurring there. Where Q. dumosa is absent in the SJ transect Quercus pollen percentages are 3.2 - 11.3% in the chaparral. Moderate values (1.5 - 7.9%) are recorded in the higher elevations sites near the upper elevations of the SJ transect, and probably reflect either the local occurrence of Q. vaccinifolia or excess pollen from lower below. High values of Quercus in the pinyon-juniper zone of the SJ transect are associated with the occurrence of Q. kelloggii. The lowest pollen percentages (0.5 - 3.1%) were recorded from the upper montane of the SB range.

**Pseudotsuga:** P. menziesii is the only species in this genus within the two ranges, primarily within the lower montane Quercus-Pinus forest, but sometimes occurring within riparian localities in the chaparral. Only two of our study sites had this species. Pseudotsuga pollen is often present in pollen assemblages due primarily to its thin cell wall that readily breaks down and poor dispersal (Erdtmann 1969). Though generally absent Pseudotsuga pollen occurred at 1.6% at the upper montane (SB-3), one site where the tree was present.

**Cupressus:** Two species found in the study area are identified in the Cupressaceae pollen type. *Cupressus californica* is found sporadically on the coast side of the mountain.
ranges but becomes predominant on the east slope of Mt. San Jacinto in the pinyon-juniper community where moderate pollen percentages (10.1-27.8%) were recorded. Calocedrus decurrens (incense cedar) is found throughout the lower montane Quercus-Pinus communities of both mountain ranges where Cupressocyparis pollen occurs in moderate (7.9-29.4%) percentages. The poikilos type also occurs in somewhat lower pollen percentages in the chaparral of the SJR range.

Alnus - White alder (A. rhombifolia), the only alder found in the study area, prefers riparian locations up to ca. 2000 m elevation. Although nearly every pollen had at least one grain of 'Alnus, the highest pollen percentages are found in the chaparral (one sample with the tree present to 16.2% in SJR; to 7.2% in SJ), with sustained percentages in the lower montane Quercus-Pinus zone (1.9-16.1% in SJR; 0.5-7.3% in SJ).

Adenostoma - A. fasciculatum occurs on the lower and upper facing slopes of both mountain ranges in the chaparral, while A. sparsifolium occurs predominantly on the west and southwest slopes of the San Jacinto Mountains. Adenostoma pollen was very localized in the SJR transect, but occurred in nearly all of the samples taken from the SJ transect. Adenostoma pollen is present (to 7.6%) within the chaparral communities of both ranges. On Mt. San Jacinto, Adenostoma pollen is represented by a strongly bimodal distribution (Fig. 5). In the more isolated San Bernardino Mountains, it occurs in samples only from the chaparral community, as well as open sites in the summit samples.

Pineus - Grass pollen is most abundant (up to 15.6%) in the grassland community west of Mt. San Jacinto (Fig. 5). In the transect vegetation, grasses are mostly restricted to the lowest elevation valley grasslands and chaparral (Figs. 4 & 5), but are also found in the more open sites in the lower montane forest, as well as pinyon-juniper site on the southeastern flank of the San Jacinto range. Most members of this family are wind-pollinated, dispersed widely, and are rarely separable below the familial level. As such, high percentages of Poaceae pollen are indicative more of a vegetation type, such as grassland, and not of a particular species.

Cereusarype-type - This pollen type includes related species in the Rosaceae, often found as chaparral and montane chaparral species in both ranges. The generally widespread elevation range is demonstrated by the near universal occurrence of pollen of this family in both transects. Greatest percentages (to 7.2%) occur within the chaparral and lowest montane samples on the SJ transect. Specimens of C. rhodanthus are found at these locations.

Chrysolepis - Chrysolepis Arctostaphylos. - These species generally occur as an upper elevation chaparral component in the Pinus-Abies and upper montane communities. For
instance, *Chrysolepis sempervirens* was found as high as 3100 m on the slopes of Mt. San Gorgonio in the SB transect. Pollen of *Chrysolepis* reached moderate percentages (11.9%) where it occurred as the dominant understorey shrub. *Chrysolepis* pollen was less important in the SJ transect. 

*Gymnosporus* includes several species distributed from the low elevation chaparral to upper montane communities. However, its distribution on these transects was considerably reduced to sites in the Pine-Brush forest (Figs. 4 & 5). Pollen percentages were generally greater in the Quercus-Pinus forest of the SJ (3.6%) and SB (17.3%) transects.

*Arctostaphylos* occurs as a shrubby subdominant within montane communities as well as a dominant within the chaparral. The highest occurrence of *Arctostaphylos* pollen was in the chaparral of the SB transect (Fig. 4). Although *Arctostaphylos* shrublets were recorded from several sites along both transects (Quercus-Pinus, Pinyon-Juniper, subalpine and pahoke-Juniper types) only sporadic occurrence of pollen was noted. Only when *Arctostaphylos* occurred as the dominant plant within the upper chaparral community did pollen percentages reach significance (29.8%).

**Artemisia, Othon**—At least 200 genera of *Artemisia* occur in California (Hickman 1993). Though several studies have separated individual genus phylogenetically within this family (e.g., Markgraf & D'Arauto 1975), a comprehensive key for North America does not exist. The Other Asteraceae includes all members of the family not included as *Artemisia, Atriplex, Cirsium*, and *Liguliflora*.

Because members of this family occur in all vegetation types, occurrence of *Artemesia* pollen from the transects provides circumstantial results. For instance, *Artemesia* pollen occurs in virtually all samples on the SB transect (Fig. 4). On the other hand, *Artemesia* pollen is concentrated at the lower elevation, more open, sites in the SJ transect (Fig. 5), reaching 14.6% in grassland and 29.4% in the Sanon Desert.

**Chrysophalus-Ammophilaeces**—Hickman (1993) lists 33 genera within the Chenopodiaceae of which 17 have similar pollen morphologies. Separation of species within this group has also been difficult. As with the *Artemisia*, Chen/Amph/Amar pollen is found in all samples on the SB transect. It is widespread on the SJ transect, but is concentrated at lower elevation sites within the grasslands and agricultural fields (to 5.8%) and the pahoke-Juniper and Sanon desert vegetations (6.5%). These values probably reflect the occurrence of weedy species in the former, and occurrence of amphi/0calo in the lowlands of the latter.

**Brassicaceae**—We lumped all pollen of the *Brassicaeae* into a single pollen type. The pollen type occurs in virtually all of the pollen samples on the SB transect (up to 2.3% in one instance). On the SJ transect its maximum occurrence is in the grassland and agricultural communities, where it consists of 6.3 to 32.6% of the pollen sum. These high percentages undoubtedly reflect weedy members of the *Brassicaeae* in agricultural fields.

**Rutaceae**—Pollen of the *Rutaceae* was identified from the lower coast-facing slopes of Mt. San Jacinto (Fig. 3), sites
located within the grasslands, agricultural fields and lower chaparral there. This can be attributed to the extensive cultivated Chenopodiaceae growing there.

*Aristida*. Pollen of *Aristida* was recovered as 1% grains in most samples of both transects. However the plant itself occurred only in the Garnet Valley (SE-15, Appendix 2) of the San Jacinto study area, where pollen percentages reached 37%. Sagebrush pollen was also identified from the San Bernardino Mountains, and is thought to represent pollen moved long distances from the Mohave Desert to the north and east of the range.

*Ephedra*. *Ephedra* occurred near two sites on the east slope of Mt. San Jacinto in the Sonoran desert community. At these sample locations, pollen occurred in low (1–2%) percentages. The highest elevation sites in both mountain ranges typically had one or two grains of *Ephedra*, attributable to long distance transport from the desert regions below.

*Larrea*. *Larrea tridentata* (creosotebush) was recorded at one of the two Sonoran desert sites on the SJ transect, although the plant is widespread throughout the Sonoran desert. Pollen of *Larrea* was recorded at both of the sites in moderate amounts (1.3 to 3.7%).

Cluster analysis of each transect

The pollen data from the San Bernardino Mountains transect forms four clusters (Fig. 6), while six clusters are identified from the San Jacinto Mountains data (Fig. 7). In general, the forest communities are similar in both mountain ranges. The differences between the two transects were due to plant communities sampled exclusively in one or other of the ranges, primarily in the lower elevations of the San Jacinto, and highest elevation of the San Bernardino transects. Two clusters occur with samples from the SJ transect only (Fig. 7). Cluster SJ-I is the two Sonoran Desert samples. Pollen is dominated by *Quercus* and *Cupressaceae*, but the most diagnostic pollen types are *Ephedra* and *Larrea* with pollen of *Aristida* and *Chenopodiaceae*. The pollen assemblages of Cluster SJ-II are dominated by non-arboreal types, and include samples from the grassland and agricultural regions on the west side of the range. Pollen of *Puccinea*, the Cheno-Am group and the Asteraceae and Brassicaceae families are common. Pollen of trees, common in all other clusters in this analysis, is absent or substantially reduced over samples from higher elevations. *Pine* pollen averages 2.8%, *Quercus* 10%, and *Cupressaceae* 5.6%. Pollen of *Aster* is absent, but pollen of agricultural (Chenopodiaceae) and introduced shade (*Pinus*) trees is exclusive to the grassland samples (Appendices 1 & 2).

Cluster SJ-III separates chenopod samples from the San Jacinto Mountains. The cluster is typified by very low *Pino* (avg. = 2.1%, 0.5–5%) and *Chenopodiaceae* (avg. = 0.2%, 0–0.2%), moderate *Quercus* (avg. = 10%), *Cupressaceae* (avg. = 3.9%, 1–5.9%), and the presence of moderate to high amounts of chenopod species pollen. *Atriplex* is the dominant pollen type; a bimodal peak of *Atriplex* occurs on both sides of the range with percentages to 72.6%. Unlike in the San Jacinto Mountains, chaparral in not easily distinguished in the San Bernardino transect. A single sample defines Cluster SJ-III (sample SJ-3), and is distinguished by high *Asteraceae* pollen. Otherwise, the two additional chenopod samples fall into other clusters (see below).
San Bernardino Mountains Moss Polster Cluster Analysis

Fig 6. Unconstrained cluster analysis of the San Bernardino Mountains modern polystones. Percentage transect data. SB-III - chaparral, SB-IV a and SB-IV b - lower montane Quercus - Pino woodland; SB-VI - Pines - Alto dominated forest; SB-VII - subalpine forest.
San Jacinto Mountains Moss Polster Cluster Analysis

Fig. 7: Unconstrained cluster analysis of the San Jacinto Mountains modern pollen percentage transect data. SJ-I = Sonoran Desert; SJ-II = Valley grassland and agricultural land; SJ-III = chaparral; SJ-IV b and SJ-IV c = lower mountain Quercus – Pine woodland; SJ-V = Juniperus – dominated woodland; SJ-VI = Pines – J. A. Moss dominated forest.
San Bernardino and San Jacinto Ranges, Combined Cluster Analysis

Figure X: Unsupervised cluster analysis of all Transverse and Peninsular Ranges samples. "A" = Sonoran Desert; "B" = Valley grassland and agricultural land; "C" = chaparral; "D" = Rocky Mountain Quaternary Pine woodland; "E" = Pines. This forest and chaparral.
monument forest, or clavier separately based on the highest percentages of Anacampseros pollen (Fig 9).

A grassland cluster ("B"), exclusively from the San Jacinto Mountains transect (477-723 m) was discriminated. These elevations were not sampled in the San Bernardino Mountains transect. The cluster is characterized by the highest Pooa (0.7-2.4%), Bromus (25.0-1.0%), and Asteraceae (0.4-2.4%) pollen percentages, pollen of ericoid trees, and low Pinus (2.8-1.2%). Quercus (0.0-5.3%), and Cupressaceae (5.6-1.1%). These values reflect the long-distance dispersion of aridland pollen types to the lower regions of the study area.

Two samples were differentiated from the Sonoran Desert, found only on the San Jacinto transect (cluster "A"). These samples are described in the previous section.

CONCLUSIONS

Our study assesses in understanding the modern pollen rain from a region that spans the summer-dry to winter-wet transition in southern California. The cluster analyses allowed us to distinguish phylogenetically a minimum of five major groups corresponding largely to different vegetation units in the Transverse and Peninsular ranges. Lower elevation grasslands and modern agricultural farm and croplands are easily distinguished from chapparal and other vegetation types dominated by non-arboreal pollen. These assemblages, in turn, are separated from the montane forests that cover much of the ranges. Within each range, we were able to discriminate lower montane vegetation dominated by Quercus and Pinus from that dominated by Quercus and Carya/obtus from that dominated by Quercus and Cupressus. Although it only occurred within the study area on Mt. San Gorgonio, our analysis also separated the subalpine zone from the upper montane zone at the highest elevations.

Quercus and Pinus are the dominant modern pollen types on both transects, occurring in all samples. Additionally, important pollen types include Abies, Cupressaceae and Asteraceae. Relative changes in proportions of these five types largely differentiate one vegetation type from another. However, each vegetation type includes several additional pollen types that serve to further characterize the assemblage. For instance, while Asteraceae is probably the best indicator of chapparal vegetation (especially in the SJ transect), other species are important including Anacampseros, Cyperus and Rosaceae. In the montane samples, especially in the SJ transect, Chrysopogon pollen is a regular occurrence.

The pollen assemblages from the grasslands and modern agricultural land west of the San Jacinto Mountains demonstrate the impact of human activities on the modern pollen record of the region. This vegetation is dominated by the occurrence of Pooa, Bromus, Asteraceae, and Chenopodiaceae, with Rutaceae (Citrus sp.) and Eucalyptus sp. pollen types. Most of the former, e.g., Bromus, Asteraceae, Chenopodiaceae, are likely a direct result of regional and even those species favored by the disturbance to natural vegetation caused by agriculture, while the latter trees are introduced cultivars for fruits or shade. In the case of Citrus and Eucalyptus, these pollen types are found exclusively in this zone, and are important indicators for the lowest elevations of the SJ transect. Several Old World species of Betula (B. nigra, B. geisleri, B. tortuosa) have become widely distributed within the area during the 20th century (Minnich & Drezan 1989).

Though pollen assemblages collected from chapparal vegetation distinguish modern chapparal in the San Jacinto transect, the assemblages from the San Bernardino Mountain ranges are less diagnostic. This may be a function of the sites themselves, as vegetation at chapparal sites on the SB transect often included Quercus and Cupressus, which are prevalent on the SJ transect. Consequently, Quercus contributed greater amounts of modern pollen to chapparal assemblages at the San Bernardino Mountain. Three important findings relate to the lower montane forest. First, we were able to distinguish the Quercus-Carya/Carya (the Quercus/Pinus forest) from the Sierra Nevada to the north (Anderson & Davis 1988). This similarity of type may be due to the relative sizes of the mountain ranges, atmospheric mixing in the much larger Sierra Nevada may be greater due to the relative consistence of regional wind patterns. Third, Abies is much more important in the local pollen rain in the Transverse and Peninsular Ranges (both in other California studies).

Even though a relatively congruous pattern of pollen changes for major vegetation types is exhibited for the combined pollen assemblages (Fig 9) distinct differences can be identified for each mountain range. For instance, Abies-dominated shows the chapparal assemblage of the San Jacinto range. In the SJ transect, Abies-dominated is subdominant to Anacampseros. Abies occurs in a dominant modern cypress, and the pollen is common, as high as 3100 m in the slopes of Mt. San Gorgonio in the San Bernardino Mountains. Pollen of Chrysopogon also occurred in the SJ transect, but was considered less important in that range. Abies occurs in higher percentages in the SJ transect (Appendix B), which may be related to proximity to the Sonoran Desert to the east. The samples from the Sonoran Desert sites themselves are like no other, with diagnostic pollen of Larrea and Ephedra. Despite minor differences between the two ranges, our analysis did not identify major differences in floristic extent of pollen zones. Small discrepancies are more likely due to the bias in sampling and the vegetational representation between the two transects. Thus we conclude that the compositional analysis is probably the most useful representation of pollen distribution for these inland mountain ranges of southern California.

ACKNOWLEDGEMENTS

We are grateful for the assistance of several individuals in this study. Tainted samples came from Susan G. Davis and Bill Oregon of Applied Earthworks, Inc., while financial support came from the Metropolitan Water District. We thank Susan Smith and Ron Robinson for assistance with calculations and the graphs, and Geoffrey Spaulding for introducing us to the region and for helpful discussions on the research. We also thank several anonymous reviewers for their thoughtful comments.

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</tbody>
</table>

| Total Elements | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  |

| Terrestrial Pollen Sum  | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  |

| Terrestrial Pollen Total | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  |