

describe known PCEs in terms that are more specific than the description of physical and biological features. Specifically, PCEs may include, but are not limited to, the following: roost sites, nesting grounds, spawning sites, feeding sites, seasonal wetland or dryland, water quality or quantity, host species of plant pollinator, geological formation, vegetation type, tide, and specific soil types.

Based on our current knowledge of the life history and ecology of the 15 listed vernal pool species, the relationship of their essential life history functions to their habitat, and the ecological and hydrologic functions of vernal pool complexes, as summarized above in the Background section, we determined that all of the 15 vernal pool species share the following two PCEs. These are:

(1) Vernal pools, swales, and other ephemeral wetland features of appropriate sizes and depths that typically become inundated during winter rains and hold water for sufficient lengths of time necessary for the 15 species to complete their life cycle.

(2) The geographic, topographic, and edaphic features that support aggregations or systems of hydrologically interconnected pools, swales, and other ephemeral wetlands and depressions within a matrix of surrounding uplands that together form hydrologically and ecologically functional units called vernal pool complexes. These features contribute to the filling and drying of the vernal pool, maintain suitable periods of pool inundation, and maintain water quality and soil moisture to enable the 15 vernal pool species to carry out their lifecycles.

The first PCE provides the necessary soil moisture and aquatic environment required for seed germination, cyst hatching, growth, maturation, reproduction, and dispersal, and the appropriate periods of dry-down for seed and cyst dormancy. Both the wet and dry phases of the vernal pool help to reduce competition with strictly terrestrial or strictly aquatic plant or animal species. The wet phase provides the necessary cues for hatching, germination, and growth, while the drying phase allows the vernal pool plants to flower and produce seeds and the vernal pool crustaceans to mature and produce cysts. We conclude this element is essential to the conservation of the 15 vernal pool species because these species are ecologically dependent on seasonal fluctuations, such as absence or presence of water during specific times of the year, and duration

of inundation and the rate of drying of their habitats. They cannot persist in perennial wetlands or wetlands that are inundated for the majority of the year, nor can they persist without periodic seasonal inundation.

The second PCE (the entire vernal pool complex, including the pools, swales, and associated uplands) is essential to maintain both the aquatic phase and the drying phase of the vernal pool habitat. Although the vernal pool species addressed in this rule do not occur in the strictly upland areas surrounding vernal pools, they are dependent on these upland areas to maintain the aquatic and drying phases of the vernal pool. The germination of vernal pool plants and hatching of cysts is dependent on the timing and length of inundation of the vernal pool habitat. The rate of vernal pool drying, during which vernal pool plants must flower and produce seeds, is also largely controlled by interactions between the vernal pool and the surrounding uplands (Hanes *et al.* 1990; Hanes and Stromberg 1998). The uplands also provide a source of nutrients and food sources for the 15 vernal pool species and provide habitat for pollinator species that may be specifically adapted to some of the plant species in this rule (Thorp 1998; Eriksen and Belk 1999). The uplands also provide habitat for avian species and other animals known to aid in the dispersal of the 15 vernal pool species (Zedler and Black 1992; Silveira 1998).

The first of these PCEs provides for space, physiological requirements, shelter, and reproduction sites for the 15 vernal pool species. Vernal pools and other ephemeral wetlands provide space during their wetted periods for individual and population growth and normal behavior of vernal pool species by providing still, freshwater habitat of appropriate depth, duration, temperature, and chemical characteristics for: (1) Juvenile and adult vernal pool crustaceans to hatch, swim, grow, reproduce and behave normally; (2) the aquatic stage of the seven Orcuttiae tribe plants to germinate and grow under water; and (3) saturating areas of ground to the extent and duration necessary to allow the four non-Orcuttiae plants to germinate and grow. Vernal pools and other ephemeral wetlands also provide soil space during both dry and wetted periods for the maintenance of dormant cyst and seed banks, which allow populations of vernal pool species to maintain themselves throughout the unpredictable and highly variable environmental conditions experienced by their nondormant life history stages.

Vernal pools and other ephemeral wetlands also provide various physiological requirements for both vernal pool plants and crustaceans. For crustaceans they provide water, oxygen, and food such as plankton, detritus, and (in the case of vernal pool tadpole shrimp) other small crustaceans. For vernal pool plants, they provide water and various nutrients from detritus that sinks to the bottom. They also provide oxygen for the aquatic leaves of Orcuttiae tribe plants.

By drying seasonally, ephemeral wetlands provide cover or shelter from many aquatic predators and competitors (*see* background section). Similarly, by undergoing seasonal inundation, these areas provide shelter for vernal pool plants from terrestrial plants which would otherwise outcompete them for space, light, water, or nutrients.

Finally, vernal pool crustaceans require wetted ephemeral wetlands in which to mate, and both vernal pool crustaceans and vernal pool plants deposit cysts or eggs in these wetland areas, which must then dry to allow hatching or germination. Wetted ephemeral wetlands may also tend to attract waterfowl, which act as important seed and cyst dispersers (Proctor 1965; Silveira 1998).

The second PCE, upland areas and vernal swales hydrologically associated with ephemeral wetlands, is essential for maintaining the seasonal cycle of ponding and drying in the ephemeral wetland areas. Upland areas are therefore essential for providing the same physical and biological factors as are provided by the ephemeral wetland areas. Additionally, they provide an important (and often primary) source of detritus, which is an important food source for vernal pool crustaceans and nutrient source for vernal pool plants. Upland and swale areas also provide habitat for waterfowl, amphibians, mammals, or insects, all of which are important for seed, pollen, or cyst dispersal. Certain upland and swale areas may also help disperse seeds and cysts more directly, and also provide for population growth by channeling flood waters from overflowing ephemeral wetland areas so that seeds, cysts, or adult individuals are washed from one such wetland to another.

We have used vernal pool complexes as the basis for determining populations of vernal pool crustaceans since the species were first proposed for listing. The final rule to list the four vernal pool crustaceans states that “[t]he genetic characteristics of the three fairy shrimp and vernal pool tadpole shrimp, as well as ecological conditions, such as watershed contiguity, indicate that