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NOTES ON NATIVE VASCULAR PLANTS FROM MIMA MOUND–VERNAL POOL TERRAIN AND THE IMPORTANCE OF PRESERVING COASTAL TERRACES IN ORANGE COUNTY, CALIFORNIA

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ABSTRACT

We report the following noteworthy collections of native vascular plants from mima mound fields in coastal Orange County, California: *Deschampsia danthonioides, Lepidium strictum,* and *Sagina saginoides* (new county records), *Lepidium oblongum* var. *oblongum* (previously excluded from the flora), *Deinandra paniculata, Holocarpha virgata* subsp. *elongata,* and *Navarretia prostrata* (new localities in the county), and *Hordeum brachyantherum* subsp. *californicum* (uncommon species of local interest). A herbarium study, preparation of voucher specimens, and a generalized distribution, facultative wetland status, and taxonomic notes, where appropriate, are cited for each taxon. An overview of the mima mound micro-relief associated with coastal terraces in southern California is also provided.

Key words: biodiversity, coastal terraces, conservation, geomorphology, mima mounds, Orange County, California, rare plants, tectonism, vernal pools, wetlands, wetland indicator status.

INTRODUCTION

Most mima mounds in California are believed to be the long-term byproduct of the earth-moving activities (bioturbation) of pocket gophers (Cox and Scheffer 1991). The mounds typically occur on stable landforms (>100,000 years old) where soils (pedogenic profiles) are strongly developed, and usually characterized by a relatively impermeable layer (claypan or silcrete duripan) in the subsoil that locally impedes drainage. With the onset of seasonal rain, the duripan forms the base for locally perched water levels, and the gophers thus construct loosely consolidated mounds (mima mounds) above the rising water (Amundson 1998). The mounds, with their actively bioturbated, low-density soils, are usually well drained, and are often the foci of shrub establishment (Cox 1986). Vernal pools, which are generally small, shallow and complex ephemeral wetlands, develop in the inter-mound depressions. These pools are typically hydrologically isolated from perennial inflow by the ring of rodent-occupied mima mounds, and hence have internal drainage (Shlemon et al. 1997; Shlemon and Riefner 2006). Within these inter-mound pools, ponded water comes and goes throughout the year, but is present at least for a short time in most years. Thus, the vernal pool basins and poorly drained through-flowing swales associated with mima-type topography support a predominantly facultatively hydrophytic herbaceous flora adapted to seasonal inundation, including the well-known vernal pool endemics (Zedler 1987). These temporary aquatic habitats are the primary or exclusive habitat for a rich array of highly specialized organisms, plus widespread species from wetland and upland edge habitats that share the capacity to deal with dramatic, seasonal changes in the local hydrology (Zedler 2003).

Mima mounds and vernal pools are inexorably intertwined, for there are no mounds without intervening depressions, and without depressions there are no swales or vernal pools. The key element that links mima mounds with vernal pools (mima mound topography) is the underlying relatively impermeable soil horizon, whether it is comprised of primary (depositional) or pedogenic (derived from in situ weathering) clay (Soil Survey Staff 1993). The micro-relief of mounds, temporary pools, and incipient channels and swales, where soils vary widely in extent, depth, moisture availability and inherent fertility, provides a complex pattern of diverse microhabitats for upland and facultative wetland plant colonization over a relatively small area. Here local micro-relief ranges from a few centimeters to several meters resulting in a landscape mosaic of closely spaced, relatively open habitats, each distinguished by small-scale differences in soil types (Birkeland 1999). Accordingly, the combination of year-to-year variability of rainfall in a Mediterranean-type climate, local hydrology, and the micro-site differences in soil characteristics and inundation regimes of individual pools, may significantly affect the per-

formance of individual plants and populations of some endemic vernal pool annuals (Collinge et al. 2003). Additionally, the vernal pool basins consist of autonomous plant communities having individual rare species and specialized community types that are often restricted to distinct regions (Barbour et al. 2003).

Geologic uplift (tectonism) and glacio-eustatic sea level fluctuations along the California coastline have helped to create a series of wave-cut terraces that often support distinctive biotic zones associated with elevation, micro-climate, and age-dependent soil development of the ''ecological staircase'' (Schoenherr 1992). Mima mound micro-relief in coastal Orange County and San Diego County is initially produced by slow regional uplift, followed by long-term weathering that promotes soil development on coastal terraces. These surfaces, often tens to hundreds of thousands of years old, may produce strongly developed soil profiles with poorly drained substrates, usually with clay pan (argillic) or silcrete (duripan) horizons (Shlemon and Hamilton 1978). Vernal pools, then, are a manifestation of mima mound micro-relief associated with these relatively stable, uplifted coastal terraces (Abbott 1999). In addition, local co-seismic uplift of coastal deltaic and estuarine terrain may cause ''instant'' drainage, resulting in channel incision, and generally altering micro-relief, and hence vegetation extent and pattern (Boggs and Shepard 1999). Both rapid, local uplift, and the slow, long-term uplift of coastal terrain can therefore produce extensive, natural ecosystem change, a phenomenon that has generally received little attention by many biologists (Shlemon and Riefner 2006).

This study focuses on two remnant mima mound fields reported by Riefner and Pryor (1996); viz., the mima mound–vernal pool terrain at San Clemente State Beach and mima mound micro-relief lacking vernal pools near Moulton Meadows Park in Laguna Beach. Traditionally, biologists have focused their attention on vernal pools and their endemic biota. In contrast, geologists (mainly geomorphologists) frequently emphasize mound genesis, but often overlook the pools. Consequently, mima mounds have received little conservation attention by biologists in southern California (Gray and Bramlet 1994*a*). Herein, we describe the mima-mound habitat and summarize the historical significance of this overlooked, but important habitat for rare plants in Orange County. Additionally, the low-density, unconsolidated soils of the individual mima mounds, with their numerous active rodent tunnels and abandoned soil-filled burrows (krotovinas), have also been overlooked by wildlife biologists as important burrowing and aestivation habitats for obligate pool-breeding amphibians, including the California tiger salamander (*Ambystoma californiense)* and the western spadefoot toad (*Scaphiopus hammondii*). Accordingly, the terrestrial periphery of the mounds and upland corridors that connect isolated pool and ephemeral wetland habitats are critical for maintaining herpetofaunal biodiversity (Gibbons 2003). Because soil-geomorphic relationships are important for biologists to understand the pattern and extent of certain ecosystems (Riefner et al. 2002), we also provide an overview of the landscape evolution of mima mound micro-relief on coastal terraces in southern California.

VASCULAR PLANT RECORDS

Recent fieldwork, as well as investigations in herbaria (RSA, UCR), and a review of the literature, has brought to our attention several taxa previously unreported in Orange County from mima mound and vernal pool habitats.

Plants New to Orange County

Deschampsia danthonioides (Trin.) Munro (Poaceae; annual hairgrass) is a wide-ranging native annual of moist to drying open sites, meadows, streambanks, vernal pools, and temporary ponds known from the Modoc Plateau south throughout the California Floristic Province and Baja California, Mexico, and east to Arizona and Arkansas (Wilken 1993). In southern California, it is often associated with vernal pools (Bauder and McMillan 1998). Annual hairgrass has not been recorded previously from the County (Roberts 1998; Bowler and Bramlet 2002; Bowler and Elvin 2003), and should be added to the Orange County list of ''species of special interest'' (Gray and Bramlet 1994*b*). Annual hairgrass has been assigned a facultative wetland (FACW) indicator status category (Reed 1988), which includes species usually found in wetlands (estimated probability 67–99%), but occasionally found in non-wetlands. We identify wetlands as those areas of the landscape that receive inundation or soil saturation at a duration and frequency that exclude many organisms not tolerant of flooding or soil saturation (Brinson and Malvárez 2002). Although there is considerable variation with respect to the width of its panicle, annual hairgrass is not easily confused with any other wetland grass found in vernal pools and moist meadows in southern California (Mason 1957).

Lepidium strictum (S.Watson) Rattan (Brassicaceae; prostrate peppergrass) is an uncommon herb in California that is also known from Oregon and Colorado (Rollins 1993). This peppergrass has not been recorded previously from Orange County (Roberts 1998; Bowler and Bramlet 2002; Bowler and Elvin 2003). *Lepidium strictum* is known in Los Angeles County from the Whittier Hills (Schneider-Ljubenkov and Ross 2001), is rare in Ventura County (Magney 2002), and scarce in Riverside County (Roberts et al. 2004). It has not been reported from treatments of the Brassi-

caceae in other local floras covering Los Angeles County (Mattoni and Longcore 1997; Wishner 1997, 1998, 2000, 2002; Boyd 1999), nor in San Diego County (Rebman and Simpson 2006). Although *Lepidium strictum* appears to be uncommon in the south coast region, it is likely undercollected and should not be added to the Orange County list of species of special interest at this time. *Lepidium strictum* almost always occurs outside wetlands under natural conditions and is not included on the National List (Reed 1988); for the purpose of discussion here, UPL will designate an upland plant that does not occur in wetlands in California (estimated probability >99%) or in any region within the United States. Prostrate peppergrass may present difficulties in identification, but the combination of a prostrate habit with leaves divided or lobed below, persistent sepals, and the generally ovate fruit with prominent veins and ascending valve tips readily separate this from other species of *Lepidium* (Rollins 1993).

Sagina saginoides (L.) H.Karst. (Caryophyllaceae; arctic or alpine pearlwort) is a circumboreal species that ranges south into Montana and Wyoming, and in California as far south as the Transverse and Peninsular Ranges (Hartman 1993). It occupies moist banks, streamsides, and dry creeks from (100) 1000–3800 m elevation. This small perennial has not been recorded previously from the county (Roberts 1998; Bowler and Bramlet 2002; Bowler and Elvin 2003), and is rare or absent (no voucher specimens are known from San Diego County) from the south coast region (Hartman 1993; Mattoni and Longcore 1997; Boyd 1999; Magney 2002; Wishner 1997, 1998, 2000, 2002; Roberts et al. 2004; Rebman and Simpson 2006). Although it may be easily overlooked because of the grass-like appearance of its matted and often sterile basal rosettes, arctic pearlwort should be added to the list of Orange County species of special interest (Gray and Bramlet 1994*b*). Arctic pearlwort has been assigned an obligate (OBL) wetland indicator status (Reed 1988) which identifies a species that almost always occurs in wetlands (estimated probability >99%). *Sagina saginoides* has not been cited previously from mima mound-vernal pool habitats in southern California. However, because vernal pool ecosystems have evolved in balance between ''isolation and connectedness,'' vernal pool terrain may support broad-ranging taxa that are most often associated with other wetland types (Zedler 2003), including Engelmann's spike-rush (*Eleocharis obtusa* [Willd.] Schult. var. *engelmannii* [Steud.] Gilly; Riefner et al. 2002). Herein, we also report the first known record of *Sagina saginoides* from the western Santa Monica Mountains in Ventura County, where it grows along the edge of an old stock pond and a seasonal pool. Accordingly, arctic pearlwort should be searched for in other seasonal pool and wetland habitats throughout the south coast region.

Plants Previously Excluded from the Orange County Flora

Lepidium oblongum Small var. *oblongum* (Brassicaceae; wayside peppergrass) is a wide-ranging annual found along roadsides, in disturbed habitats, and on slopes from the Great Valley and the southwest region of cismontane California, the central United States, and in Central America (Rollins 1993). In Orange County, it was previously reported from Newport Back Bay, but was excluded from the flora owing to lack of documentation (Roberts 1998). It has not been reported from recent floristic studies in Orange County (Bowler and Bramlet 2002; Bowler and Elvin 2003). Local floras covering Los Angeles County (Mattoni and Longcore 1997; Boyd 1999; Schneider-Ljubenkov and Ross 2001) or the Santa Ana Mountains (Lathrop and Thorne 1978, 1985; Boyd et al. 1995*a*; Boyd 2001) have not reported wayside peppergrass in treatments of the Brassicaceae. However, it has been reported from San Diego County (Rebman and Simpson 2006) and Ventura County (Magney 2002), and was cited by Wishner (1997) as potentially present in the Santa Monica Mountains. *Lepidium oblongum* almost always occurs outside wetlands under natural conditions (UPL) and is not included on the National List (Reed 1988). Wayside peppergrass is easily confused with prostrate peppergrass (*Lepidium strictum*). Wayside peppergrass is distinguished from the latter species by non-persistent sepals, and larger obovate or round fruits that lack prominent veins (Rollins 1993). Although *Lepidium oblongum* var. *oblongum* appears to be uncommon in the south coast region, it is likely undercollected and should not be added to the Orange County list of species of special interest at this time.

Species of Interest to the California Native Plant Society (CNPS)

Deinandra paniculata (A.Gray) Davidson & Moxley (Asteraceae; paniculate or San Diego tarplant), is a CNPS List 4 species known from Orange, Riverside, San Bernardino, and San Diego counties, and from Baja California, Mexico (Tibor 2001). It grows in coastal scrub and valley and foothill grasslands, usually in vernally mesic situations (Tibor 2001). Paniculate tarplant has been assigned a facultative upland (FACU) indicator status (Reed 1988). A FACU plant usually occurs in non-wetlands (estimated probability 66–99%), but occasionally may be found in wetlands (estimated probability 1–33%). Riefner and Pryor (1996) reported this species from vernal pool terrain in northwestern San Diego County, and from mima mound terrain in the Dana Hills and at San Clemente

State Beach in Orange County. Marsh (1992) did not report it from the Moulton Meadows area of Laguna Beach. Paniculate tarplant is easily confused with the more common fascicled tarplant (*Deinandra fasciculata* (DC.) Davidson & Moxley). Paniculate tarplant is bristly below and glandular above, has 8–13 ray flowers, and importantly, has only a single head per peduncle. Paniculate tarplant also tends to flower later in the season (August through October) than fascicled tarplant.

Holocarpha virgata (A.Gray) D.D.Keck subsp. *elongata* D.D.Keck (Asteraceae; graceful tarplant), a CNPS List 4 plant, is known from Orange, Riverside, and San Diego counties (Tibor 2001). It inhabits cismontane woodland, chaparral, coastal scrub, and valley and foothill grasslands (Tibor 2001), usually on nearly level, sparsely vegetated terrain (Reiser 2001). In Riverside County, it is well known from the Santa Rosa Plateau and scarce elsewhere (Tibor 2001; Roberts et al. 2004). It is declining in San Diego County (Reiser 2001), but it is still locally abundant at some localities (Boyd et al. 1995*b*). It is known in Orange County only from Trabuco Canyon, and generally, its distribution is not well documented (CNDDB 2004). Graceful tarplant almost always occurs outside of wetlands under natural conditions (UPL; estimated probability >99%) and is not included on the National List (Reed 1988). However, Zedler (1987) includes graceful tarplant as one of the plants often found in vernal pool basins, but it is more common in other terrestrial habitats. Fascicled tarplant (*Deinandra fasciculata*) occurs in similar habitats (Zedler 1987), and also has not been assigned a facultative status. Both species should be re-evaluated in forthcoming revisions of the National List; many plants that characterize seasonal wetlands in California are not included or are incorrectly characterized on this list (Ferren et al. 1996). Accordingly, graceful tarplant is not recognized as a vernal pool indicator species in the south coast region (Bauder and McMillan 1998; City of San Diego 2003). Graceful tarplant could easily be confused with the common Kellogg's tarplant (*Deinandra kelloggii* (Greene) Greene) owing to its 3–7 showy ray flowers. However, graceful tarplant flowers much later in the season (Reiser 2001), and has conspicuous, stalked open-pit glands that make for easy identification.

Navarretia prostrata (A.Gray) Greene (Polemoniaceae; prostrate navarretia), a CNPS List 1B plant, has been collected in Alameda, Los Angeles, Merced, Monterey, Orange, Riverside, San Bernardino, and San Diego counties (Tibor 2001). It inhabits vernal pools, floodplains, and other mesic, usually alkaline, sites in coastal scrub and valley and foothill grasslands (Tibor 2001). In Orange County, it is know only from Fairview Park in Costa Mesa (Bauder and McMillan 1998). A small population was discovered in northwestern San Diego County, but prostrate navarretia was not found during the initial surveys of the San Clemente mima mound field in southwestern Orange County during the Riefner and Pryor (1996) study. Prostrate navarretia has been assigned an obligate (OBL) wetland indicator status (Reed 1988), as it is a species that almost always occurs in wetlands (estimated probability >99%).

Uncommon Plants of Local Interest

Hordeum brachyantherum Nevski subsp. *californicum* (Covas & Stebbins) Bothmer, N.Jacobsen & Seberg (Poaceae; California barley) occupies meadows, pastures, and streambanks throughout the California Floristic Province and Oregon below 500 m (Barkworth 1993). California barley is best known in our region from the Santa Rosa Plateau in western Riverside County (Lathrop and Thorne 1985; Roberts et al. 2004). It is scarce (Raven et al. 1977; Boyd 1999) to rare (Magney 2002) on coastal lowlands, and is not well known in Orange County or San Diego County. In recent floristic studies of Orange County, Bowler and Bramlet (2002) did not find California barley, but Bowler and Elvin (2003) found the grass in the San Joaquin Freshwater Marsh Reserve. California barley is uncommon in the County, but it should not be added to the list of Orange County species of special interest at this time (Gray and Bramlet 1994*b*). California barley has a FACU wetland status (usually occurs in nonwetlands, estimated probability 66–99%, but occasionally may be found in wetlands, estimated probability 1–33%; Reed 1988). *Hordeum brachyantherum* subsp. *californicum* was not recorded from vernal pool terrain by Marsh (1992), Bauder and McMillan (1998), or the City of San Diego (2003). However, it is rare to common along the margins of vernal pools at several sites in Santa Barbara County (Ferren and Pritchett 1988; Pyke et al. 2003).

Hordeum brachyantherum Nevski subsp. *brachyantherum* (meadow barley) has a distribution and range of habitats similar to those of subsp. *californicum,* but often occurs at higher elevations; up to 3400 m (Barkworth 1993). Meadow barley is also apparently uncommon in the south coast region (Roberts 1998; Magney 2002; Rebman and Simpson 2006). It is easily distinguished from subsp. *californicum* by its mostly glabrous to short-hairy basal leaf sheaths (versus short and long hairy in subsp. *californicum*) and the lemma awn of the central spikelet generally being shorter than 4.5 mm (versus less than 7.5 mm in subsp. *californicum*). Zedler (1987) includes meadow barley as one of the plants documented from vernal pool terrain that are often more common in other aquatic, marsh, and seepage habitats. Accordingly, it was also not recognized as a vernal pool indicator species in the

south coast region by Bauder and McMillan (1998) or the City of San Diego (2003). However, *H. brachyantherum* subsp. *brachyantherum* and *H. brachyantherum* subsp. *californicum* are reported from vernal pool habitats in Santa Barbara County (Ferren and Pritchett 1988; Ferren et al. 1998; Pyke et al. 2003). *Hordeum brachyantherum* subsp. *brachyantherum* is presumed extirpated in Orange County and was last collected in 1934 at Bryant Ranch, which is in the present-day city of Garden Grove (Roberts 1998). Both subspecies of this perennial barley are uncommon plants of local interest and should be searched for in other mima mound–vernal pool habitats throughout coastal southern California.

DISCUSSION

In Orange County, mima mound–vernal pool terrain was presumed virtually extirpated prior to 1950 (US Fish and Wildlife Service 1998). Historically, only Corona del Mar, El Toro, and Dana Point were known to have supported numerous pools (Allen 1984). As recently as 1992, only a few, disturbed vernal pool sites were thought to remain (Marsh 1992), and in 1996, remnant mima-type topography was reported for the County (Riefner and Pryor 1996). Based on examination of old aerial photographs, Keeler-Wolf et al. (1998) found evidence that vernal pool terrain similar to the mesas of northern San Diego County extended at least as far north as San Clemente and Laguna Beach. We have examined historic geodetic survey maps (US Coast and Geodetic Survey 1885), and historic aerial photographs, the Robert Stevenson Aerial Photograph Collection flown in 1952 (Stevenson 1952, Coastal Archive Collection of G. G. Kuhn), which show that extensive mima mound fields and vernal pools were once common on the coastal terraces of northwestern San Diego County from at least Carlsbad to San Onofre, and in Orange County from San Clemente north into Corona Del Mar and Newport Beach. We are presently mapping the remaining fragments of these historic habitats.

As shown on the Stevenson photographs (see Fig. 1), mound-and-pool terrain principally occurs on the surface of two discrete uplifted marine terraces, extending from the top of the sea cliffs inland. These terrace sediments generally consist of basal regressive marine sand and overlying, prograding continental deposits. These sediments directly overlie wave-planated platforms cut approximately 125,000 years ago (marine isotope substage 5e) and ca. 200,000 years ago (stage 7) (Fig. 1), respectively (Heath and Lewis 1992). The mounds are best displayed on soils with well-developed pedogenic profiles (usually bearing a duripan subsoil horizon). Many of the older and topographically higher terraces that have escaped development (i.e., the Moulton Meadows mound field) are usually too geomorphologically dissected to support a stable surface. Consequently, former vernal pools are now externally drained, and the topographic and hydrologic expression of swale topography at these sites has been greatly reduced. Also generally lacking in mound and vernal pool topography are sediments younger than about 80,000 years (substage 5a). Here, except for local areas of clay-rich (depositional origin) uplifted estuary marsh deposits, the soils are sufficiently coarse grained and promote seasonal drainage of gravitational water. Accordingly, there is apparently no need for rodent-related mound construction, and hence there is a corresponding lack of vernal pools.

Fig. 1. Aerial photograph flown in 1952 (Robert Stevenson Collection, courtesy of California Coastal Archive, Carlsbad, California) near Corona Del Mar in Orange County, California, depicting mima mound field developed on a ca. 200,000 year-old terrace and encroaching development.

Based on trench exposures and soil-stratigraphic observations, Shlemon et al. (1997) proposed a complex interplay of sea-level fluctuation, long-term regional tectonic uplift, estuary formation and dissection, and long-term bioturbation as a geological model to explain the origin of the mima mounds on the 125,000-year-old terrace at San Clemente State Beach, Orange County. In addition, pool development is also the by-product of regional tectonic uplift and long-term soil formation. Near-term, the formation and maintenance of internally-drained pool basins, i.e., vernal pools, is determined by three interacting components of the physical and biological processes: (1) continuing mound aggradations (cumulative soil development from bioturbation and aeolian depositional processes), (2) slope wash of fine-grained sediments (silts and

Fig. 2. Vernal pools are ephemeral wetlands that develop in the inter-mound depressions of mima mound landscapes. These pools are typically hydrologically isolated from perennial inflow by a ring of rodent-occupied mima mounds, and hence have internal drainage. Photo taken on May 7, 1998 at San Clemente State Beach, Orange County, California.

clays) into swales from adjacent mima mounds, and (3) blockage of through-flowing swales by mima mound expansion associated with fossorial rodent activities. Conversely, major threats to the long-term stability of mima-type micro-relief and associated rare biota include: degradation and conversion of open habitats to exotic annual grasslands; an increase in the frequency of fire that promotes the establishment of exotic grasses; loss and fragmentation of habitat and sensitive plant populations by expanding urbanization; fluctuations of pocket gopher populations that directly effect mound aggradations; human-induced erosion that increases sedimentation and nutrient loading into otherwise closed depressions; and episodic landward bluff erosion along coastal terraces that externally drain pools and swales (Kuhn and Shepard 1984).

In order to protect mima-type terrain, we first recommend that these open habitats be mapped and protected, and that conservation and mitigation measures be locally focused (Barbour et al. 2003). Preservation of nearly level, stable high-level geomorphic surfaces and the diverse soil microhabitats of coastal terraces should be of primary concern. The mima mound field ecosystem consists of pool (Fig. 2), and swale and mound (Fig. 3) habitats, which collectively, have not been a focus of conservation efforts in Orange County. Many ephemeral wetlands, and their associated and often poorly known biota of the adjacent mounded micro-relief, have been clearly overlooked. Second, we propose the restoration and enhancement of mima mound and swale topography where long-term deep plowing and other human-made activities have obliterated the micro-relief around many remaining vernal pools in Orange County. These efforts could be an important potential resource for the recovery of vernal pool biota, including non-listed species, in southern California (US Fish and Wildlife Service 1998).

Accordingly, the protection and enhancement of this ecosystem would improve habitat conditions for many special-status plants that occupy the diverse microhabitats of Orange County's mima mound and vernal pool terrain, including (wetland indicator status, CNPS or Orange County (O.C.) status in parentheses): *Atriplex coulteri* (Moq.) D.Dietr. [FACU; CNPS List 1B], *A. pacifica* A.Nelson [FAC; CNPS List 1B], *Brodiaea filifolia* S.Watson [UPL; CNPS List 1B, state endangered, federally threatened], *Brodiaea jolonensis* Eastw. [UPL; O.C. locally rare], *Crassula aquatica*

Fig. 3. The micro-relief of mima mounds composed of low-density well-drained soils, and the inter-mound clayey sediments associated with low-lying seasonally saturated swales, provides a complex pattern of microhabitats for upland and facultative plant species over a relatively small spatial area. Photo taken on May 7, 1998 at San Clemente State Beach, Orange County, California.

(L.) Schönland [OBL; O.C. locally rare], *Deinandra paniculata* [FACU; CNPS List 4], *Dudleya blochmaniae* (Eastw.) Moran subsp. *blochmaniae* [UPL; CNPS List 1B], *Harpagonella palmeri* A.Gray [UPL; CNPS List 4], *Hordeum intercedens* Nevski [FAC; CNPS List 3], *Marsilea vestita* Hook. & Grev. [OBL; O.C. locally rare], *Microseris douglasii* (DC.) Sch.Bip. subsp. *platycarpha* (A.Gray) K.L.Chambers [UPL; CNPS List 4], *Muilla maritima* (Torr.) S.Watson [UPL; O.C. locally rare], *Myosurus minimus* L. subsp. *apus* (Greene) G.R.Campb. [OBL; CNPS List 3], *Nama stenocarpum* A.Gray [FACW; CNPS List 2], *Navarretia prostrata* [OBL; CNPS List 1B], *Ophioglossum californicum* Prantl [FACW; CNPS List 4], *Petunia parviflora* Juss. [FACW; O.C. locally rare], *Pilularia americana* A.Braun [OBL; O.C. locally rare], *Senecio aphanactis* Greene [UPL; CNPS List 2], and *Sibara virginica* (L.) Rollins [OBL; O.C. locally rare]. Although the two remnant mima mound fields studied here are each less than 5 hectares in size and are highly disturbed, they support 11 of the 20 special-status plants documented from Orange County's mima mound–vernal pool terrain (Marsh 1992; Riefner and Pryor 1996; Bauder and McMillan 1998; Riefner unpubl. data). Tibor (2001) reports 86 taxa on CNPS Lists 1–4 that have vernal pools (VnPls) coded as a habitat, which includes plants that are associated, at least in part, with these habitats. Keeler-Wolf et al. (1998) estimate that over 100 taxa are restricted to or are commonly found in vernal pools. These numbers will likely increase as additional study of intact mima mound field–vernal pool ecosystems reveal overlooked species and associations not previously identified in southern California. In the Central Valley, two federally listed grassland plants occupy distinct microhabitats within mima mound topography; *Pseudobahia bahiifolia* (Benth.) Rydb. (Hartweg's golden sunburst) prefers the top of mounds, and *Pseudobahia peirsonii* Munz (San Joaquin adobe sunburst) prefers heavy clays of the inter-mound depressions where the water-retention properties of the soils are high (Federal Register 1997).

Habitat loss typically occurs continuously, in small increments over long periods of time. Intuitively, each additional hectare of mima mound field lost, pool drained, or swale filled would seem to increase the regional extirpation probabilities of these rare and endemic organisms by only a small fraction. However,

given the apparent dramatic loss of these habitats in Orange County since 1952, and given the continued pressures for urban development on coastal terraces, mima-type landscapes and their unique biota are disproportionately threatened by human activity. Therefore, recovery and conservation strategies should consider the diverse spatial perspectives and opportunities that mima mound landforms provide for preserving and restoring sensitive soils, vegetation and wildlife, and ephemeral wetlands of southern California.

SPECIMENS SEEN

Deinandra paniculata: Orange County, vicinity of Moulton Meadows Park, locally abundant on mounds, along margin of trails, and in swales and meadows in mima mound field, and terrace soils of open coastal sage scrub, UTM Zone 11S N3710402 E430111 (NAD 83), alt. 868 feet (265 m), USG.S. 7.5′ Quadrangle Laguna Beach, T7S R8W Section 30, 28 Jul 2001, *Riefner 01-375* (RSA); City of Dana Point, Dana Hills, vicinity of Dana Hills High School, USG.S. 7.5′ Quadrangle Dana Point, T8S R8W Section 10/15, 6 Sep 1994, *Riefner 94-552* (RSA) [the population now likely extirpated]; San Clemente State Beach, uncommon, margin of trails, seasonally inundated swale, and on mounds, mima mound field in SW corner of park, UTM Zone 11S N3695886 E444129 (NAD 83), alt. 96 feet (29 m), USG.S. 7.5′ Quadrangle San Clemente, T9S R7W Section 10, 31 Aug 2003, *Riefner 03-337* (RSA).

Deschampsia danthonioides: Orange County, San Clemente State Beach, uncommon, margin of pool locally known as the ''frog pond'' and swale inundated during El Niño, mima mound field in SW corner of park, UTM Zone 11S N3695822 E444114 (NAD 83), alt. 90 feet (27 m), USG.S. 7.5′ Quadrangle San Clemente, T9S R7W Section 10, 15 May 1998, *Riefner 98-328* (RSA).

Holocarpha virgata subsp. *elongata:* Orange County, San Clemente State Beach, rare, margin of pool and on mound, mima mound field in SW corner of park, UTM Zone 11S N3695886 E444129 (NAD 83), alt. 90 feet (27 m), USG.S. 7.5′ Quadrangle San Clemente, T9S R7W Section 10, 14 Oct 2003, *Riefner 03-421* (RSA).

Hordeum brachyantherum subsp. *californicum:* Orange County, vicinity of Moulton Meadows Park, near Balboa Ave. and Del Mar Ave., rare, inter-mound swale and adjacent seepage channel in mima mound field, UTM Zone 11S N3710615 E430045 (NAD 83), alt. 834 feet (254 m), USG.S. 7.5′ Quadrangle Laguna Beach, T7S R8W Section 30, 4 May 2002, *Riefner 02-101* (RSA).

Lepidium oblongum var. *oblongum:* Orange County, San Clemente State Beach, rare on bluffs and trails around mima mound slopes, mima mound field in SW corner of park, UTM Zone 11S N3695790 E444049 (NAD 83), alt. 98 feet (30 m), USG.S. 7.5′ Quadrangle San Clemente, T9S R7W Section 10, 15 May 1998, *Riefner 98-331* (RSA).

Lepidium strictum: Orange County, vicinity of Moulton Meadows Park, near Balboa Ave. and Del Mar Ave., uncommon, margin of mounds and trails in mima mound field, UTM Zone 11S N3710615 E430045 (NAD 83), alt. 834 feet (254 m), USG.S. 7.5' Quadrangle Laguna Beach, T7S R8W Section 30, 26 Jul 2002, *Riefner 02-108* (RSA); vicinity of Moulton Meadows Park, near Balboa Ave. and Cortez Ave., weathered dune ridge soils with ironstone concretions in open coastal sage scrub, UTM Zone N3709995 E436287 (NAD 83), alt. 865 feet (264 m), USG.S. 7.5′ Quadrangles Laguna Beach/San Juan Capistrano, T7S R8W Section 30, 26 Jul 2002, *Riefner 02–110* (RSA).

Navarretia prostrata: Orange County, San Clemente State Beach, very rare in degraded vernal pool locally known as the ''frog pond,'' mima mound field in SW corner of park, UTM Zone 11S N3695822 E444114 (NAD 83), alt. 90 feet (27 m), USG.S. 7.5′ Quadrangle San Clemente, T9S R7W Section 10, 5 May 1998, *Riefner 98-326* (RSA).

Sagina saginoides: Orange County, vicinity of Moulton Meadows Park, near Balboa Ave. and Del Mar Ave., uncommon, swale and trailside depression in clayey soil, mima mound field, UTM Zone 11S N3710757 E430069 (NAD 83), alt. 855 feet (261 m), USG.S. 7.5′ Quadrangle Laguna Beach, T7S R8W Section 30, 22 Feb 2003, *Riefner 03-124* (RSA); Ventura County, 1.5 km N of Long Grade Canyon, near Ricardo Rd. and Patricia Rd., uncommon along the edge of old stock pond and seasonal pool, UTM Zone 11S N316518 E3783230 (NAD 83), alt. 990 feet (302 m), USG.S. 7.5′ Quadrangle Newbury Park, T1N R20W (unsectioned), 3 Jan 2004, *Riefner 04-28* (RSA).

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