Vernal Pool Tadpole Shrimp
(Lepidurus packardi)

Legal Status
Federal: Endangered.
State: None.

Global and State Conservation Status: G2G3S2S3: Global Rank, G2G3 somewhere between a G2 = Imperiled: At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors and a G3 = Vulnerable: At moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors. State Rank, S2S3 = Same as global ranks but only for the range of taxa within California.

Recovery Plan: Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon (USFWS 2005).

Species Description and Life History

The vernal pool tadpole shrimp is a typical member of the genus *Lepidurus*. Like some other tadpole shrimp species, this species appears to be unisexual (Rogers 2001). It is separated from most other nearctic *Lepidurus* species by having the nuchal organ (a large tubercle behind the eyes) intersected by a line drawn between the posterior apices of eyes, 24 to 29 body rings, and 30 to 35 pairs of legs. The caudal lamina is truncate, 0.3 to 0.1 times the length of carapace. Mature specimens have the sulcus spines triangular, with numerous small spines of varying shapes—sometimes in double rows, separating the larger spines. Smaller specimens have large acute spines, 1.2 to 1.5 times as long as they are broad. Old specimens may have the largest sulcus spines rounded. The endites three, four, and five of the second thoracic appendages project beyond the carapace margin. Length of the adult vernal pool tadpole shrimp ranges from 15 to 86 mm (0.59 to 3.39 in) from the anterior margin of carapace to the tip of the caudal lamina. The vernal pool tadpole shrimp can reach very large sizes; one specimen from Stanislaus County, California measured 86 mm (3.39 in) from the anterior carapace margin to the apex of the caudal lamina (Rogers 2001).

Lepidurus cryptus has been previously confused with the vernal pool tadpole shrimp (Linder 1952, Lynch 1972) and is inseparable morphologically from the vernal pool tadpole shrimp (Rogers 2001). Analysis of rDNA performed by King and Hanner (1998), demonstrates that *Lepidurus cryptus* is genetically distinct from the vernal pool tadpole shrimp (Rogers 2001).

The vernal pool tadpole shrimp may vary in coloration, depending on habitat, although it is most commonly green. In highly turbid water, this species may be nearly translucent to buff colored with brown mottles. In slightly turbid to clear water, the vernal pool tadpole shrimp shows greater variety; coloration may be light green, dark green, dark green mottled with brown, chocolate brown, brown with green mottles, and black.

Vernal pool tadpole shrimp are an intermediate host for the metacercariae (intermediate life stage) of an echinostome fluke (Ahl 1991), which also infects co-occurring gastropods. The parasitic fluke castrates the vernal pool tadpole shrimp. This fluke is most likely a bird parasite.

Vernal pool tadpole shrimp are a component of the zooplanktonic community within episodic, ephemeral aquatic habitats; although the larger they grow, the more time they spend at or near the bottom. Tadpole shrimp are omnivorous, with a strong preference for animal matter, and will capture and consume live invertebrates, amphibian larvae, or carrion (Longhurst 1955). Vernal pool tadpole shrimp will also filter detritus for micrometazoa.

During the dry phase of their habitat, vernal pool tadpole shrimp survive as diapausing cysts (resting eggs) in and on the substrate (Sars 1896, 1898; Eriksen and Belk 1999; Rogers and Fugate 2001). After winter rains fill their vernal pool habitats, dormant vernal pool tadpole shrimp cysts may hatch in as little as 4 days (Ahl 1991, Rogers 2001). Additional cysts produced by adult tadpole shrimp during the wet season may hatch without going through a dormant period (Ahl 1991). Vernal pool tadpole shrimp emerge from their cysts as metanauplii, a stage which lasts for 1.5 to 2 hours. Then they molt into a larval form resembling the adult. Vernal pool tadpole shrimp hatching is temperature dependent with optimal hatching occurs between 10 to 15 degrees Celsius (50 to 59 degrees Fahrenheit). Hatching rates becoming significantly lower at temperatures above 20 degrees Celsius (68 degrees Fahrenheit) (Ahl 1991). The maturation rates of vernal pool crustaceans vary extensively, depending on temperature (Eriksen and Belk 1999, Rogers 2002), and the vernal pool tadpole shrimp can reach maturity in 19 days.

The cysts lay dormant in the substrate until the pool dries and re-inundates during the subsequent rains. Beyond inundation of the habitat, the specific cues for hatching are unknown, although temperature (Hall 1959, Belk 1977, Al-Tikrity and Grainger 1990, Belk and Nelson 1995, Eriksen and Belk 1999) and conductivity (Anderson 1958; Bowen *et al.* 1988; Broch 1969, 1988; Brown and Capelan 1971; Brown 1972) are believed to play a large role. Multiple hatching within the same wet season allows vernal pool tadpole shrimp to persist within vernal pools as long as these habitats remain inundated, sometimes for 6 months or more (Ahl 1991, Gallagher 1996, Helm 1998).

Contrary to Ahl (1991), each individual is capable of producing viable cysts without sexual reproduction (Longhurst 1955, Rogers 2001). Populations are probably made up of either parthenogenic females, amphigenic females (females with lobes of testicular tissue on the ovaries) or both (Bernard 1889; Longhurst 1954; Maeda-Martinez et al.

2000; Sassaman 1991, 1995; Rogers 2001). The cysts are produced by the ovaries into a marsupium on the eleventh thoracopods, made from a modification of the subapical lobe that holds the cysts, and the exopodite that forms the "lid" of the marsupium (Fryer 1988). The female typically sheds her cysts as the shell forms over the fertilized oocyte (Murugan et al. 1996), and the cysts fall to the substrate.

Planktonic Crustacea are important in the food web, as they represent a high-fat, high-protein resource for migratory waterfowl. Mallard (*Anas platyrhynchos*), green-winged teal (*A. crecca*), bufflehead (*Bucephala albeola*), greater yellowlegs (*Tringa melanoleuca*), and killdeer (*Charadrius vociferus*) all forage actively in Central Valley vernal pools on the invertebrate and amphibian fauna during the winter months (Proctor 1964, Horne 1966, Mellors 1975, Silveira 1996, Dumont and Negrea 2002).

Habitat Requirements and Ecology

The vernal pool tadpole shrimp is entirely dependent on the aquatic environment provided by vernal pool wetland ecosystems. It depends on the presence of water in winter and early spring, and the absence of water during summer. These specific vernal pool wetlands are dependent on intact sub-watersheds and the surrounding uplands that support those watersheds. Vernal pool habitat is a component of the larger grassland ecosystem of the Central Valley.

The vernal pool tadpole shrimp needs the cold winter waters to hatch and develop—typically appearing after the first frosts, and dry summers to dry resting cysts and prevent them from fungusing. Habitats supporting the vernal pool tadpole shrimp are typically in Central Valley California floristic provinces below 300-m (984-ft) elevation. Typical habitat for vernal pool tadpole shrimp in California includes vernal pools, seasonally ponded areas within vernal swales, rock outcrop ephemeral pools, playas, and alkali flats (Eriksen and Belk 1999, Rogers 2001). Vernal pool tadpole shrimp have also been found in alkaline vernal pools. Vernal pools that support these shrimp may be grass or mud-bottomed, with clear to tea-colored or highly turbid water, and are often in grassland depression pools (USFWS 1994, Rogers 2001).

Pool volume is important in determining potential shrimp habitat because deeper pools will pond long enough to allow the shrimp to complete their life cycle. Vernal pool tadpole shrimp have been found in pools ranging from 404 m^2 to greater than 32 ha (0.1 to 80 acres) (USFWS 1994, Eriksen and Belk 1999).

Predator consumption of cysts aids in distributing populations of vernal pool crustaceans. Predators (e.g., birds and amphibians) expel viable cysts in their excrement, often at locations other than where they were consumed (e.g., Proctor 1964, Wissinger *et al.* 1999). If conditions are suitable, these transported cysts may hatch at the new location and potentially establish a new population. Cysts are also transported by wind and in mud carried on the feet of animals, including livestock that may wade through the habitat (Rogers in prep.). This type of dispersal aids ephemeral pool crustaceans to exploit a wide variety of ephemeral habitats (Rogers 2000).

Various physiochemical factors have been examined in existing vernal pool tadpole shrimp habitats, including alkalinity, total dissolved solids (TDS), and pH (Collie and Lathrop 1976, Eriksen and Belk 1999). The USFWS (1994) described the water in pools occupied by vernal pool tadpole shrimp as having low conductivity and chloride; however, specific data were not provided. Recently, the importance of many of these parameters has been called into question with evidence that the type and amount of dissolved salts may be a more important habitat requirement for vernal pool crustaceans (Rogers 2002). Considering the daily fluctuations in pH of a given habitat, this is to be expected. During the daylight hours, the hydrophytes are photosynthesizing, removing the CO_2 (from HCO_3) from the water, and raising the pH. During the night, the hydrophytes are respiring, increasing the CO_2 (and thereby, the HCO_3) in the water, and lowering the pH. If there is rainfall, the distilled precipitation will lower the pH, as will winds that cause surface action. When the habitats are drying and losing volume through evaporation, the pH, alkalinity, TDS, and electrical conductivity will increase—just as they decrease when the pools inundate or reinundate (Rogers 2002).

Some vernal pools need a certain amount of grazing. Vernal pools from which all grazing has been removed become overgrown with native and exotic plants that generate deep thatch layers on the pool substrate, unless some other disturbance (i.e., weed control programs, vehicular use of pools, fire fuels control) prevents thatch deposition. As this thatch layer decomposes, it also oxidizes the water, which can suffocate gill-breathing invertebrates (Rogers 1998). Therefore, moderate grazing may be a necessary habitat suitability component. Conversely, excessive livestock grazing can be detrimental to vernal pool tadpole shrimp.

Common wetland plant species, such as toad rush (*Juncus bufonius*), coyote thistle (*Eryringium* spp.), downingia (*Downingia ornatissma* or *bicornuta*), goldfields (*Lasthenia* spp.), woolly-marbles (*Psilocarphus* spp.), and hair grass (*Deschampsia* spp.), that co-occur with special-status shrimp species generally need the same hydrological conditions. Therefore the presence of these plant species within a potential habitat implies a greater potential for a population of these shrimp to be present.

Similarly, the hydrology of pools that are dominated by vernal pool plant species that require short inundation periods, including Mediterranean barley (*Hordeum murinum*), toad rush (*Juncus bufonius*), false dandelion (*Hypochoeris. radicata*), and Italian rye grass (*Lolium multiflorum*), may not support shrimp species.

Conversely, wetland habitats that support plant species that need water year round, including cattails (*Typha* spp.), willow (*Salix* spp.), cottonwood (*Populus* spp.), duckweed (*Lemna* spp.), nut grass (*Cyperus* spp.), Baltic rush (*Juncus balticus*), and bulrush (*Schenoplectus* spp.), cannot support special-status shrimp species because the shrimp's cysts must dry out before they can hatch (Eriksen and Belk 1999). If they remain wet or moist through the warmer summer months, the cysts will fungus.

The vernal pool tadpole shrimp is a component of a larger invertebrate community structure (Rogers 1998). This invertebrate community includes mostly planktonic Crustacea dependent on temporary wetlands, including copepods, cladocerans, and ostracodes—as well as flatworms and a suite of insect species, including vernal pool haliplid beetle (*Apterliplus parvulus*), scimitar backswimmers (*Buenoa scimitra*), Ricksecker's hydrochara (*Hydrochara rickseckeri*), and many others (Rogers 1998). These habitats are usually low in opportunistic species like mosquitoes and chironomid midges in the genus Chironomus (Rogers 1998).

Therefore, potential special-status shrimp habitat is defined as vernal pools and seasonal wetlands of sufficient size (depth and area) and seasonality that may also (but do not have to) support specific vegetation and invertebrate community structure that indicate the potential for ponding for a sufficient duration to allow the species to complete their life cycles and to maintain conducive water temperatures.

Optimal vernal pool tadpole shrimp habitat tends to be neutral to slightly alkaline, clear vernal pools that are low in dissolved salts, dominated with vernal pool plants, and sustain a complex vernal pool invertebrate community (Rogers 1998, 2001). Unfortunately, little effort has been made to accurately quantify these parameters.

Vernal pool tadpole shrimp commonly co-occur with the fairy shrimp (*Linderiella occidentalis, B. conservatio, B. lindahli, B. coloradensis*) and the vernal pool fairy shrimp (*B. lynchi*). The midvalley shrimp (*B. mesovallensis*) and *B. longiantenna* both occur within the range of the vernal pool tadpole shrimp but are typically found in different habitats.

Species Distribution and Population Trends

Distribution

There are six species of *Lepidurus* in North America (Rogers 2001) distributed throughout arctic Canada, Alaska, and Greenland and western portions of the United States and Mexico. However, the vernal pool tadpole shrimp is endemic to California (Rogers 2001).

USFWS gave the vernal pool tadpole shrimp protection as an endangered species in 1994 (59 FR 48153). The Federal Register reported that the vernal pool tadpole shrimp was known only from 14 occurrences in the Central Valley of California. Linder (1952) reported the vernal pool tadpole shrimp from the California Central Valley 1 mile north of Davis in Yolo County and from the California Great Basin.

Helm (1998) reported *L. couesii* from the east side of the Cascade Mountain Ranges in Lassen County, California, and *Lepidurus n.* sp., the "Modoc Plateau Tadpole Shrimp" from two locations in Modoc County, California (citing King pers. comm. as his source for the shrimp's identification). King and Hanner (1998) performed 12S rDNA and allozyme analysis of Lepidurus populations throughout western North America, reporting a taxon they referred to as "*L. couesii*-1" from Klamath County, Oregon, and the east side of the Cascade Mountains in Shasta and Lassen Counties, California. In addition, they mention Linder's Lassen County vernal pool tadpole shrimp material but do not comment on its implications. King and Hanner (1998) concluded that *L. couesii* populations from Manitoba, Canada may represent a separate species from "*L. couesii*-1" in the Sierra Nevada, the Cascade Mountains and the Great Basin regions of northeastern California and south-central Oregon. Furthermore, King and Hanner (1998) stated, "Because our Oregon locality seems to be the same as one of the sites from which Linder (1952) examined material (i.e., near Klamath Falls, OR) we suggest that the California/Oregon clade should retain the name *L. couesii*." However Rogers (2001) demonstrated that the specimens from King and Hanner's "*L. couesii*-1" localities are morphologically distinct from the type specimens of *L. couesii* from Montana and thus their suggestion that the specific name "couesii" be applied to the taxon they call "*L. couesii*-1" cannot be accepted. Furthermore, Rogers demonstrated that the *Lepidurus* that Linder and Lynch had identified as the vernal pool tadpole shrimp were actually an unrecognized cryptic species, which he described. This cryptic species *Lepidurus cryptus* (Rogers 2001), is morphologically indistinguishable from the vernal pool tadpole shrimp, and hence the confusion. Rogers (2001) quantitatively established the vernal pool tadpole shrimp as endemic to the Central Valley of California.

In 1994, the USFWS reported 14 known occurrences of the vernal pool tadpole shrimp in California, ranging from the Vina Plains in Tehama County, through most of the length of the Sacramento Valley to Sacramento, and west to Solano County at the Jepson Prairie (59 FR 48153). Since then, vernal pool tadpole shrimp have been reported throughout Sacramento, Colusa and Glenn Counties; as well as Central Valley portions of Tehama, Butte, Sutter, Yuba, Placer, Stanislaus, Madera, Merced, Fresno, and Tulare Counties on the east side of the valley (Eriksen and Belk 1999); and Alameda, Solano, Yolo, Colusa and Glenn Counties on the west side (Rogers 2001, USFWS 2007). In Yolo County the vernal pool tadpole shrimp has been reported from vernal pools within or near the southern Yolo Bypass, including the USAF communications facility east of Grasslands Regional Park, along the Sacramento Northern Electric Railroad grade southwest of Saxon, and at the Tule Ranch Unit of the Yolo Basin Wildlife Area (CNDDB 2008).

Habitat occupied by tadpole shrimp tends to exist on level open ground. This geomorphic setting also tends to be the most desirable for agricultural, urban, or industrial development. As a result, the grassland plateaus and floor of the Central Valley have been broadly converted by human use.

Population Trends

An unknown amount of vernal pool habitat has been lost and with it an unknown number of vernal pool tadpole shrimp occurrences. Attempts have been made to calculate lost vernal pool acreages (Holland 1978, 1988, 1998; Bauder and McMillan 1998). Due to current pressures of the increasing human populations in California and Oregon, more vernal pool tadpole shrimp habitat is being encroached on and affected throughout the species' range.

Adequate determination of remaining vernal pool tadpole shrimp occurrences throughout the animal's range, as well as population trends, is difficult. Data supporting the USFWS (1994) 14 known occurrences of the vernal pool tadpole shrimp were collected during a prolonged drought in California. Sugnet and Associates (1993) submitted a study claiming 345 "discrete locations" supporting the vernal pool tadpole shrimp. Because specific localities were not divulged, the data are unverifiable and therefore not scientifically useful in an analysis. Rogers (2001) presents a map and a list of 23 specific localities for the vernal pool tadpole shrimp represented.

The CNDDB vernal pool crustacean records (2005) may prove misleading, due to the inconsistency of the data presented. Some records refer to individual pools, while others refer to pool complexes, and others still refer to groups of complexes. Additionally, the CNDDB is not updated when a particular site or population is extirpated. Because of these issues, it is difficult to determine what actually constitutes a population or occurrence.

In addition, survey maps and records show where vernal pool crustaceans are located but do not emphasize where they are not located. Compounding these difficulties, records are typically a reflection of where surveys have been conducted, rather than a delineation of special-status shrimp distribution. Therefore, it is difficult to establish baseline conditions for this species across the entire species range, as well as within the Plan Area. Where adequate data does not exist, consistent data reporting would help to prevent ambiguous interpretation or mischaracterization of species conservation needs.

Threats to the Species and Other Conservation Issues

The Species Survival Commission of The International Union for Conservation of Nature and Natural Resources (IUCN) lists the vernal pool tadpole shrimp as, EN A2c (IUCN 2000)Endangered, meaning a population reduction of at least 50 percent is estimated, inferred, suspected or observed within the last 10 years, based on a decline in area occupancy, extent of occurrence, or quality of habitat, and the causes may not have ceased, may not be understood, or may not be reversible. As described previously, the greatest threat to vernal pool invertebrates is the elimination, loss, or modification of their habitat by development. Filling of vernal pools or modification of the watershed that supports those pools either eliminates the habitat or disrupts the pool ecosystem so that it is overcome by opportunistic invertebrate species and invasive, opportunistic, and non-native plants (Rogers 1988).

Excessive livestock grazing in vernal pool terrain can be detrimental to vernal pool invertebrate communities. High stocking rates tend to allow a great deal of manure into vernal pools that oxidizes the water, leaving gill-breathing invertebrates without oxygen (Rogers 1998). Conversely, vernal pool grasslands are disturbance systems and need a certain amount of grazing. Vernal pools from which all grazing has been removed may become overgrown with native (i.e., spikerush [*Eleocharis* spp.], coyote thistle, woolly-marbles, etc.) and exotic (i.e., manna grass [*Glyceria declinata*], Italian rye grass, etc.)

plants that generate deep thatch layers on the pool substrate. As this thatch layer decomposes, it also oxidizes the water, which can suffocate gill-breathing invertebrates (Rogers 1998). Both lack of grazing and excessive grazing cause an increase in organic matter in the habitat that eliminates the natural vernal pool invertebrate community and promotes opportunistic and invasive species (Rogers 1998). Therefore, moderate grazing or other disturbance may be a necessary habitat suitability component, and removal of grazing or excessive grazing are threats to the vernal pool tadpole shrimp.

Damage to the watershed that supports vernal pools and vernal pool complexes will affect vernal pool invertebrate communities. Elimination of the watershed will not allow the pools to pond properly and will curtail the movement of nutrients into the pool from overland flow (Rogers 1998). Run-off from paved roads entering the watershed may carry petroleum by-product residue or sediment from vehicles or road maintenance activities. Furthermore, pesticide, herbicide, fertilizer, and sediment run-off from agricultural activities that enter the watershed and are conveyed to occupied habitat may be injurious to vernal pool invertebrates. Finally, ground disturbance from development activities loosens soil that may enter the watershed and be conveyed to vernal pool habitat.

Non-native invasive species are also a threat to vernal pool invertebrate communities. There is concern that bullfrogs (*Rana catesbeiana*) may feed on federally protected vernal pool crustaceans (Balfour and Morey 1999). Manna grass and Italian rye grass are both exotic plants which tend to produce heavy thatch and eventually organic loads upon decomposition, which oxidize the water (Rogers 1998). In addition, people may introduce the non-discriminating predatory mosquitofish (*Gambusia affinis*) into vernal pools to control perceived local mosquito problems.

Habitat fragmentation is a threat to vernal pool invertebrates by preventing waterfowl or shorebirds from feeding at the pools, thereby preventing genetic flow between occupied habitats. Furthermore, small pool complexes surrounded by development may not be buffered against the run-off from developed areas. Additional threats to the vernal pool invertebrate community structure include off-road vehicle use of vernal pool habitat for recreational mud-bogging, conversion of vernal pools into deep stock tanks that do not dry during summer, and draining of vernal pools.

Restoration and creation of vernal pool tadpole shrimp habitat have been demonstrated to be feasible (Rogers 1998). However, specific habitat parameters for this vernal pool invertebrate species are still poorly understood. For example, this species appears to require a minimum pool volume and a minimum pool surface area within a given habitat. Because this species has been found in a wide variety of natural and artificial vernal pool habitats, it is likely that it is an opportunist, a common trait among temporary water fauna.

The primary data gap regarding conservation of vernal pool invertebrates is lack of distributional data for the species within and adjacent to the Plan Area. Estimates of vernal pool tadpole shrimp distribution through aerial photographic interpretation have been completed. However, some specific areas will need to be physically verified as to whether they support potential vernal pool tadpole shrimp habitat. Artificial habitats like railroad toe-drains, stock tanks, and roadside scrapes also will need to be verified. Finally, quantitative bioassessment may be necessary to determine the ecological functions and values of selected preserve area vernal pools in order to assess their suitability and value as preservation habitats. Management data gaps include the role of the surrounding uplands in vernal pool habitats and the role, seasonality, and intensity of grazing and other disturbances in vernal pool ecosystems.

Guidelines in selecting vernal pool habitat for conservation of the vernal pool tadpole shrimp and other vernal pool-dependent organisms should consider the following general principals:

- Vernal pools are not independent microcosms. Active movement of organisms occurs between adjacent pools within complexes, between adjacent complexes, and between distant complexes (e.g., Proctor 1964; Eng *et al.* 1990; Amat *et al.* 1991; Rogers 1998, in prep.; Eriksen and Belk 1999; Wissinger *et al.* 1999; Rogers and Fugate 2001).
- Vernal pools are dependent on the surrounding topography (which may be mound-intermound) as a watershed.
- Vernal pools selected for conservation must exhibit the same biological and geomorphological functions as the habitat being compensated for (e.g., pools occurring on Mehrten formations tend to be very shallow and cannot be used to replace deeper pools occurring on other landforms).
- Unimpaired vernal pools exhibiting a diverse invertebrate and botanical community are desirable as compensation for artificial habitat, such as a railroad toe-drain that supports Vernal pool tadpole shrimp but no other vernal pool invertebrates or plants.
- Vernal pool habitat comprises a spectrum of variation, including pools that are shallow, deep, of long ponding duration, of short ponding duration, of varying densities, occurring on various geomorphic surfaces and different soil types, and supporting various invertebrate and plant communities. It is imperative to preserve the greatest range of variation and attributes within vernal pool complexes to reflect the diversity of vernal pool habitats.
- Vernal pools within complexes tend to vary broadly between topography, area, depth, botanical community structure, invertebrate community structure, and vertebrate use. Therefore, restored or constructed vernal pool habitats must reflect the diversity of natural, adjacent, unimpaired reference systems.
- No estimates are currently available regarding the minimum self-sustaining population size, vernal pool size, or habitat complex size for vernal pool tadpole shrimp or other vernal pool organisms. The estimated loss of extant habitat (e.g., Holland 1978, 1988, 1998; Bauder and McMillan 1998) suggests that these species need the maximum amount of available habitat.

Vernal pools are systems that require participation from all aspects of the floristic and faunistic community, including vertebrates. To ensure success, moderate, managed grazing is needed (see discussion above under "Habitat Requirements and Ecology").

A habitat suitability summary and preliminary draft model for the vernal pool tadpole shrimp are provided below. The model predicts there are 1,054 ha (2,604 acres) of suitable habitat for vernal pool tadpole shrimp in Yolo County. The preliminary draft models may be refined during future phases of the NCCP/HCP program to incorporate additional parameters or new data.

Contributors to this species account:

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