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Temperature and water level dynamics of vernal pools in the Agate Desert, Oregon, U.S.A.

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Introduction

Vernal pools form in: (1) a "patterned ground" surface topography of swales and hummocks; (2) a subsurface duripan layer that supports a perched water table; and (3) a wet-dry seasonal cycle of precipitation (KEELEY & ZEDLER 1998). Vernal pools provide habitat for a unique assemblage of aquatic species, which appear during the wet or hydrated phase, and terrestrial species, which appear after the pools empty. These organisms, several of which have been listed as endangered, have life-cycles that allow persistence under often uncertain conditions. We present data collected over 2 successive "water years" (1 Oct to 30 Sep) for selected pools on the Agate Desert, Jackson County, Oregon, United States. The data present a snapshot of current environmental conditions in this locale and provide useful information to guide the recovery and protection of endangered species dependent on the pools (USFWS 2006).

Key words: Agate Desert, dissolved oxygen, fairy shrimp, temperature, vernal pools, water level

Methods

We positioned recording thermistors (Onstead Corporation StowAway Tidbit ®) in the sediment (2 cm below the surface) in one pool at each of 2 representative sites on the Agate Desert ("School" site: 42°26'N; 122°50'W and "TNC" site: 42°26'N; 122°53'W). The thermistors were programmed to record temperature every 10 min from November 2003 until August 2005. We also installed an array of piezometers at the TNC site, including a recording water level gauge (Solinst Leveloger ®) with correction for atmospheric pressure. This installation provided detailed information on the filling and emptying of representative pools at the TNC site. On 3 occasions, selected pools were monitored with a Hydrolab Sonde ® for at least 48 hours for *in situ* temperature, dissolved oxygen, and pH. Additional data, not reported here, were collected on filamentous algae and water chemistry. (A complete electronic copy of all data is available by request.)

Results

Temperature, pH, and dissolved oxygen varied markedly within each day (Fig. 1). Similar results were observed on the other days of observation with the Hydrolab ® and indicate the dynamic variation of environmental conditions in the pools. Temperatures observed at the same time by the thermistors were closely similar to the Hydrolab results, indicating that the thermistors provided a representative record of pool temperature during the hydrated phase as well as soil surface temperature during the dry phase. The daily variation recorded by the thermistors was used to develop a second figure summarizing the diel temperature variation (maximum and

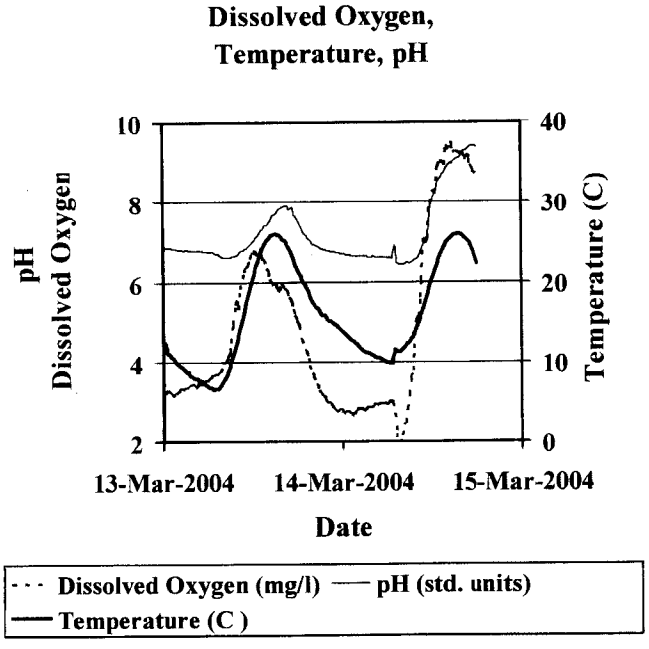

Fig. 1. Diel variation of temperature, pH, and dissolved oxygen. The maximum and minimum temperature each day were used to construct Figure 2.

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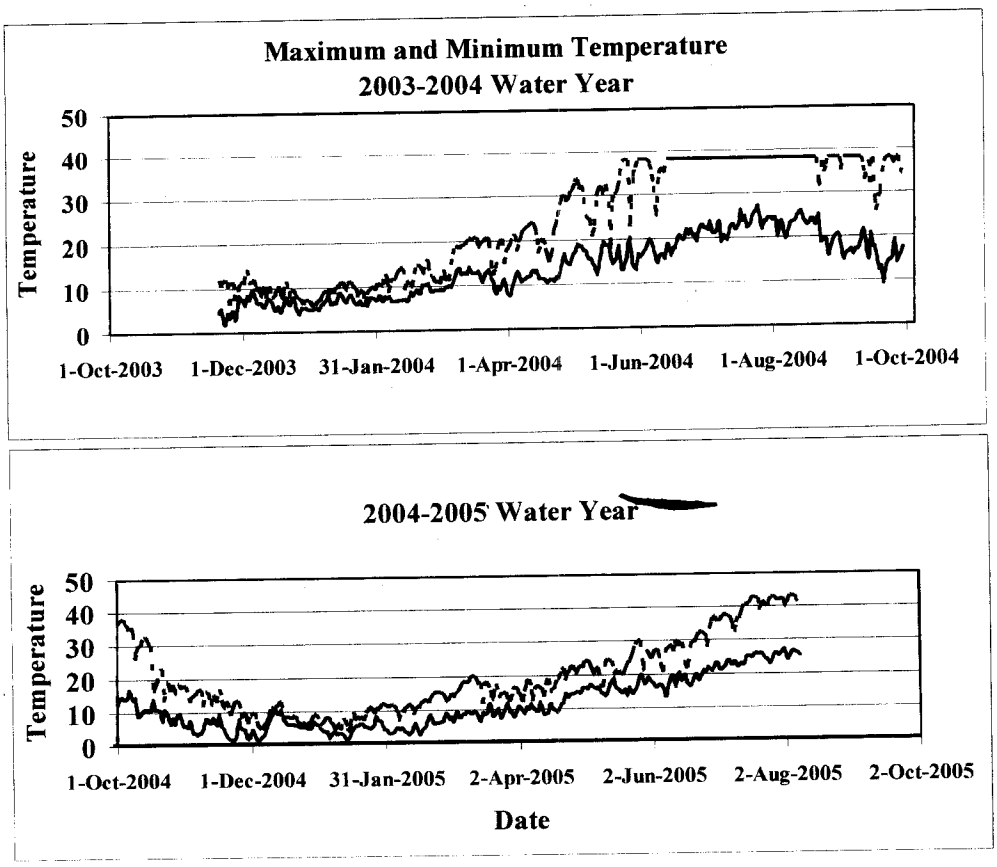

Fig. 2. Daily maximum (upper dashed line) and daily minimum temperature (lower solid line) observed in sediment surface at the TNC site. During the 2003–2004 Water Year, a thermistor limited to a maximum temperature of 38 degrees was employed. During July and August, temperatures exceeded this limit, hence the solid horizontal portion of the temperature data. During the 2004–2005 Water Year, a thermistor with a higher limit was used.

minimum temperature each day) over the 2-year period of observation at the TNC site (Fig. 2). Temperatures observed at the School site were nearly identical and are not presented separately here.

Diel temperature varied as much as 25 °C and annual temperature varied by more than 45 °C. Although ice formed at the surface of the pools during the coldest weather, the pools did not completely freeze. Daily temperatures were related to ambient weather conditions such as air temperature, precipitation, and solar radiation. The temperature variation was much greater on clear sunny days and attenuated during overcast days. During the dry phase, temperature in the surface sediment sometimes exceeded the daily air temperature maximum, especially on clear sunny days.

Pools filled in the fall when precipitation exceeded evapotranspiration for a short time and emptied in the spring when precipitation lessened and evapotranspiration increased. Water level closely followed changes in precipitation. For example, the pools emptied during

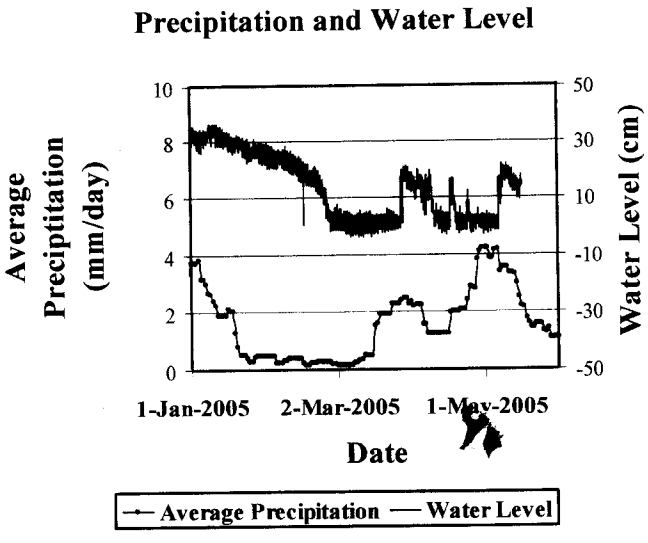

Fig. 3. Example of pool water level and average daily precipitation. (Average precipitation is the 20-day running average of daily precipitation.) Water level scale is offset for clarity

March 2005 but temporarily refilled during April and May shortly after the return of spring rain (Fig. 3). Year-to-year variation in the period of hydration is substantial at this location.

Discussion

Species associated with vernal pools are adapted to an annual cycle of hydration (approximately Nov–Apr on the Agate Desert) and extreme drying (May–Oct). Temperature plays a role in the distribution of vernal pool species (HATHAWAY & SIMOVICH 1996). For the aquatic species (including the endangered fairy shrimp *Branchinecta lynchi*), the duration of the hydrated phase is also crucial to completing their life cycle (PHILIPPI et al. 2001). Our results indicate that the vernal pools of the Agate Desert are highly dynamic with wide variation of temperature, water level, and other environmental conditions.

For the western region of the United States, various global climate models agree that temperatures will increase in coming years but provide no consensus on future patterns of precipitation (COQUARD et al. 2004). The increased temperatures may not present a severe challenge to the plants and animals associated with the vernal pools, given the already dynamic nature of the temperature regime. However, the uncertain future of rainfall may present a more serious problem since many aquatic species require an extended period of hydration to complete their life cycles (PHILIPPI et al. 2001). At present, a process is underway to conserve existing pool habitat for the preservation of the unique species associated with the pools (USFWS 2006). The process is being guided by recognition that the best hope for preserving the target species will be attained by conserving as many existing pools and unique habitat types as possible (KING et al. 1996).

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