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A FLORA OF THE VERNAL POOLS ON THE SANTA ROSA PLATEAU, RIVERSIDE COUNTY, CALIFORNIA

Earl W. Lathrop and Robert F. Thorne

INTRODUCTION

Vernal pools are temporary pools which occur in Mediterranean climates where shallow depressions in the land fill with seasonal standing water during winter rains, followed by total desiccation during the dry summer months. These shallow depressions are underlain by some impervious subsurface layer which prohibits drainage to the lower soil profiles.

Vernal-pool plants have two extreme environmental variables to surmount—periods of inundation and desiccation—in order to exist in the habitat. Species in year-round pools and marshes have only the extreme of inundation to cope with. It is this rare genetic adaptability to both environmental extremes that helps make vernal-pool plants unique.

In southern California vernal pools are found today only in San Diego and Riverside Counties. The few pools that were not destroyed by development in San Diego County are, for the most part, now preserved by various agencies. All 13 vernal pools in Riverside County are presently on the Santa Rosa Plateau near Rancho California, California. Thanks to the cooperative efforts of KACOR Development Company, the Nature Conservancy, the California Department of Fish and Game, and the California Department of Parks and Recreation, most, if not all, of the Riverside County vernal pools will also likely be preserved. It is the authors' wish that the publication of this flora, which represents a summary of our past studies of the Riverside County vernal pools, will contribute in some small way, to this conservation effort.

PHYSICAL SETTING

The Riverside County vernal pools all occur on the Santa Rosa Plateau, defined by Lathrop and Thorne (1968) as a distinct topographic unit of rolling grassland and oak-woodland-chaparral hills located at the southeastern end of the Santa Ana Mountains (Fig. 1). The pools occur on three of the flat-topped mesas common on the plateau—four on Mesa de Colorado, one on Mesa de la Punta, and the remaining eight on Mesa de Burro (Fig. 2). The area of the basin of the vernal pools, determined using a compensating polar planimeter over USDA aerial photographs (Lathrop and Thorne 1976a), varies from 0.25 ha for some of the smaller pools to 10.16 ha for the largest on Mesa de Colorado (Fig. 2). The amount and distribution of

Fig. 1. Location map of the Santa Rosa Plateau, Riverside County, California. Revised from Aliso 7(1), 1968.

precipitation for a particular season, will, of course govern the amount of water retained in the pools. During dry years some of the smaller pools do not fill, but the authors have always found that most of the larger pools will usually have some water to support at least some of the characteristic vernal-pool species.

Fig. 2. Distribution of the vernal pools on the mesas of the Santa Rosa Plateau. Drawing by Mark Ford.

The relative position of the three mesas is shown in a photograph (Fig. 3) taken from Mesa de Burro with Mesa de la Punta and Mesa de Colorado on the background. The Santa Rosa Plateau also has occasional temporary (vernal) streams (Fig. 4) running through the oak woodland, grassland, and chaparral which have interesting aquatic plants, including a few plant species common in the vernal pools.

A completely inundated vernal pool (B6 of Fig. 2) and a desiccated pool (B2 of Fig. 2) are shown in Fig. 5 and 6 respectively.

For details of the physical setting of the vernal pools, including yearly precipitation means, soils, geology, plant communities, and figures and photographs of the Santa Rosa Plateau in general, the authors refer the reader to previous issues of this journal and others which are listed in the next section on history of botanical and ecological exploration of the vernal pools on the Santa Rosa Plateau.

BOTANICAL AND ECOLOGICAL EXPLORATION

The first published account of a vernal pool on the Santa Rosa Plateau was in a florula of the plateau (Lathrop and Thorne 1968). The following year the authors described the vegetation and general characteristics of the largest pool on Mesa de Colorado (see Fig. 2, Thorne and Lathrop 1969). Because of an exceptional wet winter in 1969, the authors, during field work that spring, found additional species not previously reported in the mesa pools. We also experienced a pillwort (*Pilularia americana*) explosion and reported it in Thorne and Lathrop (1970). Pillwort is an inconspicuous and highly specialized aquatic fern that is little collected.

Student researchers joined the authors' work on the plateau pools a few years later and, as a combined result, important botanical and ecological information soon began to accumulate to help understand better these unique pools. Papers that followed were: 1) Kopecko and Lathrop (1975); 2) Collie and Lathrop (1976); 3) Lathrop (1976); 4) Lathrop and Thorne (1976a, b); 5) Lathrop and Thorne (1978); 6) Stagg and Lathrop (1983); 7) Rosario and Lathrop (1983); and 8) Thorne (1983b).

Two individual researchers are at present doing studies on the Santa Rosa Plateau vernal pools. Jon Keeley, of Occidental College, is working with *Isoetes* spp. Bradford Martin, graduate student at Loma Linda University, is working on the biogeography and niche separation of *Downingia cuspidata* and *D. bella*. Hopefully others will become interested in research on these pools in the future, to aid conservation efforts underway to preserve this unique community on the Santa Rosa Plateau.

DISJUNCT DISTRIBUTION OF VERNAL-POOL AQUATICS

Disjunct species, those with very spotty distribution patterns because of restriction to very rare habitats or because of unexplained absence from

Fig. 3-4.—3. View of a portion of the Santa Rosa Plateau looking southwest from Mesa de Burro (B) and showing Mesa de la Punta (P) and Mesa de Colorado (C) in the background.—4. One of the several temporary (vernal) streams on the Santa Rosa Plateau. View looking northwest toward Squaw Mountain, in the Cleveland National Forest, in the right background.

Fig. 5-6.—5. Inundated vernal pool on Mesa de Burro (B6 of Fig. 2), looking southeast toward the Palomar Mountain Range in the background.—6. Desiccated vernal pool (B2 of Fig. 2), looking south on Mesa de Burro.

expected habitats, are of frequent occurrence on the several mesas and in pools on the Santa Rosa Plateau (Lathrop and Thorne 1978). Some of the aquatics which are considered to be restricted to this rapidly vanishing and highly scattered habitat are not uniformly distributed on either the three mesas or in the 13 pools studied. Besides the spotty distribution on these mesas and in these pools there are even more interesting disjunctions between states and countries among some of the species in our pools (Thorne and Lathrop 1970; Thorne 1983b).

Perhaps the most extraordinary distribution pattern is that of the tiny pillwort, *Pilularia americana*, reported now from Georgia, Tennessee, Arkansas, Texas, Oklahoma, Kansas, Nebraska, Oregon to Baja California, and Valparaíso and Valdivia Provinces in central and south-central Chile. Several other vernal-pool or vernal-stream species occur both in California and central Chile: *Azolla filiculoides*, *Hydrocotyle ranunculoides*, *Psilocarphus brevissimus*, *Crassula erecta*, *Elatine chilensis*, *Lythrum hyssopifolium*, *Sida leprosa hederacea*, *Montia fontana*, *Anagallis minima*, *Ranunculus aquatilis*, *Veronica peregrina*, *Juncus bufonius*, *Lilaea scilloides*, and *Zannichellia palustris*. A few of these species are known from intermediate stations and the *Azolla*, *Hydrocotyle*, *Sida*, *Montia*, *Ranunculus*, *Juncus*, and *Zannichellia* species are widely distributed aquatics. In addition to the above species, Chilean vernal pools host species of *Blennosperma*, *Boisduvalia*, *Callitriche*, *Deschampsia*, *Downingia*, *Lasthenia*, *Myosurus*, *Navarettia*, and *Phalaris* related to our vernal-pool species, some so closely as to be suspected of being probably conspecific with them. These amphitropical disjunct species or vicariant pairs have presumably achieved their disjunct ranges by long-distance dispersal through carriage by the several species of wading birds that migrate each year between California and Chile.

CATALOG OF THE VERNAL-POOL PLANTS

General Remarks

The following list, for reasons of space, include only the species which the authors felt were representative of the vernal pools on the Santa Rosa Plateau. Included also are a few species which are found in the vernal streams on the plateau (Fig. 4). Forty-two of the most representative species in the annotated list were illustrated by a botanical illustrator, Jean Colton.

All specimens in the annotated list are on file in the RSA-POM Herbarium of the Rancho Santa Ana Botanic Garden. Families are arranged alphabetically within subdivisions, classes, or subclasses, as are also genera within families, and species within genera. Common names are given, usually only for the first species of a genus, and only if genuine or nonrepetitive of the generic name. Nomenclature of species follows that of Munz (1974), and families that of Thorne (1976, 1983a).

Habit of growth is usually given for each species. Abundance terms (see

frequency terms in Lathrop and Thorne 1978) are given for species when known. Habitat is generally within the pool itself, but may also be designated "moist borders of the pool," "dry bed," "muddy margins," etc. The authors have arbitrarily attempted to indicate which species are present in each of the pools as our survey notes and memory serve us. Ranges within the plateau pools are thus given a letter and number designation in the annotated list (see key to pools in Fig. 2).

Season of growth for most species in the vernal pools, depending on the seasonal rains, is generally from early spring until early to late in the summer. The vernal-pool species that are illustrated are indicated in the annotated list by the Fig. number in parentheses immediately following the scientific name.

Annotated List

Lycopsida

Isoetaceae

Isoetes howellii Engelm. (Fig. 7). Quillwort. Ephemeral aquatic locally abundant in some pools and shallow water of a vernal stream on the Santa Rosa Plateau. B1, B2, B5, B6, C1, C4, C2, C3, P1.

Isoetes orcuttii A. A. Eat. (Fig. 8). Locally abundant usually in the same locations with the proceeding species. B1, B2, B5, B6, C1, C2, C3, C4.

Pteropsida

Azollaceae

Azolla filiculoides Lam. Water Fern. Locally abundant, floating on shallow quiet water of several intermittent streams, but not in any of the pools.

Marsileaceae

Marsilea vestita Hook. and Grev. (Fig. 9). Clover Fern. Locally abundant in shallow water of muddy margins and present in virtually all of the pools and small streams on the plateau.

Pilularia americana A. Br. (Fig. 10). Pillwort. An inconspicuous aquatic fern locally and seasonally abundant in wet mud and shallow water. Found most often in B1, B6, B7, B4, C1, C2, C4, P1.

Angiospermae

Dicotyledonae

Araliaceae (incl. Apiaceae)

Eryngium aristulatum Jeps. var. *parishii* (C. & R.) Math. & Const. (Fig. 11).

Fig. 7-12.—7. *Isoetes howellii*, $\times 0.25$.—8. *Isoetes orcuttii*, $\times 0.25$.—9. *Marsilea vestita*, $\times 0.25$.—10. *Pilularia americana*, $\times 1.0$.—11. *Eryngium aristulatum* var. *parishii*, $\times 0.25$.—12. *Blennosperma nanum*, $\times 0.5$.

Spreading prostrate perennial locally abundant and flowering in the desiccated beds of vernal pools. B1, B3, B6, C1, C3, C4.

Hydrocotyle ranunculoides L. f. Pennywort. Locally abundant perennial with floating leaves in shallow water of streams on the plateau.

Asteraceae

Blennosperma nanum (Hook) Blake. (Fig. 12). Locally abundant annual of moist soil, forming a ring of yellow around desiccating vernal pools. Common in most of the pools of the plateau during wet years.

Cotula coronopifolia L. (Fig. 13). Brass Buttons. Locally abundant introduced perennial of mud and moist margins of vernal pools. B5, B6, C2, C4.

Gnaphalium palustre Nutt. (Fig. 14). Common annual in drying beds of most of the pools on the plateau and occasionally on stream margins.

Lasthenia chrysostoma (F. & M.) Greene (Fig. 15). Goldfield. Common early spring annual which borders the vernal moist zone, usually just outside the yellow ring of *Blennosperma nanum* found around the desiccating pools. Common near most of the pools on the plateau, but particularly B1, B6, C1, C2, C4.

Psilocarphus brevissimus Nutt. (Fig. 16). Woolly-heads. Annual locally abundant in dried beds of vernal pools. Common in most pools on the plateau.

Psilocarphus tenellus Nutt. Abundant annual of dried beds of vernal pools similar to the previous species.

Boraginaceae

Plagiobothrys undulatus (Piper) Jtn. (Fig. 17). Common annual of moist soil and standing water of all the pools.

Brassicaceae

Lepidium nitidum Nutt. (Fig. 18). Smooth-Peppergrass. Annual common on moist banks and margins of all of the pools.

Nasturtium officinale R. Br. Water Cress. Perennial in shallow water of intermittent streams of the plateau.

Callitrichaceae

Callitriche heterophylla Pursh subsp. *bolanderi* (Hegelm.) Calder & Taylor. Water-starwort. Infrequent slender aquatic plant in clear water of small streams on the plateau. Also found in at least one of the vernal pools.

Callitriche longipedunculata Morong. (Fig. 19). Annual common in nearly all of the pools in shallow standing water.

Fig. 13–18.—13. *Cotula coronopifolia*, $\times 0.5$.—14. *Gnaphalium palustre*, $\times 0.5$.—15. *Lasthenia chrysostoma*, $\times 0.5$.—16. *Psilocarphus brevissimus*, $\times 0.5$.—17. *Plagiobothrys undulatus*, $\times 0.5$.—18. *Lepidium nitidum*, $\times 0.75$.

Fig. 19–24.—19. *Callitriche longipedunculata*, $\times 1.0$.—20. *Callitriche marginata*, $\times 1.0$.—21. *Downingia bella*, Plant $\times 0.5$; Blossom $\times 1.5$.—22. *Downingia cuspidata*, Plant $\times 0.5$; Blossom $\times 1.5$.—23. *Crassula aquatica*, $\times 1.0$.—24. *Crassula erecta*, $\times 1.0$.

Callitriche marginata Torr. (Fig. 20). Dense small matted annual of shallow standing water and muddy margins of vernal pools. Common to most pools.

Campanulaceae

Downingia bella Hoover. (Fig. 21). A showy annual abundant in shallow standing water and moist margins of the pools. Found in all pools, including P1, except B3 and B2.

Downingia cuspidata (Greene) Greene. (Fig. 22). A showy annual occurring mixed with the preceding species or in isolated stands within the same pools. Found in all pools except P1.

Caryophyllaceae

Sagina occidentalis S. Wats. Pearlwort. Rare annual of a small intermittent stream on the plateau.

Crassulaceae

Crassula aquatica (L.) Schoenl. (Fig. 23). Stonecrop. Locally abundant annual in shallow water or moist soil of vernal pools. Common to most of the pools during wet years.

Crassula erecta (H. & A.) Berger. (Fig. 24). This stonecrop does not grow in the vernal pools but forms dense mats in the open dry ground in the grassland surrounding the pool. It is illustrated in this article to compare its larger size to *C. aquatica* (Fig. 23).

Datisceae

Dastisca glomerata (Presl.) Baill. Durango Root. Frequent tall perennial along and in stream beds in riparian and oak woodlands on the Santa Rosa Plateau.

Elatinaceae

Elatine brachysperma A. Gray. Waterwort. Rare aquatic annual in muddy margins of a nonvernal pool in oak woodland on the northern slope of Mesa de Relondo on the Santa Rosa Plateau.

Elatine californica A. Gray. (Fig. 25). Locally abundant in shallow standing water and bottom mud of vernal pools. B1, B2, B5, C2, P1 and most other pools during wet years.

Elatine chilensis Gay. (Fig. 26). Common submersed aquatic annual, generally in the same pools as the preceding species.

Fabaceae

Trifolium amplexens T. & G. [var. *truncatum* (Greene) Jeps.]. Sack Clover. Frequent annual in moist grassy places, as about vernal-pool borders. Common to most pools on the plateau.

Lythraceae

Lythrum hyssopifolium L. (Fig. 27). Loosestrife. Locally abundant slender annual, common to most vernal pools on the plateau, in desiccated mud and shallow margins of the pools.

Malvaceae

Sida leprosa (Ort.) K. Schum. [var. *hederacea* (Dougl.) K. Schum.]. (Fig. 28). Locally abundant perennial of desiccated beds of many of the vernal pools on the Santa Rosa Plateau.

Onagraceae

Boisduvalia densiflora (Lindl.) S. Wats. Common annual of moist places along streams in oak woodlands and chaparral but not yet found in the vernal pools.

Plantaginaceae

Plantago bigelovii Gray subsp. *californica* (Greene) Bassett. (Fig. 29). Plantain. Tiny ephemeral locally abundant on muddy margins and dry beds of many of the pools on the three mesas.

Polemoniaceae

Navarretia intertexta (Benth.) Hook. (Fig. 30). Rare small annual collected only on dry banks of pools of B1, B5, C3, and P1.

Navarretia prostrata (Gray) Greene. (Fig. 31). Locally abundant in dry beds of the majority of the vernal pools on the plateau.

Portulacaceae

Montia fontana L. subsp. *amporitana* Sennen. (Fig. 32). Small annual usually found during seasonally wet years in drainage ways in the grasslands and on the wet margins of pools B5, B6, C1, C4.

Primulaceae

Anagallis minima (L.) E. H. L. Krause. (Fig. 33). Rare tiny annual found only in a few of the desiccated vernal pools, as C2.

25 **26** **27** **28** **29** **30**

Fig. 25-30.—25. *Elatine californica*, $\times 1.0$.—26. *Elatine chilensis*, $\times 1.0$.—27. *Lythrum hysopifolium*, $\times 0.5$.—28. *Sida leprosa* var. *hederacea*, $\times 0.25$.—29. *Plantago bigelovii* subsp. *californica*, $\times 0.75$.—30. *Navarretia intertexta*, $\times 0.5$.

Samolus parviflorus Raf. Water-pimpernel. Locally abundant perennial of shallow water and moist margins of streams on the Santa Rosa Plateau.

Ranunculaceae

Myosurus minimus L. (var. *apus* Greene). (Fig. 34). Mouse-tail. Rare annual found only a few times on the desiccated margins and beds of pools C1, C4, B1, B3, B5, B6.

Ranunculus aquatilis L. [var. *capillaceus* (Thuill.) DC.]. (Fig. 35). Water Crowfoot. Common perennial of standing water of most of the vernal pools and in slow streams on the Santa Rosa Plateau.

Ranunculus californicus Benth. subsp. *californicus*. California Buttercup. Common perennial of the vernal moist borders of most vernal pools and other moist ground.

Scrophulariaceae

Mimulus guttatus Fisch. ex DC. subsp. *guttatus* (Fig. 36). Yellow Monkey-flower. Locally abundant perennial of stream banks, vernal-pool borders, and other wet grassy places.

Veronica peregrina L. subsp. *xalapensis* (H.B.K.) Penn. (Fig. 37). Infrequent annual seen or collected in pools B1, B6, C1, C2, C4, P1.

Eleocharis acicularis (L.) R. & S. (Fig. 38). Spike-rush. Common small perennial of muddy bottoms and margins of most of the vernal pools and some streams on the plateau.

Eleocharis macrostachya Britt. in Small. (Fig. 39). Tall emergent rhizomatous aquatic in some of the larger marshy pools. B1, B6, C1, C4, C2, P1.

Eleocharis montevidensis Kunth [var. *parishii* (Britt.) V. Grant]. (Fig. 40). Abundant smaller rhizomatous perennial often associated with *E. macrostachya* but also in more pools than the latter.

Juncaceae

Juncus bufonius L. (Fig. 41). Toad Rush. Common annual of the majority of the vernal pools on the mesas and along stream margins.

Juncus tiehmii Ertter (*J. kelloggii* of S. Calif. authors) (Fig. 42). An inconspicuous tiny annual locally abundant in vernal wet depressions in grasslands near many of the vernal pools on the mesas.

Juncus sphaerocarpus Nees in Funk. (Fig. 43). Annual found usually on desiccated margins of vernal pools. B1, B2, B4, B6, C1, C2.

Juncaginaceae

Lilaea scilloides (Poir.) Haum. (Fig. 44). Flowering-quillwort. Common in

Fig. 31-36.—31. *Navarretia prostrata*, $\times 0.5$.—32. *Montia fontana* subsp. *amporitana*, $\times 1.0$.—33. *Anagallis minima*, $\times 0.5$.—34. *Myosurus minimus* var. *apus*, $\times 0.5$.—35. *Ranunculus aquatilis* var. *capillaceus*, $\times 0.5$.—36. *Mimulus guttatus* subsp. *guttatus*, $\times 0.25$.

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Fig. 37-42.—37. *Veronica peregrina* subsp. *xalapensis*, $\times 0.5$.—38. *Eleocharis acicularis*, Plant $\times 0.5$; Achenes, left $\times 3.0$, right $\times 9.0$.—39. *Eleocharis macrostachya*, Plant $\times 0.15$, Achene $\times 3.0$.—40. *Eleocharis montevidensis* var. *parishii*, Plant $\times 0.20$; Achene $\times 3.0$.—41. *Juncus bufonius*, $\times 0.5$.—42. *Juncus tiehmii*, $\times 0.5$.

Fig. 43-48.—43. *Juncus sphaerocarpus*, $\times 0.5$.—44. *Lilaea scilloides*, $\times 0.25$.—45. *Lemna minima*, Plants $\times 2.0$; X-sect. Frond $\times 3.5$.—46. *Alopecurus howellii*, $\times 0.5$.—47. *Deschampsia danthonioides* var. *gracilis*, $\times 0.25$.—48. *Orcuttia californica*, $\times 1.0$.

mud and shallow water of vernal pools and in streams on the Santa Rosa Plateau. B1, B2, B5, C1, C2, B6, C4, P1.

Lemnaceae

Lemna minima Phil. (Fig. 45). Duckweed. Floating on shallow water of streams and on a few vernal pools.

Liliaceae

Brodiaea orcuttii (Greene) Baker. Infrequent corm-bearing perennial in grassy areas about several vernal pools on the Santa Rosa Plateau. C1, C2, C4, (B4?).

Poaceae

Alopecurus howellii Vasey. (Fig. 46). Foxtail. Locally abundant in dry vernal pool beds and in other muddy flats on the Santa Rosa Plateau.

Deschampsia danthonioides (Trin.) Munro var. *gracilis* (Vasey) Munz. (Fig. 47). Hairgrass. Locally abundant near margins of vernal pools and in dry beds. Common in most pools on the mesas.

Orcuttia californica Vasey. (Fig. 48). Rare grass appearing in dry beds of several of the vernal pools. C1, C3, B1, B5, B6.

Phalaris caroliniana Walt. Canary Grass. Rare annual found only on the desiccated margins of pool C4.

Potamogetonaceae

Potamogeton pusillus L. Pondweed. Rare submersed aquatic found so far only in pool C2.

Zannichelliaceae

Zannichellia palustris L. Horned-pondweed. Submersed herb of shallow water in some slow-running streams on the Santa Rosa Plateau.

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