

FLORA OF A VERNAL POOL COMPLEX IN THE MAYACMAS MOUNTAINS OF SOUTHEASTERN MENDOCINO COUNTY, CALIFORNIA

KERRY L. HEISE
University of California, Hopland Research and Extension Center,
Hopland, CA 95449

ADINA M. MERENLENDER
Environmental Science, Policy, and Management, University of California,
Berkeley, CA 94720-3110

ABSTRACT

Vernal pools in the Mayacmas Mountains of southeastern Mendocino County, CA typically occupy topographic depressions related to landslide dams and fissures. A group of pools within a 1290 ha study area range in size from 180 to 3069 m², and are located at elevations between 329 and 902 m on slopes of oak woodland and chaparral. *Eryngium aristulatum* Jepson var. *aristulatum* and *Isoetes howellii* Engelm. codominate shallow, wide-margined pools and are associated with vernal pool specialist taxa such as *Gratiola*, *Navarretia*, *Plagiobothrys*, and *Pogogyne*. Deep, narrow-margined pools are characterized by cosmopolitan wetland taxa such as *Callitriche*, *Carex*, *Eleocharis*, *Juncus*, and *Ranunculus*. Plant surveys conducted in 1996 and 1999 indicate no significant change in species abundance or composition between the two years.

The characteristic flora and fauna of California's vernal pools and their distribution is well documented (Jain 1976; Holland and Jain 1987; Zedler 1987; Keeler-Wolf et al. 1995; King et al. 1996; Bauder and McMillan 1998; Holland 1998). Of the 16 vernal pool regions in the state described by Keeler-Wolf et al. (1995), the Mendocino Region, which lies entirely in Mendocino County, is one of the least known. The purpose of this study was to provide a description of the flora of a vernal pool complex in the arid, mountainous portion of southeastern Mendocino County based on observations from 2 years. These interior cismontane vernal pools occur on relatively unstable soils that are derived from marine sedimentary rocks. A number of floristic studies have been completed in the area and the occurrence of vernal pools has been mentioned (Neilson and McQuaid 1981; Murphy and Heady 1983; De Nevers 1985; Smith and Wheeler 1991, 1992; Baad 1998), but our knowledge of vernal pool floristics remains poorly understood.

Study area and methods. The 1290 ha study area is located in the interior north coast ranges of southeastern Mendocino County. Lying just east of the Russian River and 6 km northeast of U.S. Hwy

101 near Hopland, CA, the area includes portions of the University of California, Hopland Research and Extension Center (HREC) and adjacent public and private lands (Fig. 1). The area consists of moderately steep, predominately southwest-facing slopes in the Mayacmas Mountains, with elevations ranging from 183 to 914 m. Many high gradient ephemeral creeks bisect this terrain creating a series of parallel ridges and deep gullies. Lying approximately 65 km inland from the Pacific Ocean, the study area experiences a typical Mediterranean climate of hot-dry summers and cool-wet winters. Rainfall for the winters of 1995–1996 and 1998–1999 totaled 1074 mm and 880 mm respectively; the 35-year average is 947 mm (Table 1).

The 12 vernal pools in this study range in elevation from 329 m to 902 m and are situated on benches originating from old landslides and soil slips. The soils are predominately fractured sandstones and shales (Sutherlin Series) or glaucophane schist and related metamorphic rocks (Yorkville Series) of the Franciscan Formation (Gowans 1958), which are especially prone to landslipping. The pool basins are underlain with a moderately compact clay hardpan. Mixed oak woodland and savan-

TABLE 1. MONTHLY RAINFALL (mm) FOR WINTERS OF 1995–1996 AND 1998–1999 AT THE UNIVERSITY OF CALIFORNIA HOPLAND RESEARCH AND EXTENSION CENTER, MENDOCINO COUNTY, CA. Elevation = 244 m. 35 year average = 947 mm.

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Tot
1995–1996					5	350	214	244	88	88	64	21	1074
1997–1998		22	17	41	215	92	325	502	150	71	111		1546
1998–1999				24	184	74	101	287	149	57	4		880

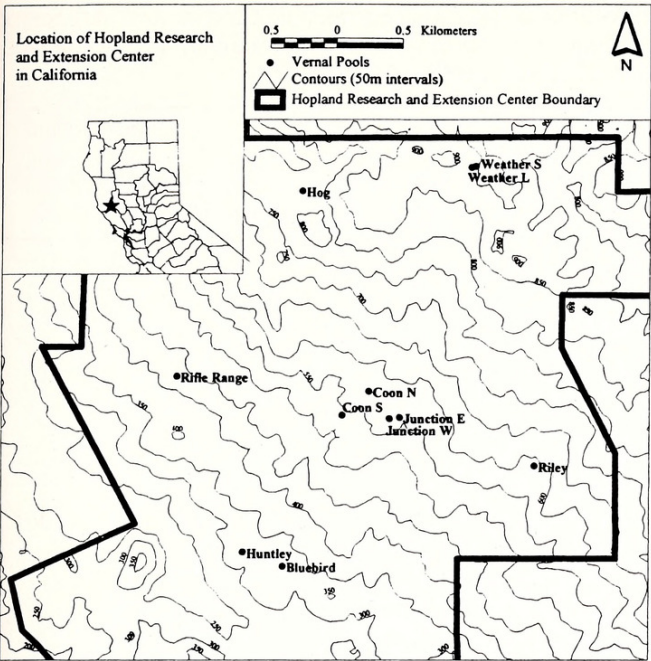


FIG. 1. Location of vernal pools at the Hopland Research and Extension Center, Mendocino County, CA. Twining pool is located 5 km northwest of Hog pool. Township 13 North, Range 11 West.

na dominate the lower elevations, whereas chaparral and patches of closed cone forest are common above 675 m (Murphy and Heady 1983). Some pools are shaded by mature *Quercus* spp. (*Quercus douglasii* Hook. & Am., *Q. lobata* Nee, *Q. garryana* Hook., *Q. agrifolia* Nee), but otherwise are surrounded by annual grassland or chamise chaparral. A group of sag ponds just outside of the study area support perennial wetland taxa such as *Scirpus*, *Typha*, and *Potamogeton*, which were absent from the larger vernal pools. Cattle were excluded from the Twining pool in 1996; all other pools, except Bluebird and Riley, are grazed by sheep.

We visited each pool in mid April, May and June of 1996 and 1999 to inventory the vascular plants. A species list was compiled for each pool, noting all species from pool center to upper strand line or interface where there was an obvious change in species composition from the adjacent upland vegetation. The DAFOR scale (Kent and Coker 1992): dominant (5), abundant (4), frequent (3), occasional (2), and rare (1) was used to obtain a subjective measure of species abundance for each pool. Tree canopy cover was determined from an ocular estimate of noon shade over the pools in June. Since all pools were round in shape the mean of 4 radii were used to determine pool area. Representative species new to the study site were collected and deposited into the HREC herbarium.

RESULTS AND DISCUSSION

Of the 90 vascular plants and one bryophyte found at the 12 vernal pools during the April–June, 1995–1996 and 1998–1999 sampling period, 63

TABLE 2. SUMMARY DATA FOR VERNAL POOLS AT THE HOPLAND RESEARCH AND EXTENSION CENTER AND ADJACENT PRIVATE LAND, MAYACMAS MOUNTAINS, MENDOCINO COUNTY, CA. Note: No grazing in Bluebird since 1989, Riley since 1956, and Twining since 1996.

	Huntley	Bluebird	Junction West	Junction East	Riley	Coon North	Coon South	Weather Small	Weather Large	Hog	Rifle Range	Twining
Elevation (m)	329	335	579	579	597	567	543	902	902	799	412	268
Grazing (Yes, No)	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	N
Pool area (sq m)	2262	612	300	490	432	180	288	180	341	3069	215	1230
Maximum water depth (cm)	42	33	45	52	105	65	100	32	40	115	68	60
Water depth (cm) 30 May 1996	9	2	0	0	80	10	40	0	0	100	0	45
Water depth (cm) 18 Jun 1996	0	0	0	2	55	0	70	8	8	100	0	38
Water depth (cm) 26 May 1999	1	0	0	0	53	0	38	0	0	75	0	12
Water depth (cm) 21 Jun 1999	0	0	5	1	35	40	0	0	0	0	0	5
% tree canopy cover	20	0	16	24	33	12	33	0	0	0	0	5
Number of plant species	29	27	16	24	33	12	33	25	23	45	18	35

TABLE 3. ABUNDANCE DATA FOR VERNAL POOLS AT THE HOPLAND RESEARCH AND EXTENSION CENTER AND ADJACENT PRIVATE LAND, MENDOCINO COUNTY, CA. Data collected April–June, 1996 and 1999. 5 = Dominant, 4 = Abundant, 3 = Frequent, 2 = Occasional, 1 = Rare. Nomenclature follows Hickman (1993).

Species	Hunt- ley-96	Hunt- ley-99	Blue- bird-96	Blue- bird-99	Junc- tion West- 96	Junc- tion West- 99
<i>Achyrachaena mollis</i> Schauer						
<i>Agrostis exarata</i> Trin.						
<i>Aira caryophyllea</i> L.			3	2		1
<i>Allium unifolium</i> Kellogg						
<i>Anagallis arvensis</i> L.			2	1	1	1
<i>Aristida oligantha</i> Michaux						
<i>Avena barbata</i> Link					2	1
<i>Briza maxima</i> L.						
<i>Briza minor</i> L.	2	2	3	2		
<i>Brodiaea elegans</i> Hoover	1		2		1	1
<i>Brodiaea stellaris</i> S. Watson						
<i>Bromus diandrus</i> Roth			1	1		
<i>Bromus hordeaceus</i> L.	2	2	1	1		
<i>Callitriche heterophylla</i> Pursh var. <i>bolanderi</i> (Hegelm.) Fassett	2	2				
<i>Carex athrostachya</i> Olney						
<i>Carex feta</i> L. Bailey						
<i>Carex subbracteata</i> Mackenzie						
<i>Castilleja attenuata</i> (A. Gray) Chuang & Heckard						
<i>Centunculus minimus</i> L.						
<i>Cerastium glomeratum</i> Thuill.	3	2				
<i>Ceratophyllum demersum</i> L.						
<i>Cicendia quadrangularis</i> (Lam.) Griseb.						
<i>Crassula aquatica</i> L. Schönl.	2	2				
<i>Cynodon dactylon</i> (L.) Pers.			4	3		
<i>Cynosurus echinatus</i> L.						
<i>Dactylis glomerata</i> L.						
<i>Danthonia californica</i> Bolander						
<i>Deschampsia danthonioides</i> (Trin.) Munro	2	2	4	4	4	3
<i>Deschampsia elongata</i> (Hook.) Munro						
<i>Downingia cuspidata</i> (E. Greene) E. Greene						
<i>Elatine californica</i> A. Gray						
<i>Eleocharis acicularis</i> (L.) Roemer & Schultes	4	4	3	4		
<i>Eleocharis macrostachya</i> Britton	5	4	5	5	2	1
<i>Elymus glaucus</i> Buckley						
<i>Eremocarpus setigerus</i> (Hook.) Benth.	3	3				
<i>Eryngium aristulatum</i> Jepson var. <i>aristulatum</i>	2	5	5	5	5	5
<i>Festuca rubra</i> L.						
<i>Galium aparine</i> L.	2		2			
<i>Geranium bicknellii</i> Britton						
<i>Geranium dissectum</i> L.					1	
<i>Glyceria leptostachya</i> Buckley						
<i>Gratiola ebracteata</i> Benth.	3	4	4	4		
<i>Heterocodon rariflorum</i> Nutt.						
<i>Hordeum marinum</i> Hudson subsp. <i>gussoneanum</i> (Parl.) Thell.	3	3	2	2	2	4
<i>Hypochaeris glabra</i> L.						
<i>Isoetes howellii</i> Engelm.	5	5	2	2		
<i>Juncus bufonius</i> L.	2	2				
<i>Juncus patens</i> E. Meyer						
<i>Juncus tenuis</i> Willd.						
<i>Juncus xiphioides</i> E. Meyer				3		
<i>Lasthenia californica</i> Lindley						
<i>Lasthenia glaberrima</i> A.DC.						
<i>Leptodictyon riparium</i> (Hedw.) Warnst.						
<i>Lilaea scilloides</i> (Poiret) Hauman						
<i>Lolium multiflorum</i> Lam.			2	3	5	4
<i>Lolium temulentum</i> L.						
<i>Lythrum hyssopifolium</i> L.	2	2			3	2
<i>Madia gracilis</i> (Smith) Keck						
<i>Mentha pulegium</i> L.				2		
<i>Microseris douglasii</i> (DC.) Schultz-Bip.						

[illegible]

TABLE 3. CONTINUED

Species	Hunt- ley-96	Hunt- ley-99	Blue- bird-96	Blue- bird-99	Junc- tion West- 96	Junc- tion West- 99
<i>Mimulus guttatus</i> DC.	2	2	2	3		
<i>Mimulus pilosus</i> (Benth.) S. Watson						
<i>Montia fontana</i> L.						
<i>Navarretia intertexta</i> (Benth.) Hook.	3	3			2	1
<i>Phalaris aquatica</i> L.						
<i>Plagiobothrys bracteatus</i> (T. J. Howell) I. M. Johnston	3	2			3	5
<i>Poa annua</i> L.	2	1				
<i>Poa secunda</i> J. S. Presl						
<i>Pogogyne zizyphoroides</i> Benth.	2	1			2	1
<i>Polypogon interruptus</i> Kunth	1	1				
<i>Polypogon monspeliensis</i> (L.) Desf.	3	3	3	1		
<i>Potamogeton foliosus</i> Raf.						
<i>Psilocarphus tenellus</i> Nutt.						
<i>Ranunculus aquatilis</i> L.						
<i>Ranunculus lobbii</i> (Hiern) A. Gray	2	1				
<i>Rumex crispus</i> L.			2	2	1	2
<i>Silene gallica</i> L.						
<i>Sisyrinchium bellum</i> S. Watson						
<i>Spiranthes pornifolia</i> Lindley			1	3		
<i>Spirodela polyrrhiza</i> (L.) Schleiden	2	1				
<i>Stellaria media</i> (L.) Villars						
<i>Taeniatherum caput-medusae</i> (L.) Nevski				1		
<i>Trichostema laxum</i> A. Gray						
<i>Trifolium dubium</i> Sibth.						
<i>Trifolium variegatum</i> Nutt.	3	3	2	3		
<i>Trisetum canescens</i> Buckley						
<i>Triteleia hyacinthina</i> (Lindley) E. Greene			2			
<i>Veronica peregrina</i> L. subsp. <i>xalapensis</i> (Kunth) Pennell	2	1	2	3	1	1
<i>Vulpia bromoides</i> (L.) S. F. Gray	2	2	3	1		
<i>Vulpia myuros</i> (L.) C. Gmelin						
<i>Zigadenus micranthus</i> Eastw.						
Total number of species	29	27	24	24	15	15

(70%) were native species (Appendix 1). Species richness ranged from 12 at Coon North pool to 45 at Hog pool (Table 2). *Centunculus minimus* L., *Crassula aquatica* (L.) Schönl., *Deschampsia danthonioides* (Trin.) Munro, *Downingia cuspidata* (E. Greene) E. Greene, *Elatine californica* A. Gray, *Eryngium aristulatum* Jepson var. *aristulatum*, *Gratiola ebracteata* Benth., *Isoetes howellii* Engelm., *Plagiobothrys bracteatus* (T. J. Howell) I. M. Johnston, *Pogogyne zizyphoroides* Benth., and *Ranunculus lobbii* (Hiern) A. Gray, were restricted to vernal pools in the study area, but absent from other nearby wetland types. Of these species, Hog pool had the highest number (7) compared to Riley and Coon North pools, which had none. *Eleocharis acicularis* (L.) Roemer & Schultes, *E. macrostachya* Britton, *Eryngium aristulatum* var. *aristulatum*, *Gratiola ebracteata*, *Hordeum marinum* Hudson subsp. *gussoneanum* (Parl.) Thell., and *Plagiobothrys bracteatus* had the highest constancies, occurring in 8 out of 12 pools. Species richness was highest in a band approximately 1 meter below the high strand line where a mix of introduced annuals and native wetland species occurred. Below this

band and extending toward the pool centers, *Eryngium aristulatum* var. *aristulatum*, *Eleocharis macrostachya*, and *Isoetes howellii* were common and usually the dominant species (Table 3). Of 27 exotic species, *Briza minor* L., *Hordeum marinum* ssp. *gussoneanum*, *Lolium multiflorum* Lam., and *Polypogon monspeliensis* (L.) Desf. were the most abundant, commonly encroaching into the pools from the outer margin. Exotic species were rare toward the pool centers.

There were no significant changes observed in species composition and abundance between the two sampling periods of 1995–1996 and 1998–1999 (Table 3). Although the two winters fell close to the 35 year rainfall average of 947 mm, a wet late spring and early summer in 1996 lengthened the period of inundation by several weeks over those in 1999. Surprisingly, the pool phase was shorter after the El Niño winter of 1997–1998, which produced 1546 mm of rainfall (Table 1). Results from cover estimates taken in September of 1997 are shown in Table 4 and reflect the summer pool vegetation.

The variables that seem to influence differences

TABLE 3. EXTENDED CONTINUED

Junc- tion East- 99	Junc- tion East- 99	Riley- 96	Riley- 99	Coon North- 96	Coon North- 99	Coon South- 96	Coon South- 99	WS- 96	WS- 99	WL- 96	WL- 99	Hog- 96	Hog- 99	Rifle Range- 96	Rifle Range- 99	Twin- ing- 96	Twin- ing- 99
		1	2					1	1			1	3				
		1	1														
4	4					2	1	1	1					2	4	3	1
							1									2	2
3	3					3	4	2	2	4	4	1	3				
				1	1				2	1		1	2	3	3	1	2
				1	1												
4	4													3	2		
		1	2														
2	1		2			2	2			1		2	2	2	2	1	1
																3	3
2	1																
				2	3		5					3	4			2	2
		3	5			4	3	2	2			2	2			2	2
		1	4	1	1							1	1			1	1
						2										1	1
												2	1				
		1				1											
				2	1												
3	1																
1	3											2	2				
		1	2			4	4	3	2			2	2			2	3
		2		1	1												
						2	1					1	1				
1	2					2	2			1	2	1	2		1		
								2	2	1	2					3	3
								1				2					
			2									1					
19	24	29	28	11	12	27	30	22	24	15	20	43	40	15	18	35	32

between pools in this study are pool depth and profile, length of inundation phase, degree of shade, and management. Deep pools such as Riley, Coon South, Coon North, and Hog experience longer periods of inundation and often support taxa more typical of perennial wetlands such as *Juncus*, *Eleocharis*, and *Carex*. Riley and Coon South pools are also steep-profiled with narrow margins, a topography that did not support vernal pool specialist plants common on shallow-profiled pools with wide margins. Coon South was the only vernal pool underlain with a dense mat of the aquatic moss *Lepidodictyon riparium*. Although Coon North and Riley pools are both deep, densely shaded, steep-profile pools, they had little in common floristically. Coon North, which receives heavy sheep use, was essentially devoid of herbaceous vegetation, while Riley, protected from livestock use since 1956, had a dense band of *Carex subbracteata* Mackenzie, *Eleocharis macrostachya*, and *Agrostis exarata* Trin around its upper perimeter. Both pools lack *Eryngium aristulatum* var. *aristulatum* and *Isoetes howellii* which were characteristic of many of the other vernal pools. Hog is the largest (3069 m²) and

deepest (115 cm) vernal pool but has a very shallow profile, thus supporting a diverse mix of perennial wetland and vernal pool specialist taxa.

Huntley, Bluebird, Junction West, Junction East, Weather Small, Weather Large, Rifle Range, and Twining pools are relatively shallow with wide margins and little or no tree canopy. *Eryngium aristulatum* var. *aristulatum* was a dominant species in both Junction West and Junction East, which lie adjacent to each other. Junction East was the deeper of the two with *I. howellii* as a codominant, whereas *Lolium multiflorum* codominated in Junction West. Weather Large and Weather Small, paired pools similar in many respects, were both codominated by *E. aristulatum* var. *aristulatum* and *I. howellii*. Huntley and Bluebird pools lie within 500 m of each other at similar elevations and are both codominated by *E. macrostachya* and *E. aristulatum* var. *aristulatum*. Rifle Range pool was originally a shallow profile vernal pool with an area of ca. 1200 m². Excavation of the fragmented shales that overlay the surface resulted in the creation of several small, deep pools, which are dominated by *E. aristulatum* var. *aristulatum* in the basins and



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