9. SAN JOAQUIN VALLEY VERNAL POOL REGION

All three shrimp species occur within the San Joaquin Valley Vernal Pool Region.

9.1. Vernal Pool Habitat

Approximately 225,745 acres of vernal pool grassland existed within, or immediately adjacent to, this region when the Recovery Plan was published in 2005 (see **Figure 9.1**, **Figure 9.2**, **Table 9.1**; Witham et al. 2013). Approximately 212,860 acres remained as of 2012, with 14,911 acres (6.6% of 2005 total) lost between 2005 and 2012 (Witham et al. 2014). However, 2,025 additional acres were identified that were either not present or not visible on the 2005 aerial imagery. Of the habitat lost, 180 acres (1.2%) were to urbanization and 14,731 acres (98.8%) were to agricultural conversion (56.6% to bare plowed agricultural land, 36.3% to alfalfa or irrigated pasture, 5.8% to orchards, and 0.1% to agricultural residences) (Witham et al. 2014).

By 2018, approximately 206,960 acres of vernal pool grassland remained, with a total of 20,914 acres (9.3% of 2005 total) lost between 2005 and 2018 (see **Table 9.1**; Witham 2021). However, 103 acres were identified that were either not present or not visible on the 2005 or 2012 aerial imagery. Of the habitat lost since 2005, 561 acres (2.7%) were to urbanization and 20,319 acres (97.2%) were to agricultural conversions (45.4% to orchards, 28.6% to alfalfa or irrigated pasture, 17.4% to bare plowed agricultural land, and 5.7% to other agricultural uses) (see **Table 9.2**; Witham 2021). Note that many patches of vernal pool grassland that had been converted to bare plowed land in 2012 had been fully converted to agricultural use, mainly orchards, by 2018. There were also conversions of 34 acres of vernal pool grasslands to managed wetlands with hydrology that no longer supported vernal pool species.

This vernal pool region had the greatest amount of extant vernal pool habitat in 2005 of all the vernal pool regions, and this is still true today (Witham 2021). This region also exhibited the second highest amount of vernal pool losses in the Central Valley, after the Southern Sierra Foothills Vernal Pool Region, although proportional to total habitat there were three other regions with a greater percentage of losses (Witham 2021). The vast majority of vernal pool losses within this region have been to agricultural conversions (97.2%), which is unsurprising given that the region is composed primarily of agricultural lands and very few cities or towns. Many of these losses are likely due to land conversions to orchards or other agricultural uses that should be regulated by the Clean Water Act but that are proceeding illegally without the necessary 404 permit from the Corps (Witham et al. 2014; Witham 2021). This region also had the third highest amount vernal pool losses to urbanization, but due to the large amount of habitat in the region this only represented 0.2% of all losses.

As of 2018, roughly 125,561 acres of vernal pool grassland was estimated to be protected in this region, or immediately adjacent to it (see **Figure 9.3**, **Figure 9.4**, **Table 9.1**; Witham 2021; Vollmar et al. 2017). This represents 61% of the currently remaining vernal pool grassland in the region and 56% of the vernal pool grassland that existed in 2005, the Recovery Plan's baseline. This vernal pool region has the greatest amount and largest percentage of protected vernal pool habitat of all regions in the Central Valley, mainly due to the Service's large National Wildlife Refuges which protect nearly all of the remaining vernal pool habitat in western Merced County (Witham 2021).

9.2. Species Occurrences

9.2.1. Vernal Pool Fairy Shrimp

There are 42 occurrence records of the vernal pool fairy shrimp documented within, or immediately adjacent to, the San Joaquin Valley Vernal Pool Region in the Diversity Database (see **Figure 9.5**, **Figure 9.6**; Diversity Database 2022). Approximately half of these occurrences are listed as on land owned by a government agency or land management organization, and half are listed as on private land not owned by a land management organization (Diversity Database 2022). All 42 occurrences are presumed extant by the Diversity Database; 32 occur within extant vernal pool grassland based on Witham's (2021) mapping efforts, 1 occurs within extirpated vernal pool grassland, and 9 are outside of mapped vernal pool grassland.

The protected areas contain, at least partially, 20 of the 42 Diversity Database records (48%) for the vernal pool fairy shrimp in this region. However, this does not mean that 48% of all occurrences of the vernal pool fairy shrimp in this region have been protected, as the Diversity Database is not an appropriate source for determining all known occurrences (individual Diversity Database records are not necessarily equivalent to occurrences, and some known occurrences may not be documented in the Diversity Database). Only 7 of the 42 Diversity Database polygons (17%) are entirely within the protected areas; the difference between the number of records partially and entirely within the mapped protected areas is likely a reflection of the irregular size and shape of polygons in the Diversity Database, as well as slight discrepancies in the overlap between the two databases.

9.2.2. Vernal Pool Tadpole Shrimp

There are 30 occurrence records of the vernal pool tadpole shrimp documented within, or immediately adjacent to, the San Joaquin Valley Vernal Pool Region in the Diversity Database (see **Figure 9.7**, **Figure 9.8**; Diversity Database 2022). Approximately half of these occurrences are listed as on land owned by a government agency or land management organization, and half are listed as on private land not owned by a land management organization (Diversity Database 2022). All 30 occurrences are presumed extant by the Diversity Database; 28 occur within extant vernal pool grassland based on Witham's (2021) mapping efforts, 1 occurs within extirpated vernal pool grassland, and 1 is outside of mapped vernal pool grassland.

The protected areas contain 20 of the 30 Diversity Database records (67%) for the vernal pool tadpole shrimp in this region. Some of these occurrences were categorized as only partially protected, but visual inspection shows that this was entirely due to slight discrepancies in the overlap between the two databases.

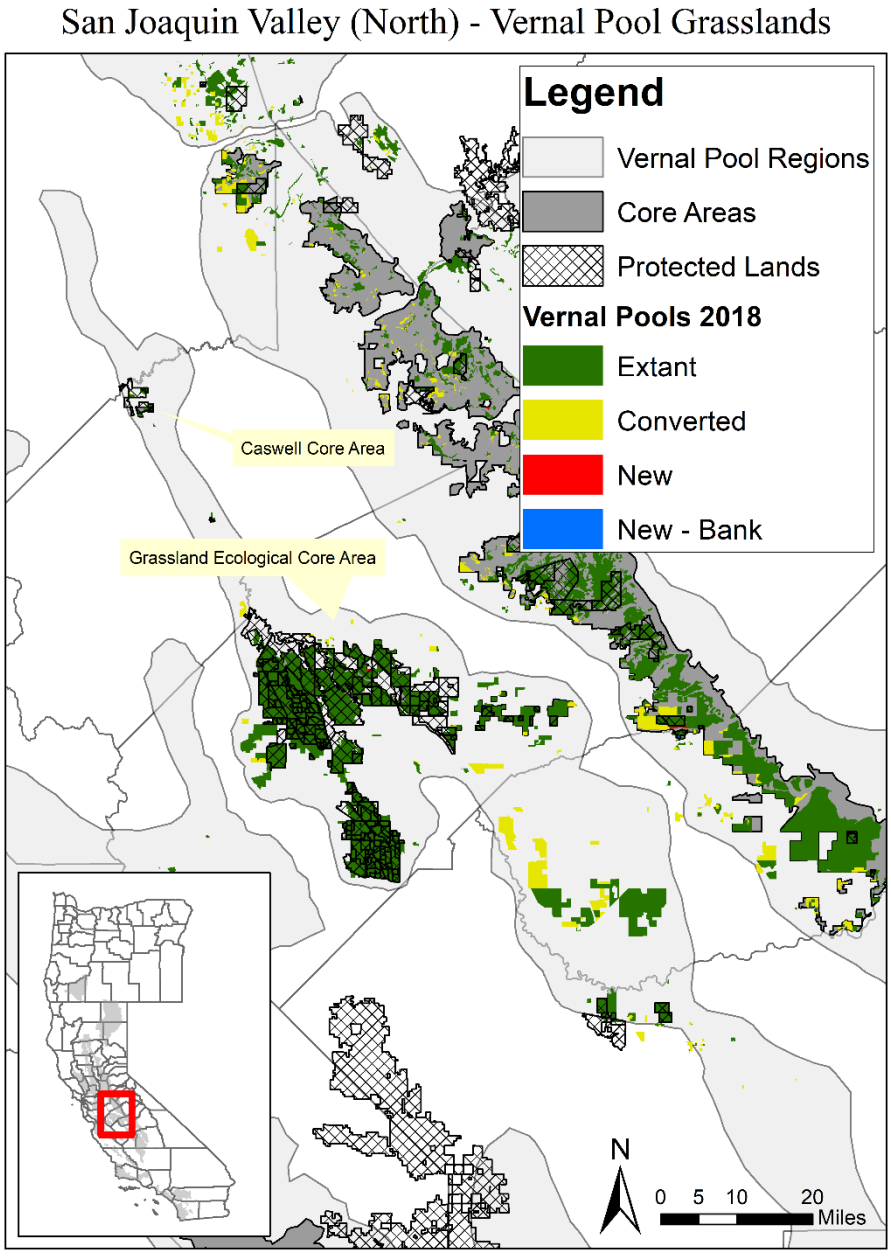

Figure 9.1. Map of vernal pool habitat within the northern San Joaquin Valley Vernal Pool Region mapped by Witham (2021) created using aerial imagery from 2018 compared to 2005 and 2012. "New" vernal pool habitat refers to areas not seen in the 2005 or 2012 aerial imagery (either missed or restored). "New - bank" refers to newly created vernal pool habitat on mitigation lands. Converted habitat refers to vernal pool habitat that was seen in 2005 or 2012 aerial imagery and by 2018 was converted to other land uses. Modified habitat as described by Witham (2021) was altered but still provides suitable vernal pool habitat (e.g., mitigation banks, lands managed for waterfowl), and so is mapped as extant. Zoom in for finer resolution.

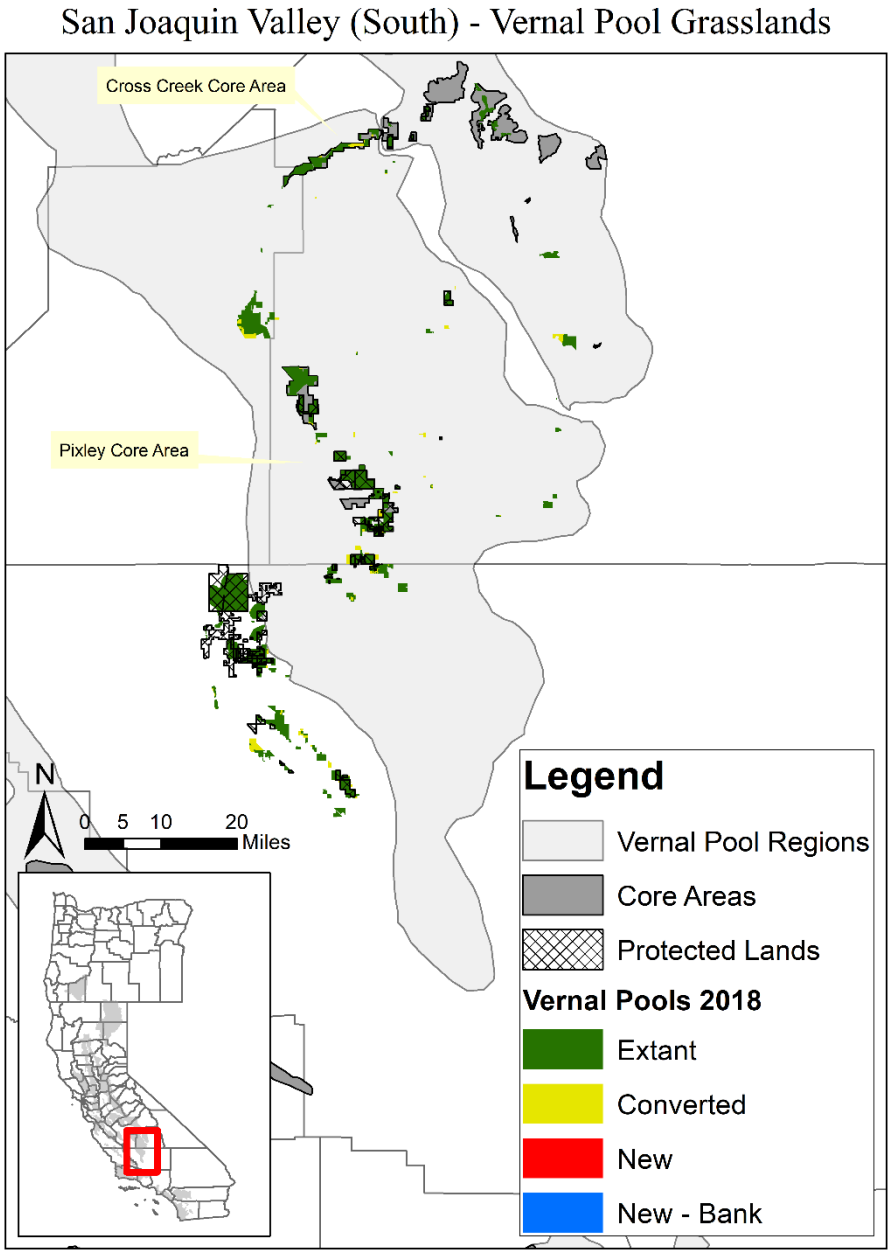

Figure 9.2. Map of vernal pool habitat within the southern San Joaquin Valley Vernal Pool Region mapped by Witham (2021) created using aerial imagery from 2018 compared to 2005 and 2012. "New" vernal pool habitat refers to areas not seen in the 2005 or 2012 aerial imagery (either missed or restored). "New - bank" refers to newly created vernal pool habitat on mitigation lands. Converted habitat refers to vernal pool habitat that was seen in 2005 or 2012 aerial imagery and by 2018 was converted to other land uses. Modified habitat as described by Witham (2021) was altered but still provides suitable vernal pool habitat (e.g., mitigation banks, lands managed for waterfowl), and so is mapped as extant. Zoom in for finer resolution.

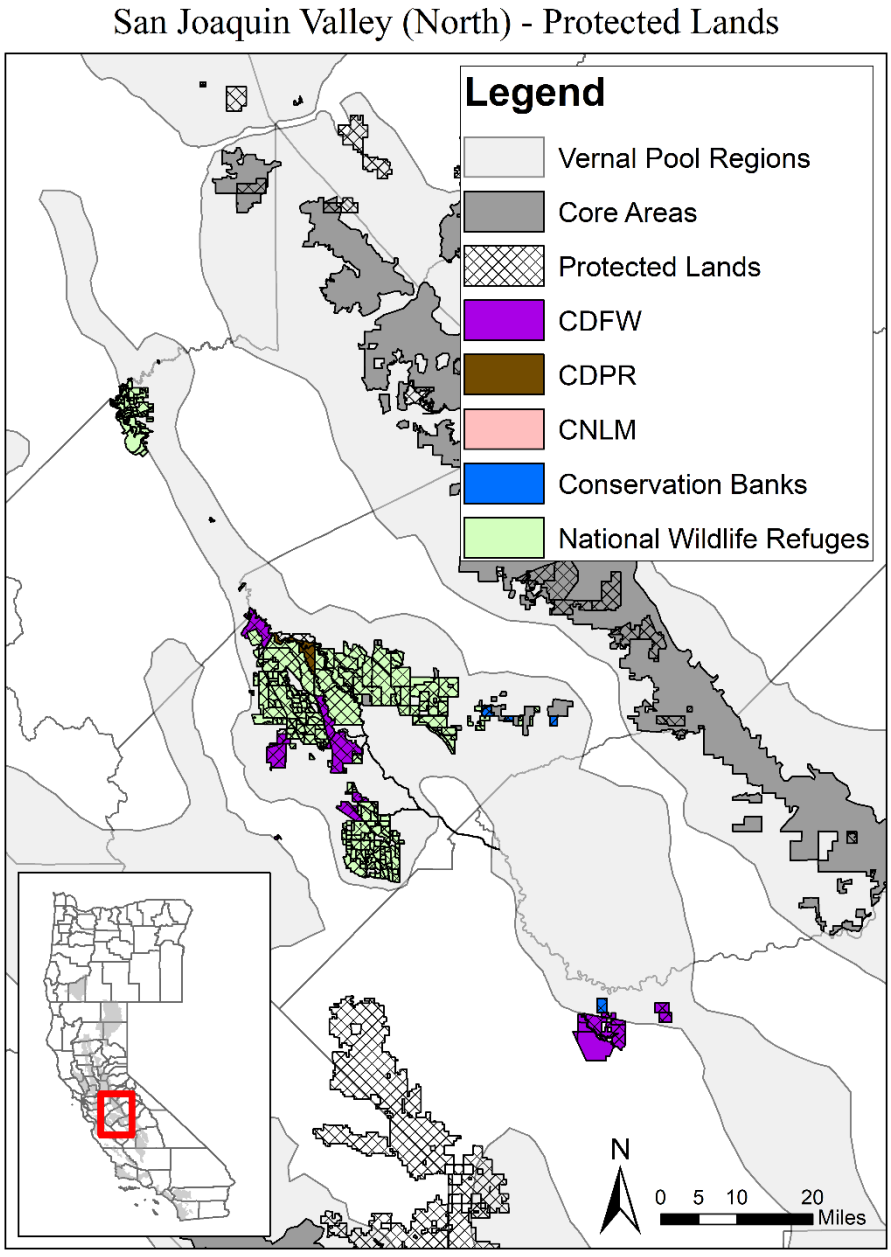

Figure 9.3. Map of protected areas that contain vernal pool grassland habitat and/or the three shrimp species within the northern San Joaquin Valley Vernal Pool Region**.** Protected lands are based on Vollmar et al. (2017) and include various preserves. Zoom in for finer resolution. CDFW = California Department of Fish and Wildlife, CDPR = California Department of Parks and Recreation, CNLM = Center for Natural Lands Management.

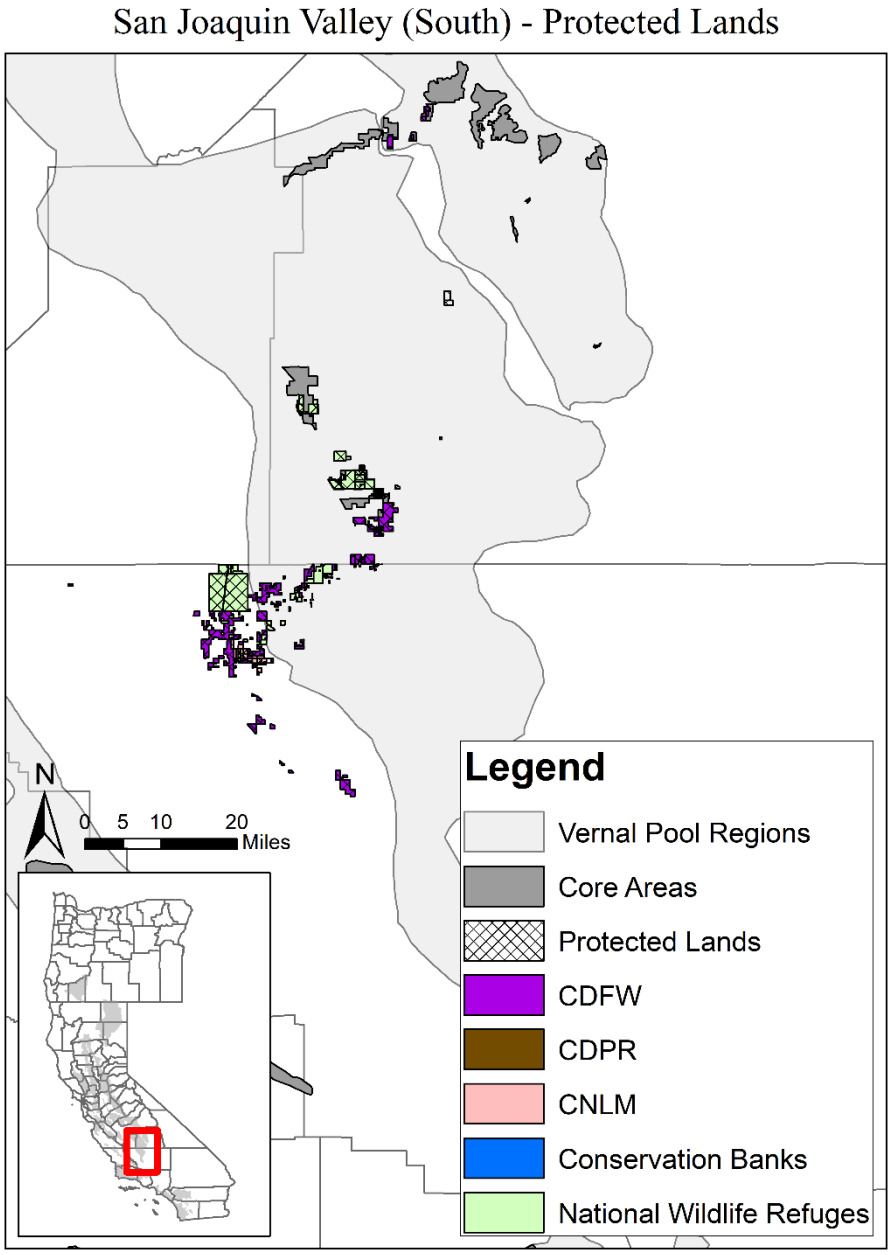

Figure 9.4. Map of protected areas that contain vernal pool grassland habitat and/or the three shrimp species within the southern San Joaquin Valley Vernal Pool Region**.** Protected lands are based on Vollmar et al. (2017) and include various preserves. Zoom in for finer resolution. CDFW = California Department of Fish and Wildlife, CDPR = California Department of Parks and Recreation, CNLM = Center for Natural Lands Management.

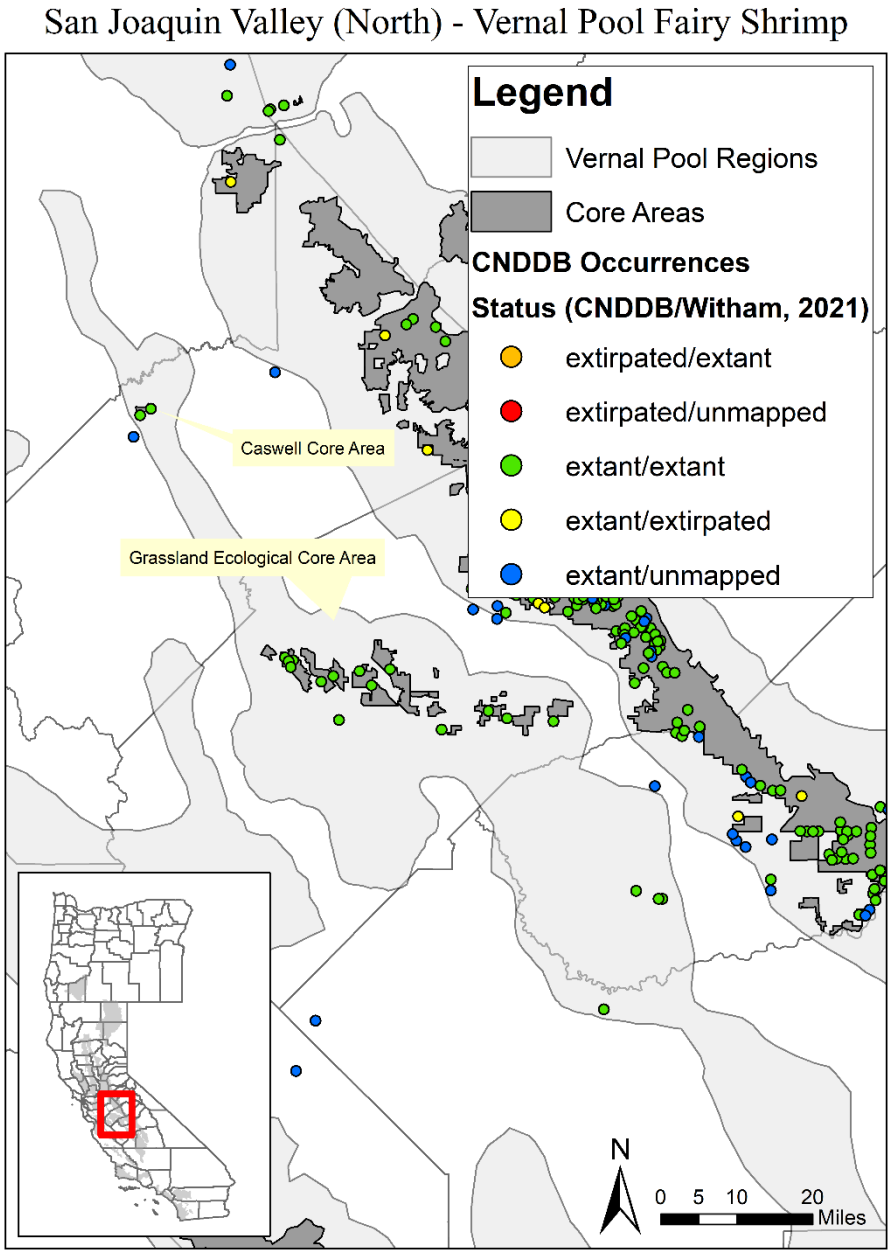

Figure 9.5. Map of known occurrences of vernal pool fairy shrimp recorded in the Diversity Database (2022) in the northern San Joaquin Valley Vernal Pool Region. Points may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both Diversity Database occurrence records and Witham's (2021) map of vernal pool habitat.

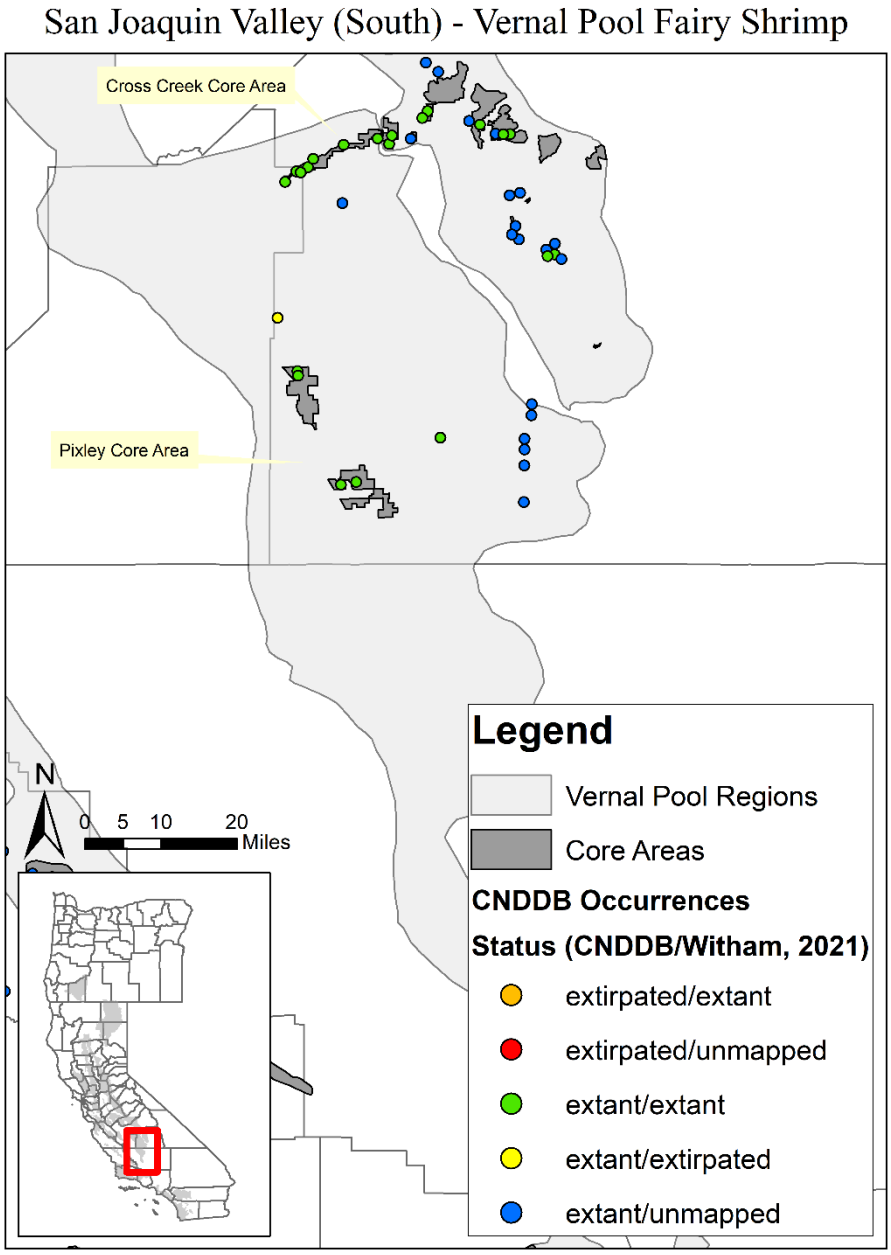

Figure 9.6. Map of known occurrences of vernal pool fairy shrimp recorded in the Diversity Database (2022) in the southern San Joaquin Valley Vernal Pool Region. Points may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both Diversity Database occurrence records and Witham's (2021) map of vernal pool habitat.

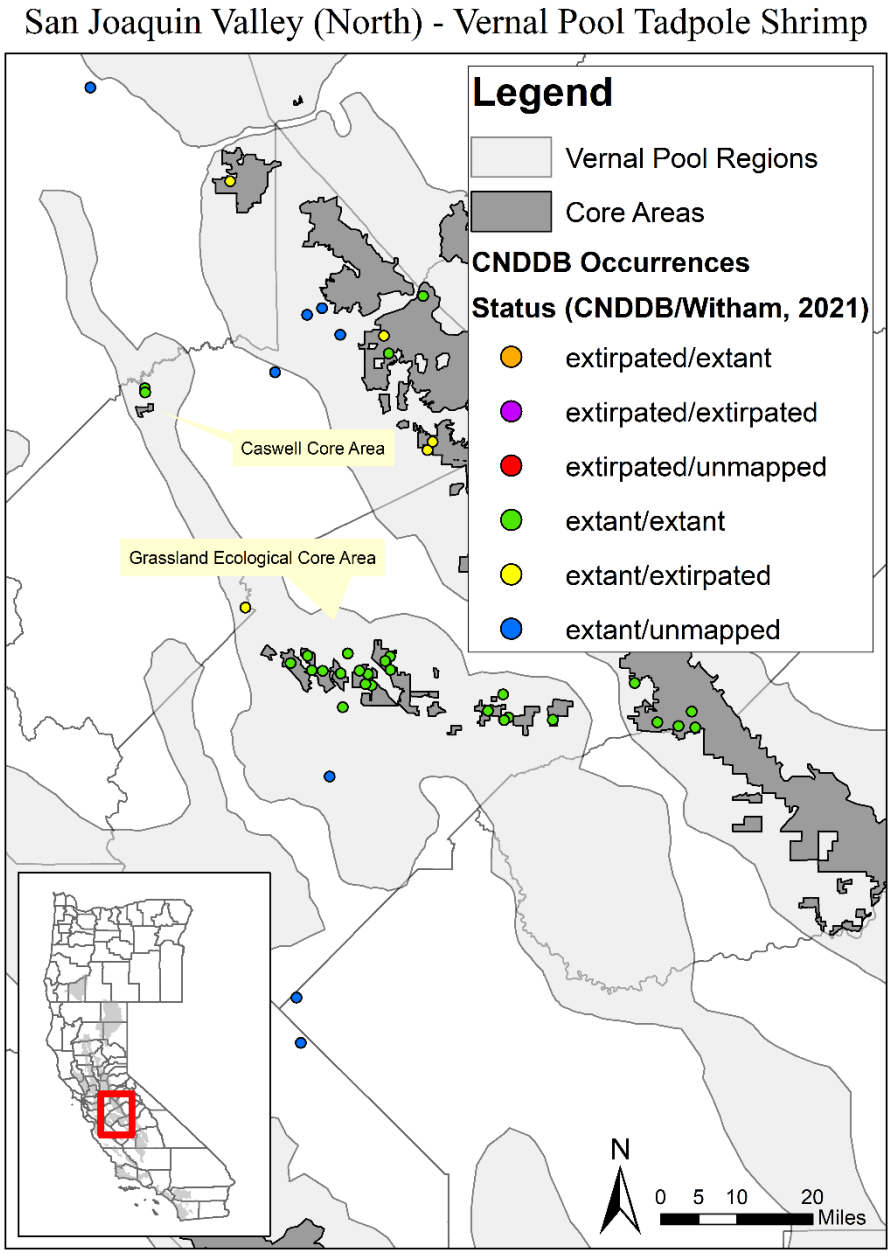

Figure 9.7. Map of known occurrences of vernal pool tadpole shrimp recorded in the Diversity Database (2022) in the northern San Joaquin Valley Vernal Pool Region. Points may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both Diversity Database occurrence records and Witham's (2021) map of vernal pool habitat. The two core areas in the northern portion of the region are displayed, though not all core areas are designated for the vernal pool tadpole shrimp.

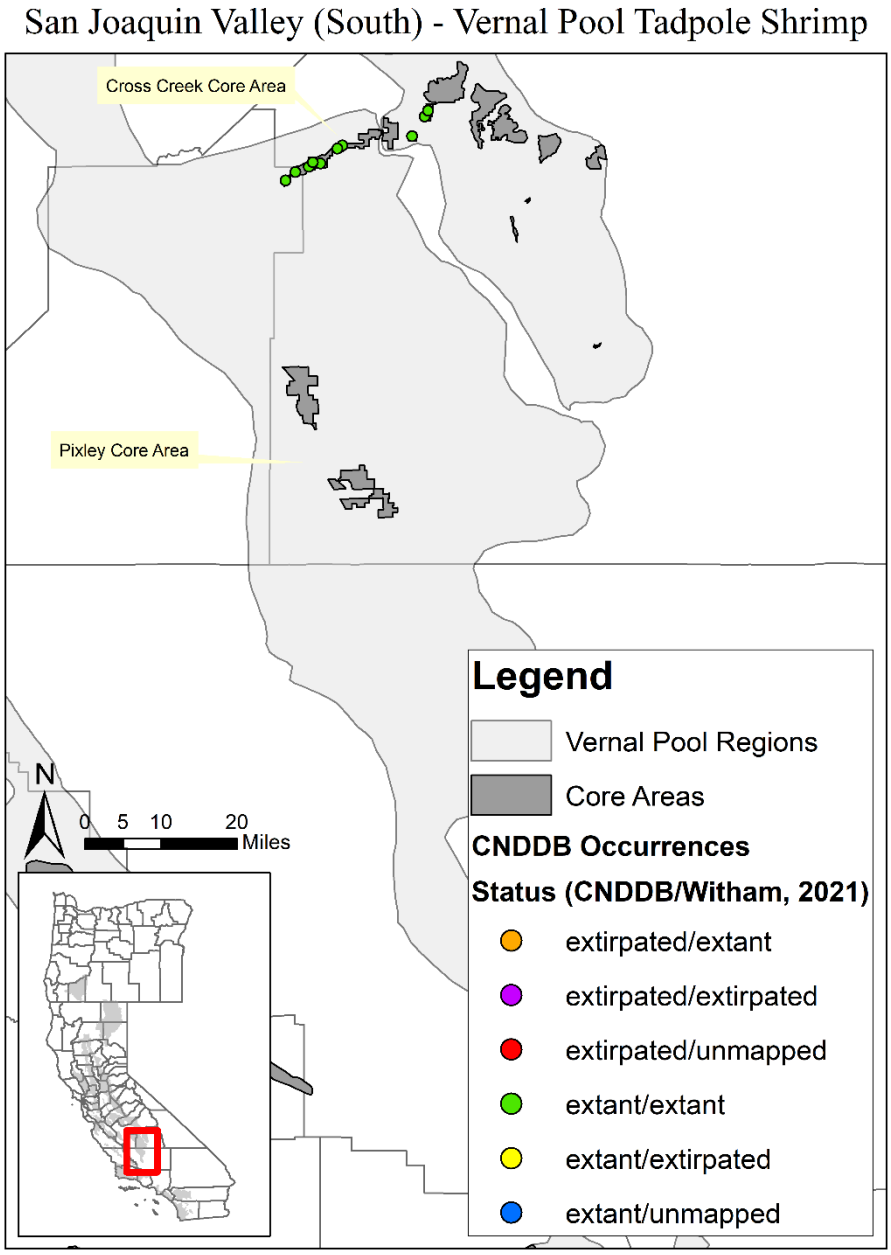

Figure 9.8. Map of known occurrences of vernal pool tadpole shrimp recorded in the Diversity Database (2022) in the southern San Joaquin Valley Vernal Pool Region. Points may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both Diversity Database occurrence records and Witham's (2021) map of vernal pool habitat. The two core areas in the southern portion of the region are displayed, though not all core areas are designated for the vernal pool tadpole shrimp.

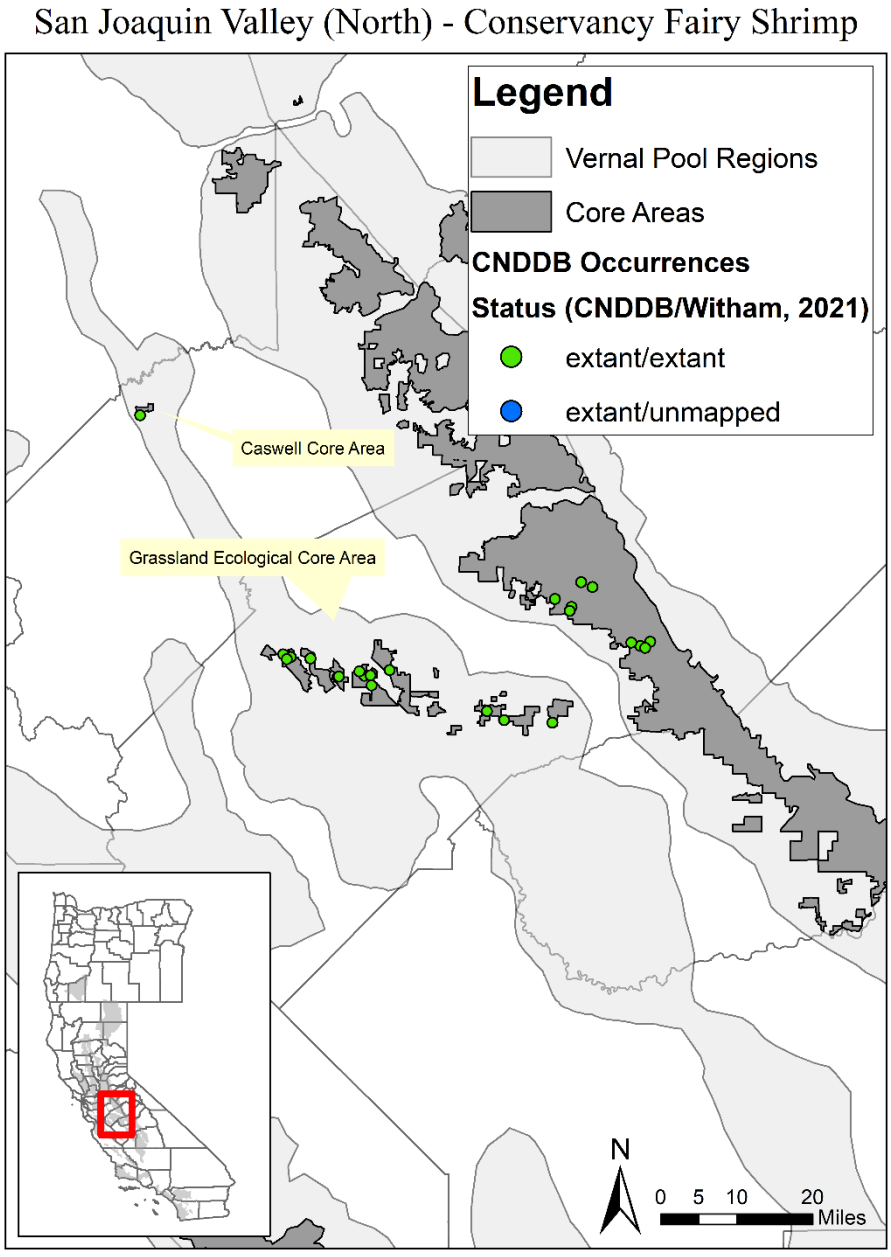

Figure 9.9. Map of known occurrences of Conservancy fairy shrimp recorded in the Diversity Database (2022) in the northern San Joaquin Valley Vernal Pool Region. Points may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both Diversity Database occurrence records and Witham's (2021) map of vernal pool habitat.

Table 9.1. Acreage of vernal pool habitat and habitat converted within the San Joaquin Valley Vernal Pool Region mapped by Witham (2021). All habitat labeled as not converted, altered, or new was considered extant. Protected acreage is based on Vollmar et al. (2017).

Core Area	2005 Acres	2018 Acres Total	2018 Acres Extant (% of Total)	2018 Acres Converted – Agriculture (% of Total)	2018 Acres Converted – Urban Development (% of Total)	2018 Acres Protected (% of Total)
Caswell	395.3	395.3	395.3 (100.0%)	0.0 (0.0%)	0.0 (0.0%)	311.1 (78.7%)
Cross Creek	3,799.5	3,799.5	3,392.8 (89.3%)	406.7 (10.7%)	0.0 (0.0%)	0.0 (0.0%)
Grassland Ecological Area	30,830.3	30,855.9	30,525.0 (98.9%)	330.9 (1.1%)	0.0 (0.0%)	23,221.0 (75.3%)
Pixley	10,745.3	10,745.3	10,475.8 (97.5%)	269.5 (2.5%)	0.0 (0.0%)	5,173.2 (48.1%)
San Joaquin Valley Vernal Pool Region Total	**225,745.4**	**227,873.4**	**206,959.6 (90.8%)**	**20,318.8 (8.9%)**	**560.9 (0.2%)**	**125,561.1 (55.1%)**

Table 9.2. Acreage of vernal pool habitat losses within the San Joaquin Valley Vernal Pool Region between 2005 and 2018 mapped by Witham (2021), broken down by what the land use was converted to. All categories besides urban development and managed wetlands are considered agricultural conversions.

Core Area	Urban, Commercial, & Industrial	Orchards, Vineyards, Eucalyptus	Alfalfa and Irrigated Pasture	Bare Plowed Agricultural Lands	Other Ag (Rice, Row Crops, Dairy, Nurseries)	Agricultural Residential	Managed Wetlands	Total Losses	% Losses Urban Development	% Losses Agricultural Conversions
Caswell	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N/A	N/A
Cross Creek	0.0	39.4	126.5	5.8	235.0	0.0	0.0	406.7	0.0%	100%
Grassland Ecological Area	0.0	0.0	175.8	155.1	0.0	0.0	0.0	330.9	0.0%	100%
Pixley	0.0	4.0	0.0	195.4	70.1	0.0	0.0	269.5	0.0%	100%
San Joaquin Valley Vernal Pool Region Total	**560.9**	**9,486.8**	**5,979.3**	**3,641.2**	**1,013.5**	**198.0**	**34.0**	**20,913.8**	**2.7%**	**97.2%**

9.2.3. Conservancy Fairy Shrimp

There are 14 occurrence records of the Conservancy fairy shrimp documented within the San Joaquin Valley Vernal Pool Region in the Diversity Database, all in the northern half of the region (see **Figure 9.9**; Diversity Database 2022). These occurrences include the Mapes Ranch, Highway 165/Grasslands Ecological Area, and Sandy Mush Road populations. There are 11 occurrences on federal or state land and 3 on conservation banks (Diversity Database 2022). All 14 occurrences are presumed extant by the Diversity Database and are within extant vernal pool habitat based on Witham's (2021) mapping efforts.

The protected areas contain all 14 Diversity Database records (100%) for the Conservancy fairy shrimp in this region: 10 in the San Luis National Wildlife Refuge Complex, 1 in the Great Valley Grasslands State Park, and 3 in conservations banks.

9.3. Federal Lands

9.3.1. National Wildlife Refuges

Within the San Joaquin Valley Vernal Pool Region, all three shrimp species are known to occur within all four refuge units of the San Luis National Wildlife Refuge Complex (Grasslands Wildlife Management Area, Merced National Wildlife Refuge, San Luis National Wildlife Refuge, and San Joaquin River National Wildlife Refuge). A Comprehensive Conservation Plan was prepared for the San Joaquin River National Wildlife Refuge in 2006 (Service 2006) and the rest of the San Luis Complex in 2015 (Service 2015). The vernal pool fairy shrimp is also known to occur within the Pixley National Wildlife Refuge of the Kern National Wildlife Refuge Complex. The other two units of the Kern National Wildlife Refuge Complex, Kern National Wildlife Refuge and Tulare Basin Wildlife Management Area, do have vernal pool habitat but do not have known occurrences of the vernal pool fairy shrimp. A Comprehensive Conservation Plan was prepared for the Kern and Pixley National Wildlife Refuges in 2005 (Service 2005b), and a stepped down Natural Resource Management Plan was prepared for the Kern National Wildlife Refuge Complex in 2021 (Service 2021a).

The San Joaquin River National Wildlife Refuge consists of 12,887 acres located in northern Stanislaus County (Service 2006b). The Refuge was established in 1987 with the primary goal of protecting and managing wintering habitat for Aleutian Canada geese (*Branta canadensis leucopareia*); since then, the Refuge's focus has expanded to include other threatened and endangered species, including the vernal pool fairy shrimp. The Refuge has mapped 372 acres of native grassland; only 4 acres of features characterized as vernal pools are mapped, but seasonal and semi-permanent wetlands are also mapped throughout, some of which may provide suitable habitat for the vernal pool fairy shrimp (Service 2006b). These areas generally correspond to the 826 acres of extant vernal pool habitat mapped by Witham (2021) (the large difference in acreage may be due to differences in the method of calculation). Approximately 43 acres of vernal pool habitat that was present on the Refuge in 2005 was lost between 2012 and 2018 (Witham 2021). Management objectives on the Refuge include protecting populations of the three shrimp species by mapping vernal pools, avoiding earthmoving or alteration of topography to vernal pools and associated uplands, and using appropriate grazing regimes (Service 2006b).

The vernal pool fairy shrimp was observed on Mapes Ranch within the San Joaquin River National Wildlife Refuge in 1991 and 1998, and *Branchinecta* cysts were identified in the soil in 2011; the species was also observed in other locations on the Refuge in 1998 (Diversity Database 2022). During more recent annual surveys of vernal pools on the San Luis National Wildlife Refuge Complex, the San Joaquin River National Wildlife Refuge was only surveyed in 2017, and the survey occurred too late in the season to detect the vernal pool fairy shrimp (Service 2018b). The vernal pool tadpole shrimp was observed in the northeastern corner of the Refuge south of Beckwith Road in 1998 and 2000 (Diversity Database 2022) and most recently in 2018 (Service 2018b). The Conservancy fairy shrimp was observed on Mapes Ranch within the Refuge in 1991 in two vernal pools (Diversity Database 2022). The Service is not aware of any surveys of this occurrence since 1991; the San Joaquin River National Wildlife Refuge was surveyed in 2017, but not the portion of the Refuge with the Conservancy fairy shrimp (Service 2018b). Mapping of the vernal pools on the Refuge for all three shrimp species has been consistently identified as a priority in recent years, but has not yet occurred (Service 2018b; F. Takahashi, Service, *in litt*. 2021). Based on the information available to the Service at the time, the previous 5-year review for the Conservancy fairy shrimp (Service 2012b) stated that the Mapes Ranch occurrence was still privately owned and that the hydrology on the site may have been altered, possibly extirpating the Conservancy fairy shrimp. However, this portion of Mapes Ranch did have a Refuge conservation easement placed on it in 2010, so the property should be being managed according to the Refuge's Comprehensive Conservation Plan (Service 2006). Surveys of Mapes Ranch are needed to determine if the Conservancy fairy shrimp remains extant.

The other three units of the San Luis National Wildlife Refuge Complex are located in Merced County within the largest continuous block of freshwater wetlands remaining in California (Service 2015). The Merced National Wildlife Refuge is 10,262 acres, the San Luis National Wildlife Refuge is 26,878 acres, and the Grasslands Wildlife Management Area consists of 75,225 acres of conservation easements on private land. The vast majority of these areas are extant potential vernal pool grasslands and they comprise approximately half of all extant vernal pool grasslands mapped in the San Joaquin Valley Vernal Pool Region (Witham 2021). However, some of these areas are currently managed for waterfowl with hydrology that does not support vernal pool species. As of 2015, the Service has identified 389 vernal pools on parts of the San Luis and Merced Refuges (Service 2015), and more vernal pools have been mapped in more recent surveys as well (Service 2019; Service 2020d; Service 2021b). The largest concentrations of vernal pools are found on the Kesterson and West Bear Creek units of the San Luis Refuge and the Snobird and Arena Plains units of the Merced Refuge (**Figure 9.10**). Vernal pools have also been identified on easement lands within the Grasslands Wildlife Management Area, but they have not been comprehensively mapped (Service 2015).

The vernal pool fairy shrimp was identified in several locations throughout the Refuge Complex in 1993 and 1994, with five additional Diversity Database occurrences recorded since 2008 (Diversity Database 2022). The vernal pool tadpole shrimp was identified in several locations throughout the Refuge Complex in 1993, 1994, and 2000, with four additional Diversity Database occurrences recorded in 2015 (Diversity Database 2022). The vernal pool fairy shrimp and vernal pool tadpole shrimp have been consistently documented during recent annual surveys between 2018 and 2021, with occurrences on the Merced Refuge's Arena Plains and Snobird subunits and San Luis Refuge's Kesterson, West Bear Creek, and East Bear Creek subunits

(Service 2018b; Service 2019; Service 2020d; Service 2021b). The Conservancy fairy shrimp has been identified on the Merced Refuge's Arena Plains and Snobird units and the San Luis Refuge's Kesterson and East Bear Creek units. On the Arena Plains unit, there is one Diversity Database occurrence that was observed in 1994 and 2015 (Diversity Database 2022); however, the species was not observed during surveys in 2018, 2019, and 2020 (Service 2018b; Service 2019; Service 2020d). On the Snobird unit, there are three Diversity Database occurrences that were observed in 2015, and the species was observed during surveys in 2019, 2020, and 2021 (Service 2019; Service 2020d; Service 2021b; Diversity Database 2022). On the Kesterson unit, one occurrence was recorded in 1994, and this occurrence plus two more were observed in 2016 (Diversity Database 2022); however, the species was not observed during surveys in 2018, 2019, and 2020 (Service 2018b; Service 2019; Service 2020d). On the East Bear Creek unit, there are two Diversity Database occurrences: one on the west side near the San Joaquin River recorded in 1994 and one on the east side near the Snobird unit in 2015 (Diversity Database 2022). The Conservancy fairy shrimp was not identified on the east side of the unit when surveyed in 2019, but it was observed in two pools on the west side of the unit when surveyed in 2020 (Service 2019; Service 2020d).

The Kern National Wildlife Refuge Complex is made up of three units with the primary purpose of protecting and managing wetland habitat for migratory birds (**Figure 9.4**). Pixley National Wildlife Refuge consists of approximately 6,939 acres located in southwestern Tulare County, Kern National Wildlife Refuge consists of 11,249 acres located in northern Kern County, and Tulare Basin Wildlife Management Area consists of 4,439 acres located in northern Kern County. Witham (2021) mapped almost the entirety of Pixley and Kern as vernal pool grassland habitat based on aerial imagery, but vernal pools have only been documented on four subunits within Pixley and two subunits within Kern (Service 2021a). Currently, the ecological health of the vernal pools on these two refuges is not well understood due to the lack of biological surveys or inventories (Service 2021a). A small amount of vernal pool grassland occurs within the Tulare Basin Wildlife Management Area as well (Witham 2021), but this area is either not known to contain vernal pools or hasn't been surveyed. The vernal pool fairy shrimp was first identified in 1988 at two locations on the Pixley Refuge (Diversity Database 2022). The species was most recently identified by refuge staff in 2022 in five of six pools sampled on the Pixley Refuge (K. Jimenez, Service, *in litt*. 2023). No occurrences have been recorded on the Kern Refuge or Tulare Basin Wildlife Management Area (Diversity Database 2022). However, during the 2022 surveys, one vernal pool on Kern had both versatile fairy shrimp (*Branchinecta lindahli*) and individuals which were not identified conclusively but may have been vernal pool fairy shrimp or versatile fairy shrimp (Jimenez, *in litt*. 2023).

Figure 1-5. Units of the Grasslands WMA

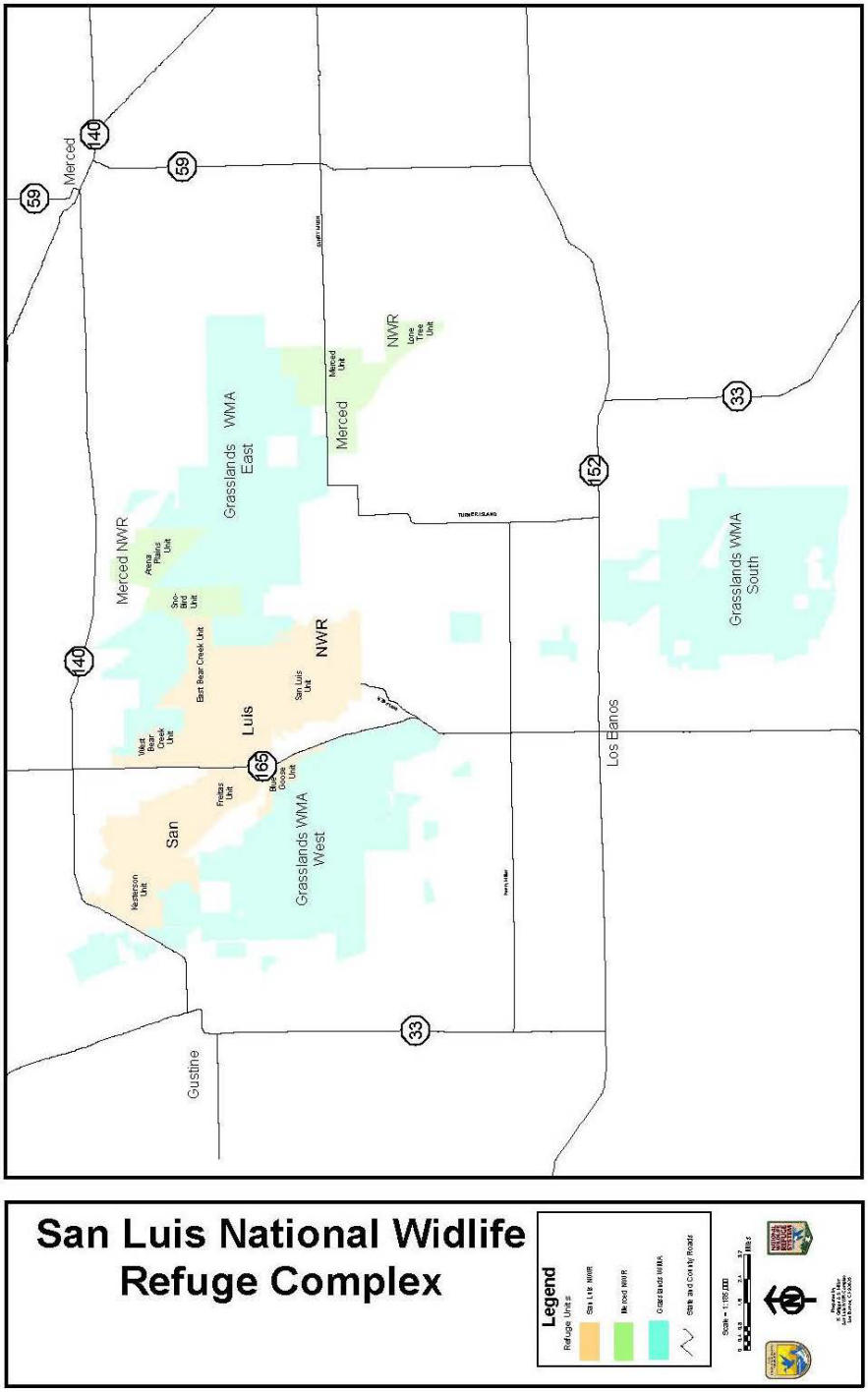

Figure 9.10. Map of the units within the Merced National Wildlife Refuge, San Luis National Wildlife Refuge, and Grasslands Wildlife Management Area. Taken from Figure 1-5 of the 2015 draft Comprehensive Conservation Plan for these refuge lands (Service 2015).

9.3.2. Military Lands

There are no military lands with known occurrences of the three shrimp species in the San Joaquin Valley Vernal Pool Region.

9.3.3. Bureau of Land Management

There are no Bureau of Land Management lands with known occurrences of the three shrimp species in the San Joaquin Valley Vernal Pool Region.

9.3.4. Other Federal Lands

There are no other federal lands with known occurrences of the three shrimp species in the San Joaquin Valley Vernal Pool Region.

9.4. Conservation Banks

There are four conservation or mitigation banks within the San Joaquin Valley Vernal Pool Region that provide credits for preserved vernal pools that support the vernal pool fairy shrimp: Alkali Sink, Deadman Creek, Dutchman Creek, and Vieira-Sandy Mush Road (see **Figure 9.3**; RIBITS 2021). These banks protect a total of 2,494 acres of land, including 114.316 acres of preserved vernal pools for the vernal pool fairy shrimp (Table 6). The four banks have sold a total of 56.741 acres of preservation credits (50%) for the vernal pool fairy shrimp (RIBITS 2021). Alkali Sink Conservation Bank is sold out of credits for the vernal pool fairy shrimp, though this bank only had 0.4 acres of vernal pool preservation credits. This region has much less land protected within conservation banks than other regions in the Central Valley, particularly considering that this region has the largest amount of vernal pool grassland of any vernal pool region. However, this region does have the greatest amount and largest percentage of protected vernal pool habitat of all regions in the Central Valley, indicating that conservation banking has contributed less to the overall protection of vernal pool habitat in this region than it has in most other regions.

There are three conservation or mitigation banks within the San Joaquin Valley Vernal Pool Region that provide credits for preserved vernal pools that support the vernal pool tadpole shrimp: Deadman Creek, Dutchman Creek, and Vieira-Sandy Mush Road (see **Figure 9.3**; RIBITS 2021). These banks protect a total of 1,548 acres of land, including 113.916 acres of preserved vernal pools for the vernal pool tadpole shrimp (Table 6). Many of these preserved pools also provide habitat for the vernal pool fairy shrimp. The three banks have sold a total of 56.341 acres of preservation credits (50%) for the vernal pool tadpole shrimp (RIBITS 2021).

There are three conservation banks within the San Joaquin Valley Vernal Pool Region that are known to support the Conservancy fairy shrimp: Deadman Creek, Dutchman Creek, and Vieira-Sandy Mush Road (see **Figure 9.3**; Diversity Database 2022). However, only the Dutchman Creek Conservation Bank provides credits for preserved vernal pools that support the Conservancy fairy shrimp (RIBITIS 2021). Dutchman Creek specifically provides preservation credits for 8.32 acres of vernal pools that provide habitat for the Conservancy fairy shrimp, 5.85 acres (70%) of which have been sold. On Deadman Creek, the Conservancy fairy shrimp was first observed in 2008 and has been consistently observed during regular monitoring, most

recently in 2019 (Diversity Database 2022). On Dutchman Creek, the species was observed in 6 of 42 sampled pools in 2008, 6 additional pools in 2010, and most recently in 2016 (Westervelt Ecological Services 2016; Diversity Database 2022). On Vieira-Sandy Mush Road, the species was observed in one pool in 2014 (Diversity Database 2022).

9.5. Habitat Conservation Plans

There are two regional Habitat Conservation Plans (HCPs) and three project-level HCPs within the San Joaquin Valley Vernal Pool Region that include one or more of the three shrimp species as a Covered Species (**Figure 9.11**).

9.5.1. Kern Water Bank HCP

The Kern Water Bank HCP covered the development and operation of the Kern Water Bank Project, which includes the creation of a bank for water conservation as well as the creation of a conservation bank on the property (Kern Water Bank Authority 1997). This HCP was permitted in 1997 and has a 75-year permit term. The permittee is the Kern Water Bank Authority. The HCP includes 164 covered species, covering any species that may have conceivably been present in the area; this is no longer common practice when developing an HCP. All three shrimp species are covered species; however, no vernal pool habitat was present or impacted by the development of the water bank, and the conservation bank does not contain any vernal pool habitat or provide credits for the three shrimp species.

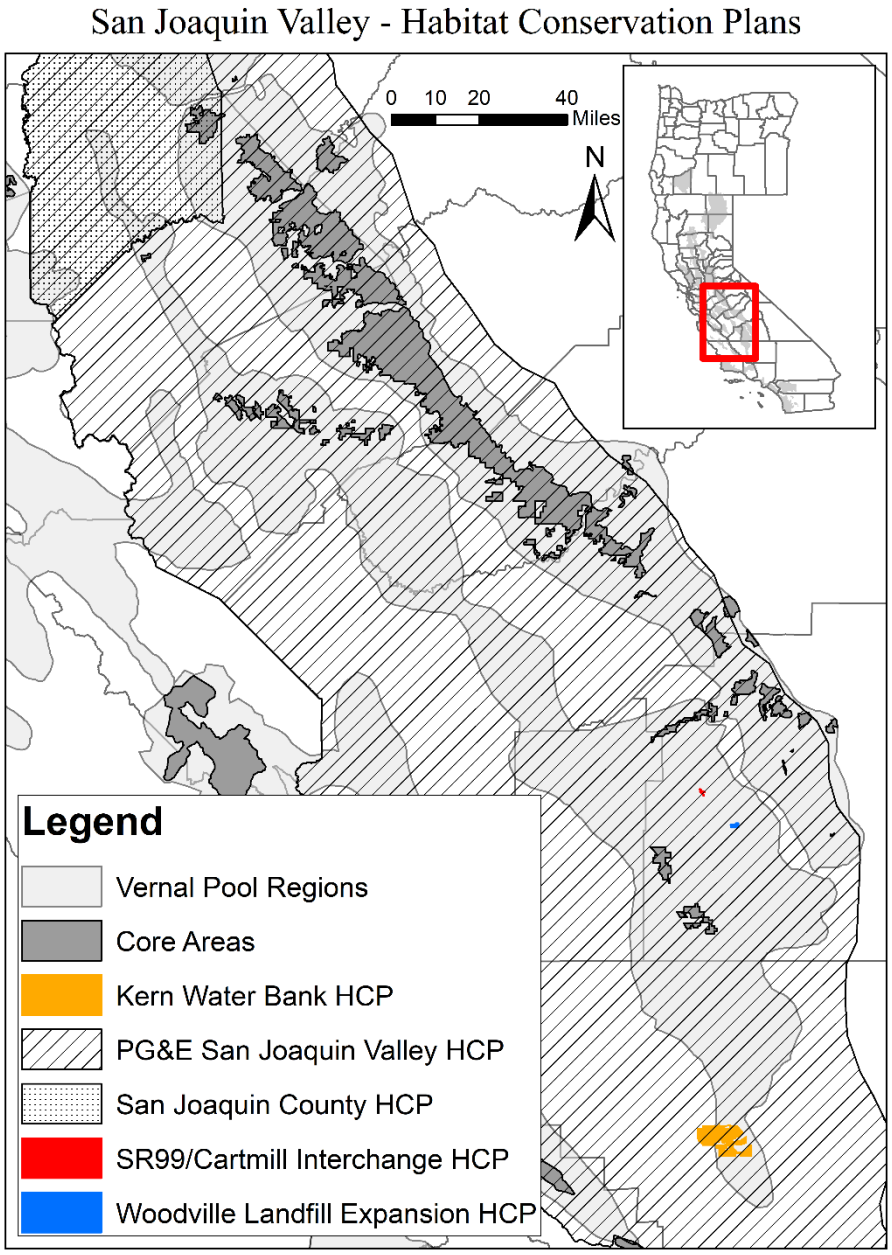

Figure 9.11. Map of the habitat conservation plans (HCPs) within the San Joaquin Valley Vernal Pool Region that include any of the three shrimp species as Covered Species.

9.5.2. PG&E San Joaquin Valley Operations and Maintenance HCP

The Pacific Gas & Electric Company's (PG&E) San Joaquin Valley Operations and Maintenance HCP covers PG&E activities within portions of nine San Joaquin Valley counties, spanning the San Joaquin Valley Vernal Pool Region, Southern Sierra Foothills Vernal Pool Region, and the southernmost extent of the Southeastern Sacramento Valley Vernal Pool Region in San Joaquin County (Jones and Stokes Associates 2006b). This HCP was permitted in 2007 and has a 30-year permit term. The purpose of the HCP is to enable PG&E to continue to conduct current and future operations and maintenance activities within the 9 San Joaquin Valley counties while avoiding, minimizing, and mitigating temporary and permanent impacts on threatened and endangered species habitat. The HCP's conservation strategy includes mitigation for permanent and temporary impacts to species habitat, which may be in the form of purchasing and/or placing easements on high quality habitat, purchase of conservation bank credits, contributions to existing conservation planning and recovery efforts, or habitat enhancement or restoration.

The HCP estimated that less than 1 acre of vernal pool fairy shrimp and vernal pool tadpole shrimp habitat will be permanently or temporarily lost annually, and 2 acres of vernal pool fairy shrimp habitat and 1 acre of vernal pool tadpole shrimp habitat will experience other less intensive disturbance each year (Jones and Stokes Associates 2006b). The Conservancy fairy shrimp is not a covered species. Permanent loss of vernal pool fairy shrimp and vernal pool tadpole shrimp habitat will be mitigated at a 3:1 ratio and temporary habitat loss at a 0.5:1 ratio. The actual amount of mitigation will depend on the actual acreage of effects documented when projects are implemented. The HCP does not specify in which vernal pool region this habitat will be preserved, but it does estimate that, over the first 5 years, 1.03 acres will be preserved in the northern San Joaquin Valley, 2.31 acres in the central San Joaquin Valley, and 0.55 acres in the southern San Joaquin Valley based on the anticipated locations of covered activities. As of December 31, 2017, there had only been 0.01 acre of permanent loss and 0.07 acre of temporary loss for vernal pool fairy shrimp habitat and no permanent loss and 0.06 acre of temporary loss for vernal pool tadpole shrimp habitat (PG&E 2018). A total of 9.28 acres and 7.97 acres of mitigation had been purchased as conservation credits for the vernal pool fairy shrimp and vernal pool tadpole shrimp, respectively, far exceeding the mitigation need (PG&E 2018). Of these credits, 2.44 acres were purchased from Great Valley Conservation Bank in the northern San Joaquin Valley for both shrimp species, 5.53 acres from Drayer Conservation Bank in the central San Joaquin Valley for both shrimp species, and 1.31 acres from Sand Creek Conservation Bank in the southern San Joaquin Valley for the vernal pool fairy shrimp only; all three of these banks are in the Southern Sierra Foothills Vernal Pool Region.

9.5.3. San Joaquin County HCP

See section 6.5.3 for a description of this HCP.

9.5.4. State Route 99/Cartmill Avenue Interchange Low-effect HCP

The State Route 99/Cartmill Avenue Interchange Low-effect HCP covers the construction of road improvements at the intersection of State Route 99, M Street, and Cartmill Avenue between post miles 31.2 and 32.4 in the City of Tulare (ICF 2013). The Permit Area encompasses 218.9 acres, including the 54.32-acre project construction area and the 164.58-acre area of potential

indirect effects. This HCP was permitted in 2013 and had a 5-year permit term that ended in 2018, and the permittee is the City of Tulare.

The vernal pool fairy shrimp was the only shrimp species included as a covered species. There were two small seasonal wetlands within or near the project that provide potential habitat for the vernal pool fairy shrimp. One of these wetlands was filled by the project, resulting in 0.071 acres of habitat loss. This loss was mitigated with the purchase of 0.213 acres of preservation credits for the vernal pool fairy shrimp from the Deadman Creek Conservation Bank.

9.5.5. Woodville Solid Waste Disposal Site Expansion HCP

The Woodville Solid Waste Disposal Site Expansion HCP covers the expansion of a Tulare County landfill site 7 miles southeast of the City of Tulare (Jones and Stokes Associates 2006c). The Permit Area encompasses 414.11 acres, including the 53.32-acre expansion area, the 77.58-acre borrow area, the 158.26-acre vernal pool conservation area, and the 124.95-acre silage area and San Joaquin kit fox (*Vulpes macrotis mutica*) conservation area. This HCP was permitted in 2007 and has a 41-year permit term, and the permittee is the County of Tulare.

The vernal pool fairy shrimp was the only shrimp species included as a covered species. There were 1.77 acres of vernal pools that provided potential habitat for the vernal pool fairy shrimp in the expansion area that were filled by the project. This loss was mitigated with the preservation of the 158.26-acre vernal pool conservation area, which contains 5.35 acres of vernal pools. This preserve was placed under conservation easement and is regularly monitored and managed. Monitoring over the past 10 years has only positively identified the versatile fairy shrimp (*Branchinecta lindalhi*) on site (Kamansky's Ecological Consulting 2022). However, these surveys did not include the pools in the southwestern corner of the site that are most likely to support the vernal pool fairy shrimp; these pools were extensively thatch-covered and did not yield sufficient hydrology to support the vernal pool fairy shrimp during most surveys (Kamansky's Ecological Consulting 2022).

9.6. Other Preserves

The California Department of Fish and Wildlife (CDFW) owns five Ecological Reserves within or adjacent to the San Joaquin Valley Vernal Pool Region that contain vernal pool habitat: Alkali Sink, Kerman, Allensworth, Semitropic, and Buttonwillow. None of these preserves have final management plans (J. Battistoni, CDFW, *in litt*. 2022). Alkali Sink and Kerman Ecological Reserves are located in Fresno County, are approximately 930 acres and 1,800 acres in size, respectively, and are almost entirely composed of vernal pool grasslands, as well as a small patch of vernal pool grasslands south of Alkali Sink on the Mendota Wildlife Area (see **Figure 9.3**; Witham 2021). The most recent surveys of these Ecological Reserves by CDFW happened in 2012 (Battistoni, *in litt*. 2022). On the Alkali Sink Ecological Reserve, the vernal pool fairy shrimp was found in two vernal pools, while the vernal pool tadpole shrimp and Conservancy fairy shrimp were not found (Battistoni, *in litt*. 2022); the vernal pool fairy shrimp was also observed immediately north of the preserve in 2009 (Diversity Database 2022). On the Kerman Ecological Reserve, there are historic records of the vernal pool fairy shrimp and vernal pool tadpole shrimp, but only the common species *Branchinecta lindahli* and *B. mackini* were identified during recent surveys (Battistoni, *in litt*. 2022). The Allensworth, Semitropic, and

Buttonwillow Ecological Reserves are located in the Tulare Basin in Tulare and Kern Counties and are approximately 5,100 acres, 14,900 acres, and 1,400 acres in size, respectively (**Figure 9.4**). A majority of these preserves are mapped as vernal pool grasslands (Witham 2021), though CDFW describes the habitat as alkali rain slicks/pools and not proper vernal pools (Battistoni, *in litt*. 2022). Only the common species *B. lindahli* and *B. mackini* were identified during recent surveys. The vernal pool tadpole shrimp has never been observed as far south as these Ecological Reserves. Both Allensworth and Buttonwillow Ecological Reserves had historic records of potential vernal pool fairy shrimp that could not be conclusively identified, and on both preserves the pools where those occurrences were documented have since been destroyed or disturbed (Battistoni, *in litt*. 2022).

CDFW also owns three Wildlife Areas within the San Joaquin Valley Vernal Pool Region that contain vernal pool habitat: North Grasslands, Los Banos, and Volta. None of these Wildlife Areas have final management plans (Battistoni, *in litt*. 2022). All three areas are located in Merced County adjacent to the San Luis National Wildlife Refuge Complex and are 7,400 acres, 6,200 acres, and 3,800 acres in size, respectively. An estimated 1,379 acres, 4,950 acres, and 2,918 acres of vernal pool grasslands have been mapped within each Ecological Reserve, respectively (Witham 2021). No occurrences of the three shrimp have been recorded within these Wildlife Areas; the nearest known occurrences are from the San Luis National Wildlife Refuge (Diversity Database 2022).

The California Department of Parks and Recreation (CDPR) owns the 2,862-acre Great Valley Grasslands State Park in Merced County along the San Joaquin River and the northern border of the San Luis National Wildlife Refuge Complex. Based on aerial imagery, approximately 1,360 acres of vernal pool grassland was mapped in the part of the park south of the San Joaquin River and adjacent to the San Luis National Wildlife Refuge Complex (Witham 2021). The vernal pool fairy shrimp has not been recorded within this State Park. The vernal pool tadpole shrimp was recorded in four vernal pools in the southern portion of this State Park, most recently in 2003 (Diversity Database 2022). The Conservancy fairy shrimp was recorded within this State Park in 7 of 93 pools surveyed in 1995 (Diversity Database 2022). The Service is not aware of any more recent observations of the Conservancy fairy shrimp within the State Park.

The Center for Natural Lands Management (CNLM) owns two preserves within the San Joaquin Valley Vernal Pool Region that contain vernal pool habitat: Pixley Vernal Pools Preserve and Semitropic Ridge Preserve. The Pixley Vernal Pools Preserve is a 40-acre preserve located in Tulare County, all of which contains vernal pool grasslands. The preserve has a very high density of vernal pools, with 100 pools in 10-20 vernal pool complexes (CNLM, *in litt*. 2021a). The vernal pool fairy shrimp was first documented here in the mid-1980's by The Nature Conservancy and has been frequently detected since; the most recent survey documenting the vernal pool fairy shrimp occurred in 2019 (CNLM, *in litt*. 2021a). The Semitropic Ridge Preserve is a 3,700-acre preserve in Kern County adjacent to CDFW's Semitropic Ecological Reserve. As with the Semitropic Ecological Reserve, alkali playas are interspersed through much of the preserve, but the vernal pool fairy shrimp has not been reported to occur on the preserve (CNLM 2022a). The other two shrimp species have not been observed on either of these preserves, and these preserves are farther south than the known range of the vernal pool tadpole shrimp.

Vollmar et al. (2017) identified 17 other protected properties within the San Joaquin Valley Vernal Pool Region, including three conservation easements held by CDFW, 10 very small mitigation parcels owned by CDFW adjacent to Pixley National Wildlife Refuge, 3 conservation easements held by the Natural Resources Conservation Service (NRCS), and one preserve owned by the Sequoia Riverlands Trust.

9.7. Vernal Pool Core Areas

There are four Core Areas within the San Joaquin Valley Vernal Pool Region, all of which are designated in the Recovery Plan for the vernal pool fairy shrimp: Caswell, Cross Creek, Grassland Ecological Area, and Pixley. The Cross Creek and Grassland Ecological Area Core Areas are also designated for the vernal pool tadpole shrimp, and the Caswell and Grassland Ecological Area Core Areas are also designated for the Conservancy fairy shrimp. The Caswell Core Area has met the targeted amount of vernal pool habitat protected (see Caswell section below) and the Grasslands Ecological Area is very close. As of 2018, none had lost enough habitat, compared to the baseline level of habitat that was present in 2005, to make the protection targets unattainable (see **Table 9.1**; Vollmar et al. 2017; Witham 2021).

9.7.1. Caswell

This is a zone 1 core area with a goal of protecting 85% of vernal pool habitat for the vernal pool fairy shrimp and 95% of vernal pool habitat for the Conservancy fairy shrimp. The core area is located in Stanislaus County and is entirely within the San Joaquin River National Wildlife Refuge.

There were approximately 395 acres of vernal pool grassland within this core area when the Recovery Plan was published in 2005 (Witham et al. 2013). As of 2018, there were still 395 acres of vernal pool grassland remaining, with no habitat losses occurring since 2005 (see **Figure 9.12**, **Table 9.1**; Witham 2021). Finer scale, on the ground mapping of individual vernal pools on the Refuge has been consistently identified as a priority in recent years, but has not yet occurred (Service 2018b; Takahashi, *in litt*. 2021). Vollmar et al. (2017) estimated that there were roughly 311 acres of vernal pool grassland protected within this core area as of 2017 (Vollmar et al. 2017), representing 78.7% of the 2005 baseline. The southern portion of Mapes Ranch, the only part of the core area not identified as protected in Vollmar et al.'s (2017) database, is also now protected under conservation easement, meaning that 100% of the 2005 baseline has been protected (**Figure 9.13**).

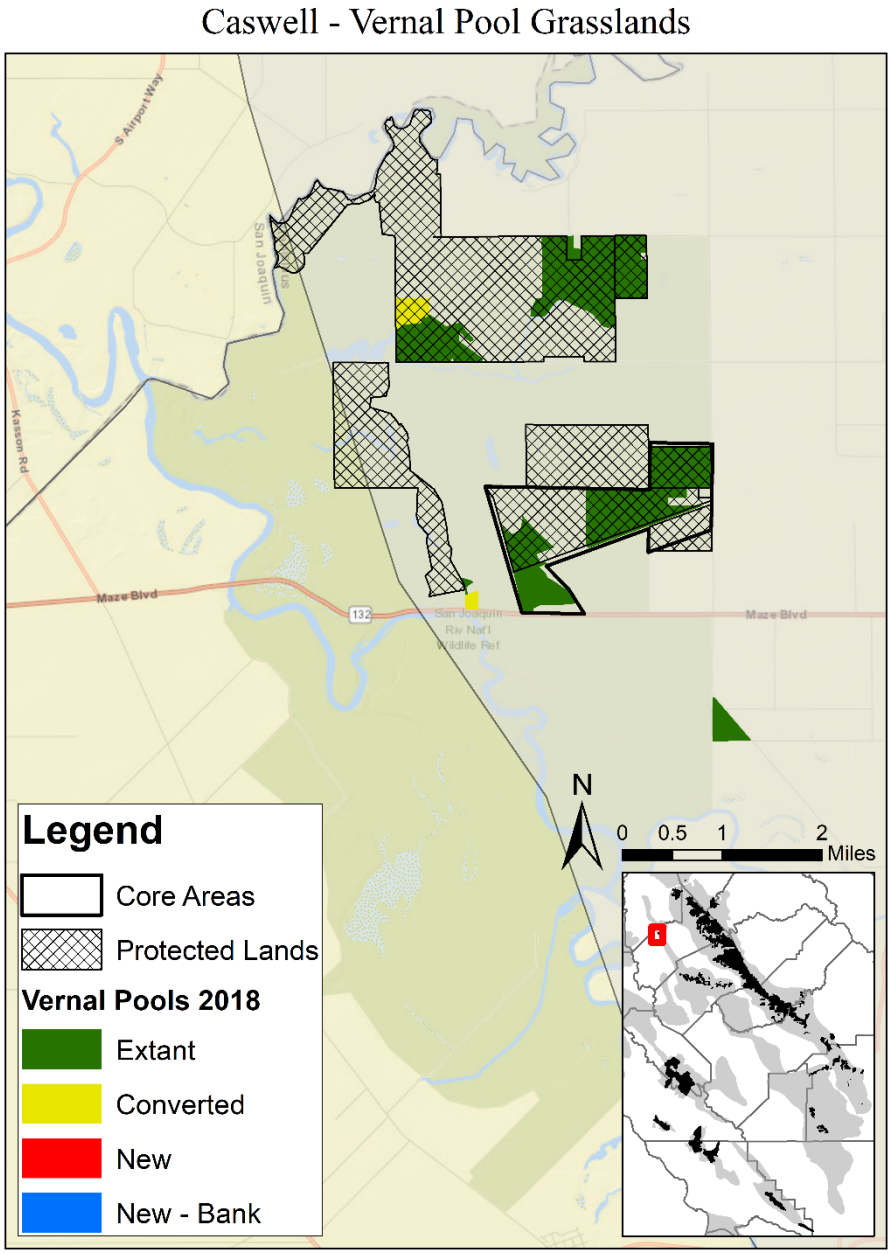

Figure 9.12. Map of vernal pool grassland habitat within the Caswell Core Area mapped by Witham (2021) created using aerial imagery from 2018 compared to 2005 and 2012. "New" vernal pool habitat refers to areas not seen in the 2005 or 2012 aerial imagery (either missed or restored). "New - bank" refers to newly created vernal pool habitat on mitigation lands. Converted habitat refers to vernal pool habitat that was seen in 2005 or 2012 aerial imagery and by 2018 was converted to other land uses. Modified habitat as described by Witham (2021) was altered but still provides suitable vernal pool habitat (e.g., mitigation banks, lands managed for waterfowl), and so is mapped as extant. Zoom in for finer resolution.

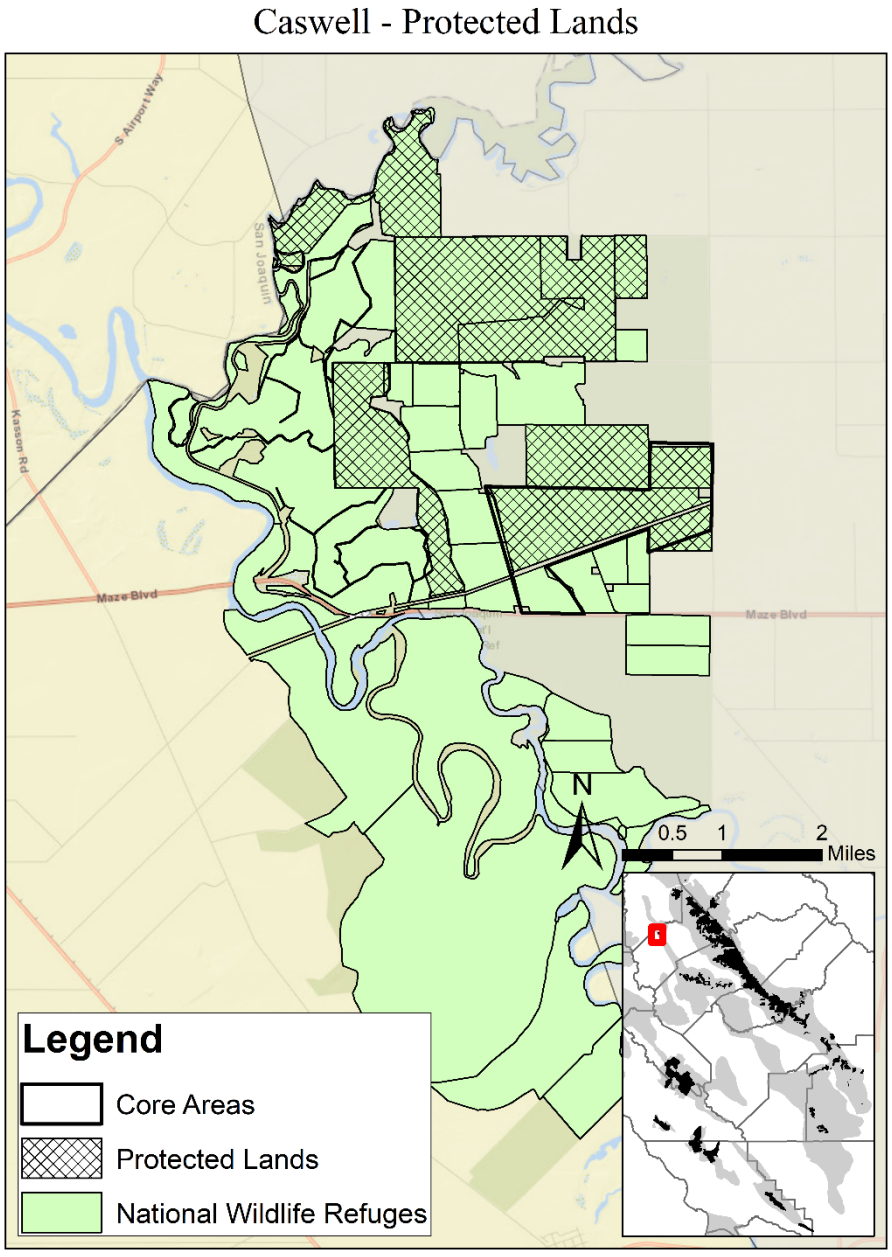

Figure 9.13. Map of protected areas within the Caswell Core Area**.** Protected lands are based on Vollmar et al. (2017) and include various preserves.

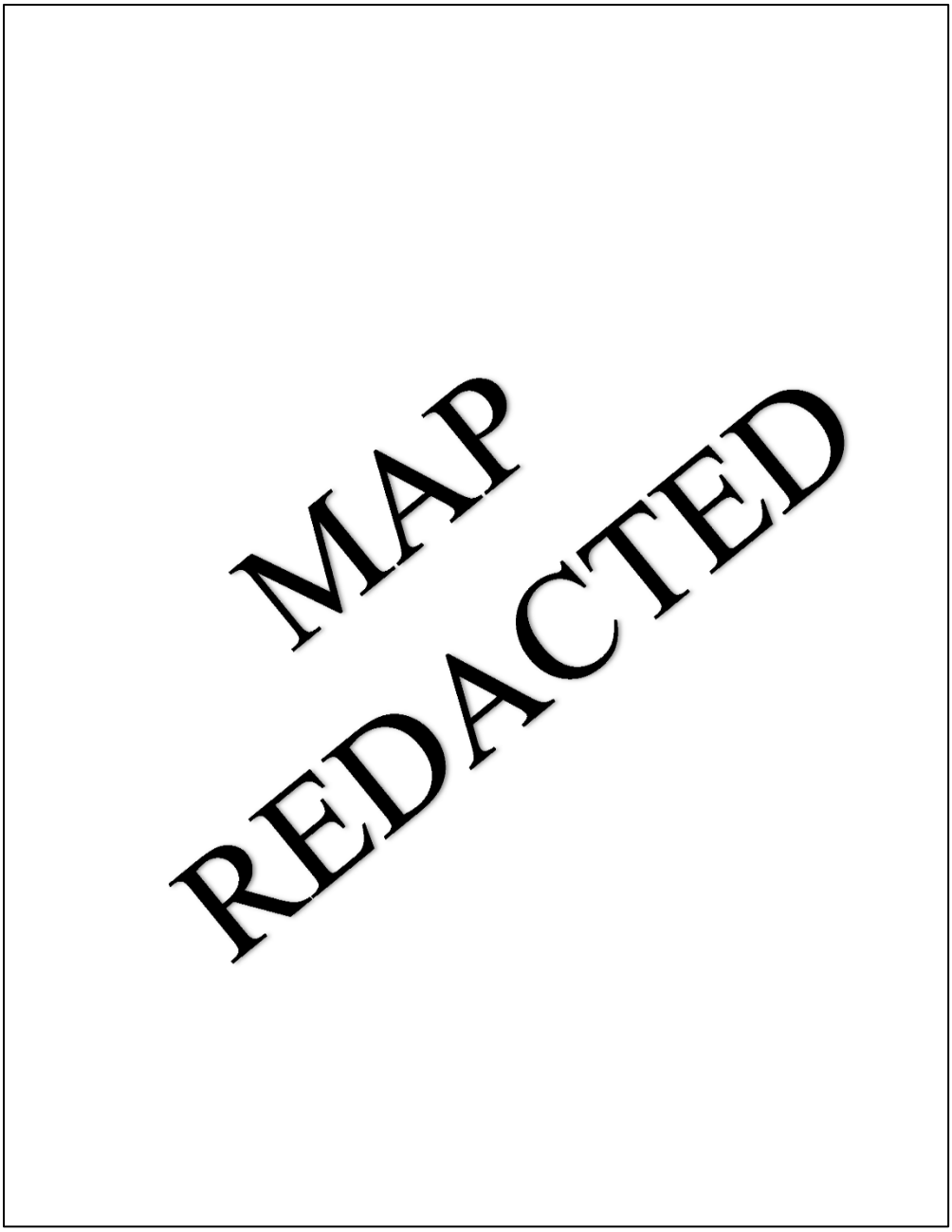

Figure 9.14. Map of known occurrences of vernal pool fairy shrimp recorded in the Diversity Database (2022) within the Caswell Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

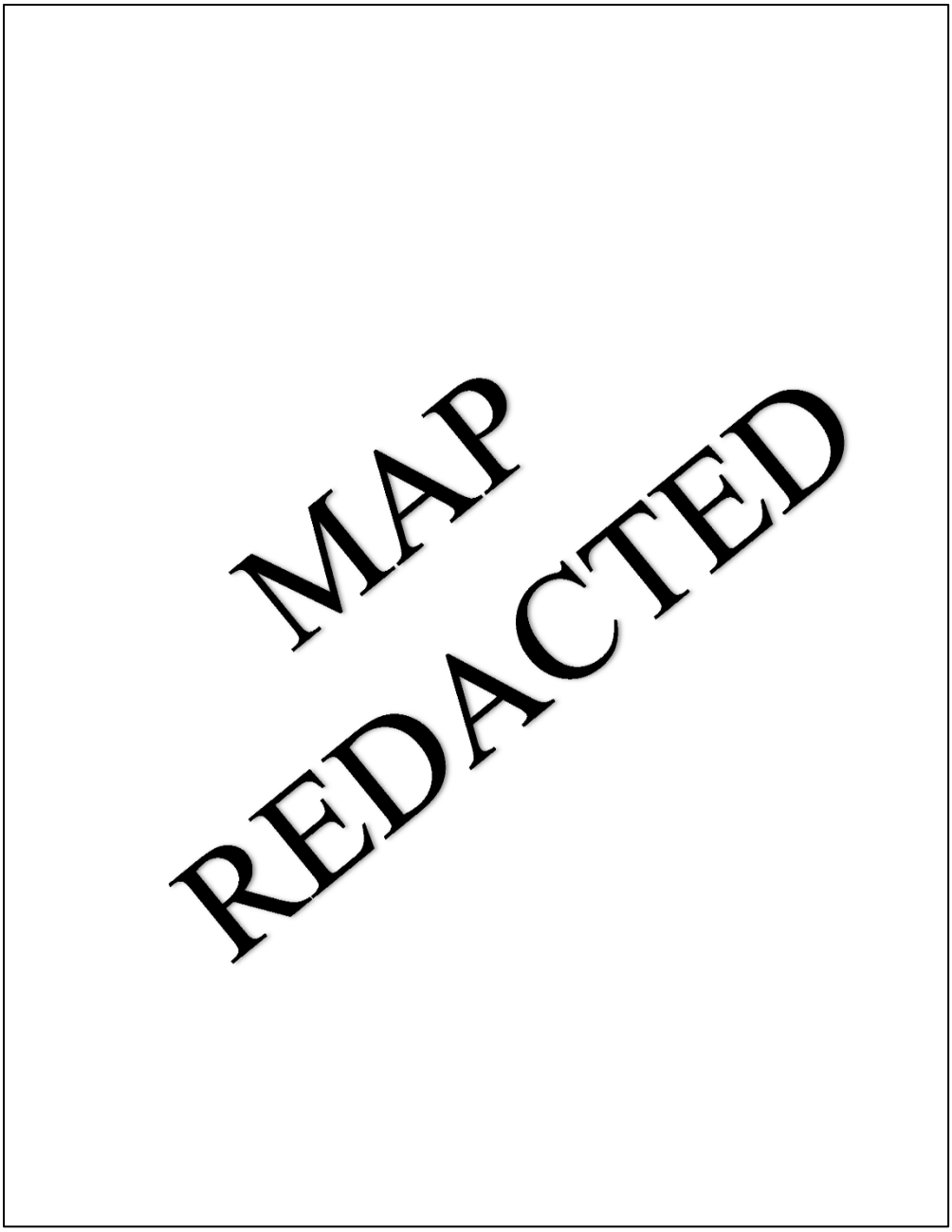

Figure 9.15. Map of known occurrences of Conservancy fairy shrimp recorded in the Diversity Database (2022) within the Caswell Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

9.7.1.1.Vernal Pool Fairy Shrimp Occurrences

There are two Diversity Database occurrence records for the vernal pool fairy shrimp within this core area, both of which are entirely protected within the Refuge (see **Figure 9.14**; Diversity Database 2022). All occurrences are presumed extant by the Diversity Database and are within extant vernal pool grasslands (Witham 2021). Of the two records, one was known at the time of listing in 1994 and both were known at the time the Recovery Plan was published in 2005. The western occurrence is located within Mapes Ranch; this part of the Refuge was not identified as a protected area in Vollmar et al.'s (2017) database, but this report considers all Refuge lands to be protected unless management is inconsistent with species needs. The vernal pool fairy shrimp was observed in 1991 and 1998, and *Branchinecta* cysts were identified during dry season surveys in 2011 despite no shrimp being observed during the previous year's wet season survey (Diversity Database 2022). The eastern occurrence is located within pastureland just south of Nelson Field and was observed in 1998 near the base of an electrical transmission line tower (Service 2006b; Diversity Database 2022). Vernal pool surveys occurred most recently on the San Joaquin River National Wildlife Refuge in 2017, but the survey occurred too late in the season to detect the vernal pool fairy shrimp (Service 2018b).

9.7.1.1.Conservancy Fairy Shrimp Occurrences

There is one Diversity Database occurrence record for the Conservancy fairy shrimp within this core area, which are entirely protected within the Refuge (see **Figure 9.15**; Diversity Database 2022). This single occurrence represents the entire Mapes Ranch population of the Conservancy fairy shrimp. The occurrence is presumed extant by the Diversity Database and is within extant vernal pool grasslands (Witham 2021). It was first recorded in 1991in two vernal pools located within Mapes Ranch. This part of the Refuge was not identified as a protected area in Vollmar et al.'s (2017) database, but this report considers all Refuge lands to be protected unless management is inconsistent with species needs. Based on the information available to the Service at the time, the previous 5-year review (Service 2012c) stated that the Mapes Ranch occurrence was still privately owned and that the hydrology on the site may have been altered, possibly extirpating the Conservancy fairy shrimp. However, this portion of Mapes Ranch was acquired by the Refuge in 2010, so the property should be being managed according to the Refuge's Comprehensive Conservation Plan (Service 2006). Surveys of Mapes Ranch are needed to determine if the Conservancy fairy shrimp remains extant. Vernal pool surveys occurred most recently on the Refuge in 2017, but not the portion of the Refuge with the Conservancy fairy shrimp (Service 2018b).

9.7.2. Cross Creek

This is a zone 2 core area with a goal of protecting 85% of vernal pool habitat for the vernal pool fairy shrimp and vernal pool tadpole shrimp. The core area is located in Kings and Tulare Counties on either side of Highway 99 north of Visalia. This core area is nearly contiguous with the Cottonwood Creek Core Area to the east in the Southern Sierra Foothills Vernal Pool Region.

There were approximately 3,800 acres of vernal pool grassland within this core area when the Recovery Plan was published in 2005 (Witham et al. 2013). As of 2018, there were 3,393 acres of vernal pool grassland remaining, with 407 acres lost since 2005 (see **Figure 9.16**, **Table 9.1**;

Witham 2021). All losses were due to agricultural conversion, including conversion to rice, row crops, dairies, or nurseries (235.0 acres, 57.8%), alfalfa and irrigated pasture (126.5 acres, 31.1%), orchards, vineyards, or eucalyptus (39.4 acres, 9.7%), and bare plowed agricultural land (5.8 acres, 1.4%) (see **Table 9.2**; Witham 2021). No vernal pool grasslands are currently known to be protected within this core area (Vollmar et al. 2017).

9.7.2.1.Vernal Pool Fairy Shrimp Occurrences

There are seven Diversity Database occurrence records for the vernal pool fairy shrimp within this core area (see **Figure 9.17**; Diversity Database 2022). As of 2018, none of the occurrences were within protected areas (Vollmar et al. 2017). All occurrences are presumed extant by the Diversity Database and are within extant vernal pool grasslands (Witham 2021). Of the seven records, three were known at the time of listing in 1994 and five were known at the time the Recovery Plan was published in 2005. The three occurrences east of Highway 99 were observed in 1992-1993 and have not been surveyed since, to the Service's knowledge (Diversity Database 2022). Of the four occurrences west of Highway 99, two were first observed in 1999, and all four were observed in 2017 when the Cross Creek properties were being evaluated as potential mitigation lands for the California High Speed Rail Authority (Diversity Database 2022).

9.7.2.1.Vernal Pool Tadpole Shrimp Occurrences

There are seven Diversity Database occurrence records for the vernal pool tadpole shrimp within this core area (see **Figure 9.18**; Diversity Database 2022). As of 2018, none of the occurrences were within protected areas (Vollmar et al. 2017). All occurrences are presumed extant by the Diversity Database and are within extant vernal pool grasslands (Witham 2021). Of the seven records, two were known at the time of listing in 1994 and five were known at the time the Recovery Plan was published in 2005. The two newer occurrences are immediately west of Highway 99 between several of the older occurrences. Six of the seven occurrences were most recently observed between 2011 and 2018, with four observed in 2017 when the Cross Creek properties were being evaluated as potential mitigation lands for the California High Speed Rail Authority (Diversity Database 2022).

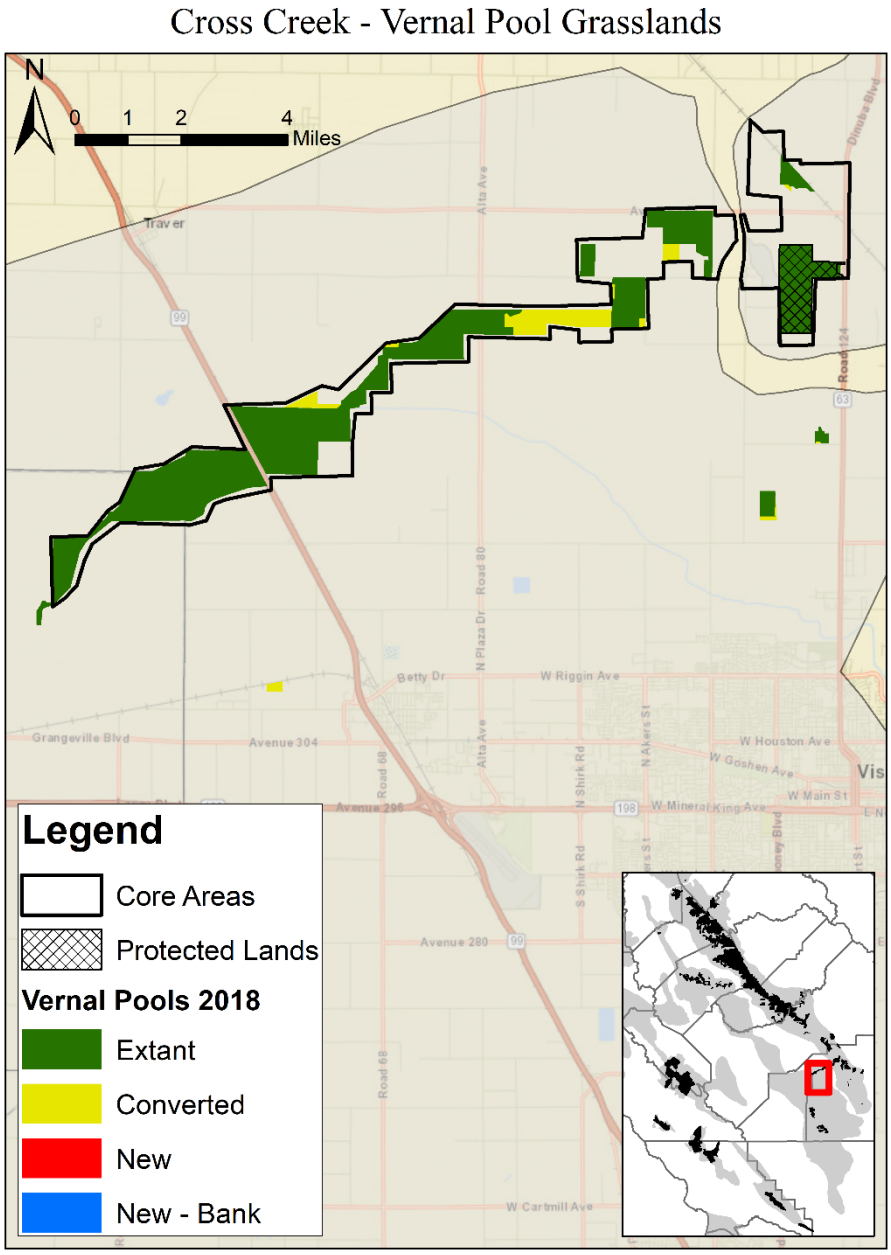

Figure 9.16. Map of vernal pool grassland habitat within the Cross Creek Core Area mapped by Witham (2021) created using aerial imagery from 2018 compared to 2005 and 2012. "New" vernal pool habitat refers to areas not seen in the 2005 or 2012 aerial imagery (either missed or restored). "New - bank" refers to newly created vernal pool habitat on mitigation lands. Converted habitat refers to vernal pool habitat that was seen in 2005 or 2012 aerial imagery and by 2018 was converted to other land uses. Modified habitat as described by Witham (2021) was altered but still provides suitable vernal pool habitat (e.g., mitigation banks, lands managed for waterfowl), and so is mapped as extant. Zoom in for finer resolution.

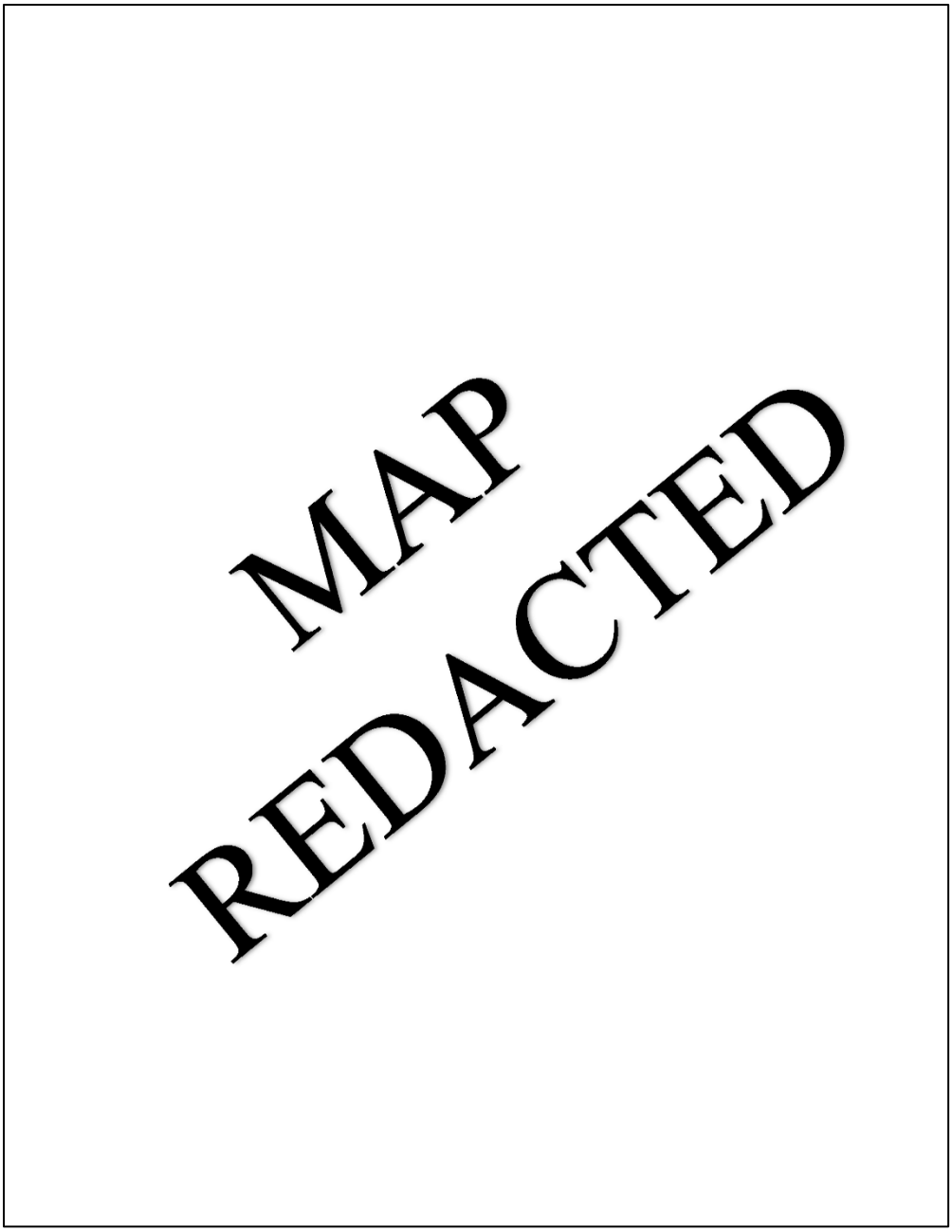

Figure 9.17. Map of known occurrences of vernal pool fairy shrimp recorded in the Diversity Database (2022) within the Cross Creek Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

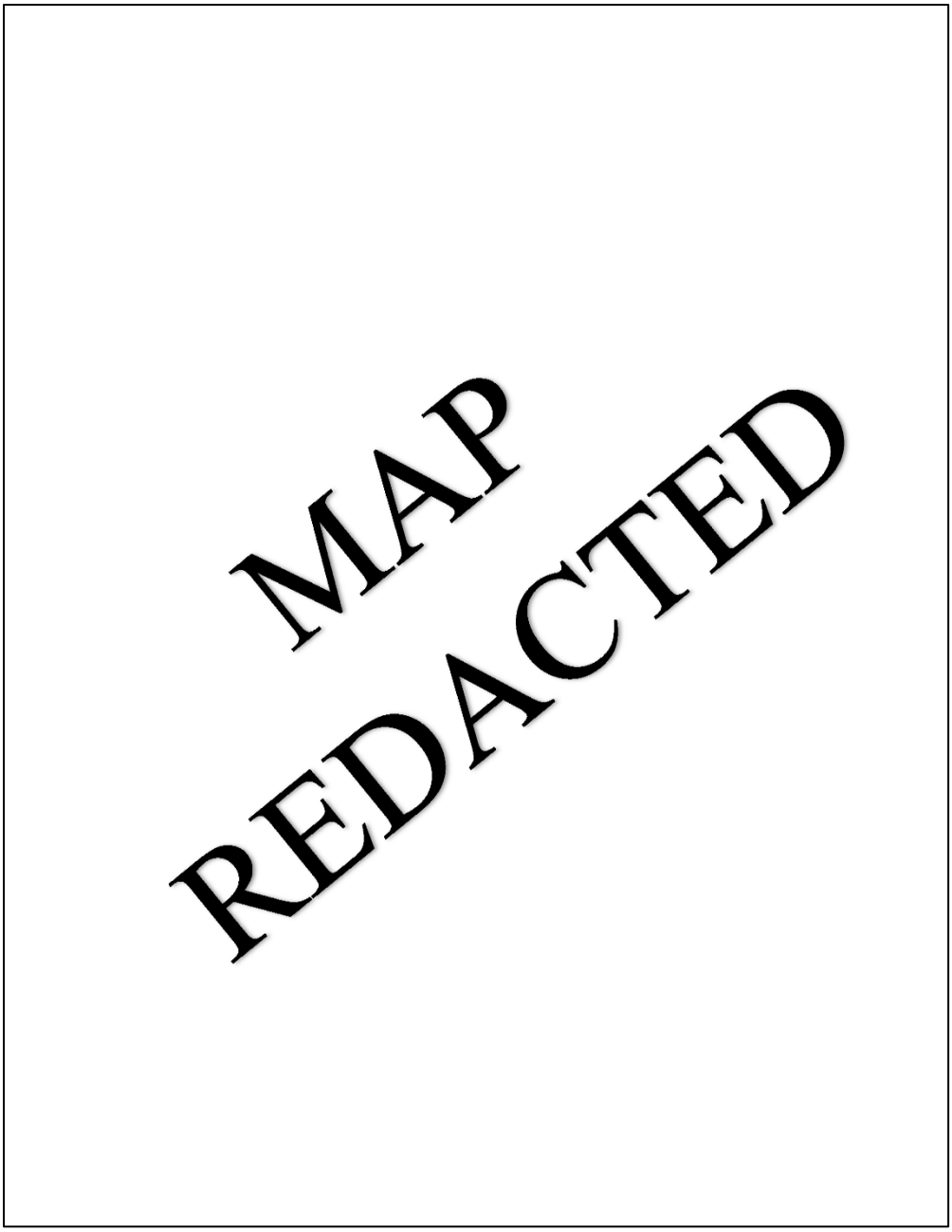

Figure 9.18. Map of known occurrences of vernal pool tadpole shrimp recorded in the Diversity Database (2022) within the Cross Creek Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

9.7.3. Grassland Ecological Area

This is a zone 1 core area with a goal of protecting 85% of vernal pool habitat for the vernal pool fairy shrimp and 95% of vernal pool habitat for the vernal pool tadpole shrimp and Conservancy fairy shrimp. The core area is located in Merced County across the northern extent of the Grassland Ecological Area, the largest continuous block of freshwater wetlands remaining in California that is found in the historic San Joaquin River Basin.

There were approximately 30,830 acres of vernal pool grassland within this core area when the Recovery Plan was published in 2005 (Witham et al. 2013). As of 2018, there were 30,525 acres of vernal pool grassland remaining (see **Figure 9.19**, **Table 9.1**; Witham 2021). Approximately 331 acres had been lost since 2005, though 26 additional acres were identified that were either not present or not visible on the 2005 aerial imagery. All losses were due to agricultural conversion to either alfalfa and irrigated pasture (175.8 acres, 53.1%) or bare plowed agricultural land (155.1 acres, 46.9%) (see **Table 9.2**; Witham 2021). Vollmar et al. (2017) estimated that there were roughly 23,221 acres of vernal pool grassland protected within this core area as of 2017 (Vollmar et al. 2017), representing 75.3% of the 2005 baseline. There are an additional 843 acres of vernal pool grassland within the Grasslands Wildlife Management Area near the Deadman Creek and Vieira-Sandy Mush Road Conservation Banks that are not included in Vollmar et al.'s (2017) database. This means a total of 24,064 acres of vernal pool grassland area protected, representing 78.1% of the 2005 baseline.

There are three conservation banks with vernal pool fairy shrimp and vernal pool tadpole shrimp preservation credits, and which also support the Conservancy fairy shrimp, in this core area: Deadman Creek, Dutchman Creek, and Vieira-Sandy Mush Road (**Figure 9.20**). These banks total 1,548 acres in size and have 113.92 acres of preservation credits for the vernal pool fairy shrimp and vernal pool tadpole shrimp (49.5% of which have already been sold). Other protected areas within this core area include the San Luis National Wildlife Refuge, Merced National Wildlife Refuge, Grasslands Wildlife Management Area, and Great Valley Grasslands State Park (**Figure 9.20**).

9.7.3.1. Vernal Pool Fairy Shrimp Occurrences

There are 12 Diversity Database occurrence records for the vernal pool fairy shrimp within this core area and 1 additional occurrence immediately adjacent (see **Figure 9.21**; Diversity Database 2022). As of 2018, all 13 of these occurrences were at least partially within protected areas (Vollmar et al. 2017). All occurrences are presumed extant by the Diversity Database and are within extant vernal pool grasslands (Witham 2021). Of the 13 records, 6 were known at the time of listing in 1994 and 7 were known at the time the Recovery Plan was published in 2005; these records are located throughout the San Luis National Wildlife Refuge Complex and on the Deadman Creek and Vieira-Sandy Mush Road Conservation Banks. The six newer occurrences were identified between 2008 and 2016 and are located on the Dutchman Creek Conservation Bank and on the Refuge Complex near the older occurrences.

9.7.3.1.Vernal Pool Tadpole Shrimp Occurrences

There are 17 Diversity Database occurrence records for the vernal pool tadpole shrimp at least partially within this core area and 2 adjacent to the core area (see **Figure 9.22**; Diversity Database 2022). As of 2018, 18 of these 19 occurrences were protected (Vollmar et al. 2017); several of these occurrence records are large polygons that encompass entire sections of the San Luis National Wildlife Refuge Complex. All occurrences are presumed extant by the Diversity Database and are within extant vernal pool grasslands (Witham 2021). Of the 19 records, 8 were known at the time of listing in 1994 and 13 were known at the time the Recovery Plan was published in 2005; these records are located throughout the San Luis National Wildlife Refuge Complex and on the Great Valley Grasslands State Park, Vieira-Sandy Mush Road Conservation Bank, and one private property to the east. The six newer occurrences were identified between 2008 and 2015 and are located on the Deadman Creek, Dutchman Creek, and Vieira-Sandy Mush Road Conservation Banks and on the eastern side of the Refuge Complex (Diversity Database 2022).

9.7.3.1.Conservancy Fairy Shrimp Occurrences

There are 13 Diversity Database occurrence records for the Conservancy fairy shrimp within this core area (see **Figure 9.23**; Diversity Database 2022). As of 2018, all 13 of these occurrences were at least partially within protected areas (Vollmar et al. 2017). The western 10 occurrences, which make up the Highway 165/Grasslands Ecological Area population, are within the San Luis National Wildlife Refuge Complex and the Great Valley Grasslands State Park. The eastern three occurrences, which make up the Sandy Mush Road population, are all within conservation banks. All occurrences are presumed extant by the Diversity Database and are within extant vernal pool grasslands (Witham 2021). Of the 13 records, 3 were known at the time of listing in 1994 and 4 were known at the time the Recovery Plan was published in 2005; these records are located in the Great Valley Grasslands State Park, the San Luis Refuge's Kesterson and East Bear Creek units, and the Merced Refuge's Arena Plains unit (all within the Highway 165/Grasslands Ecological Area population). The nine newer occurrences were identified between 2008 and 2016; these records are located on the San Luis Refuge's Kesterson and East Bear Creek units, the Merced Refuge's Snobird unit (Highway 165/Grasslands Ecological Area population), and the Deadman Creek, Dutchman Creek, and Vieira-Sandy Mush Road Conservation Banks (Sandy Mush Road population).

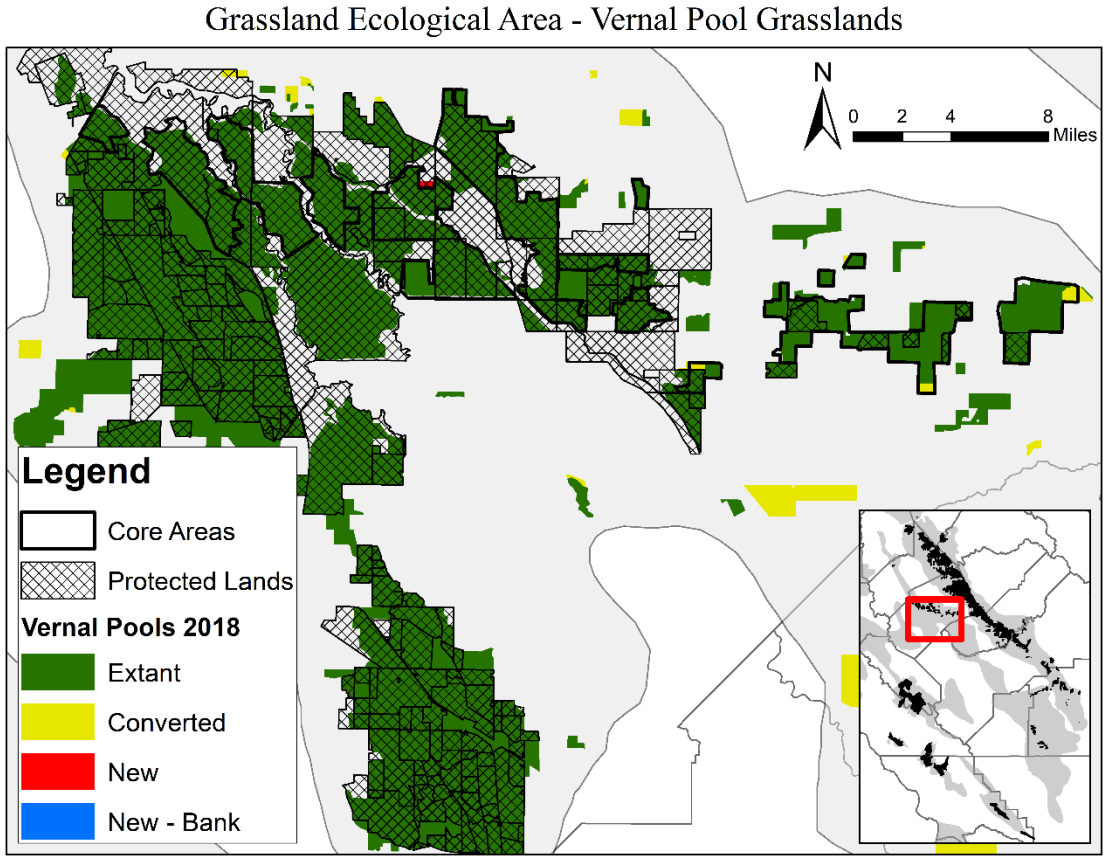

Figure 9.19. Map of vernal pool grassland habitat within the Grassland Ecological Area Core Area mapped by Witham (2021) created using aerial imagery from 2018 compared to 2005 and 2012. "New" vernal pool habitat refers to areas not seen in the 2005 or 2012 aerial imagery (either missed or restored). "New - bank" refers to newly created vernal pool habitat on mitigation lands. Converted habitat refers to vernal pool habitat that was seen in 2005 or 2012 aerial imagery and by 2018 was converted to other land uses. Modified habitat as described by Witham (2021) was altered but still provides suitable vernal pool habitat (e.g., mitigation banks, lands managed for waterfowl), and so is mapped as extant. Zoom in for finer resolution.

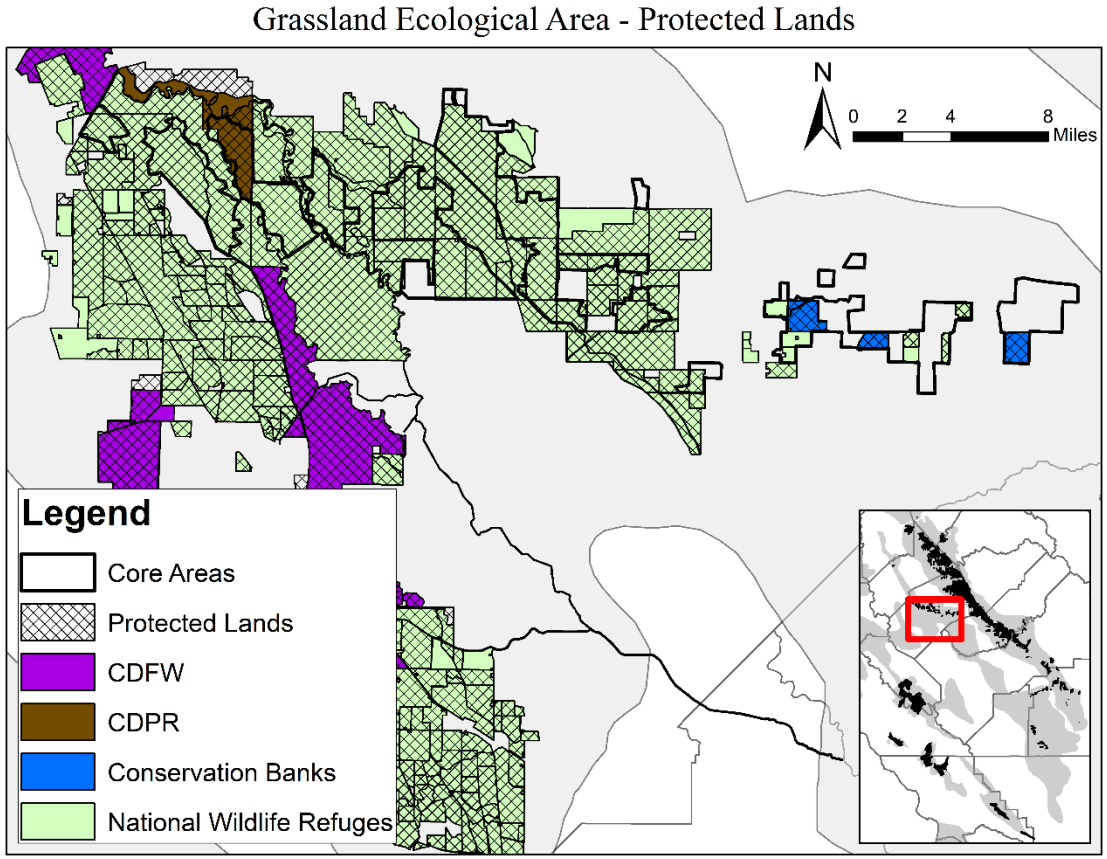

Figure 9.20. Map of protected areas within the Grassland Ecological Area Core Area**.** Protected lands are based on Vollmar et al. (2017) and include various preserves. CDFW = California Department of Fish and Wildlife, CDPR = California Department of Parks and Recreation.

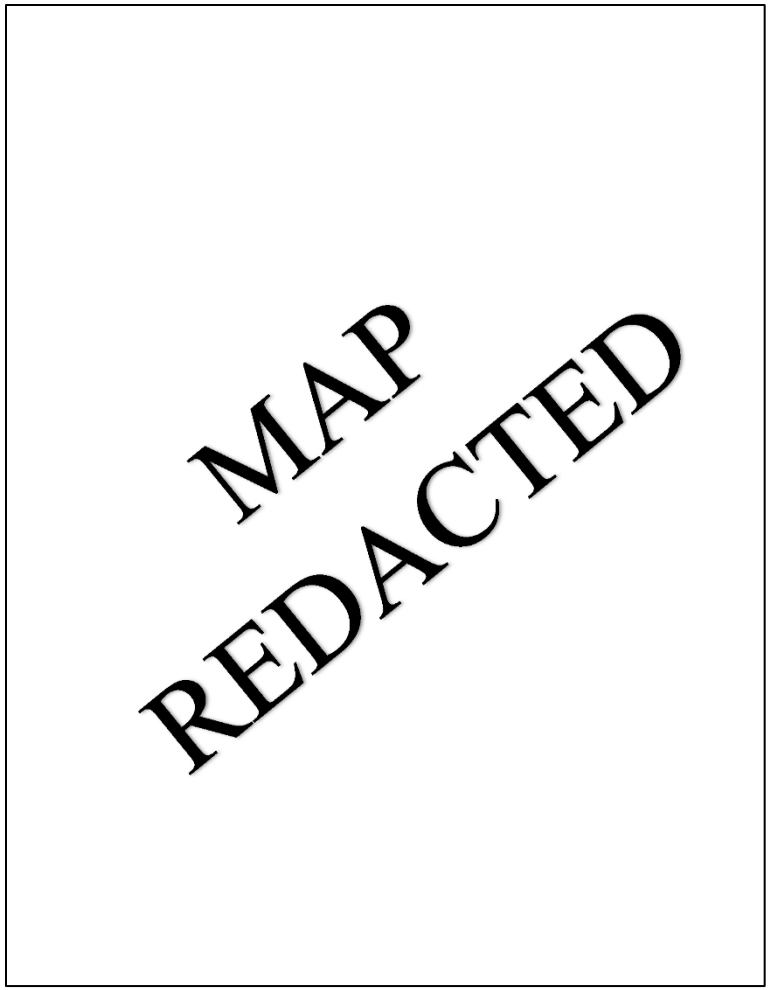

Figure 9.21. Map of known occurrences of vernal pool fairy shrimp recorded in the Diversity Database (2022) within the Grassland Ecological Area Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

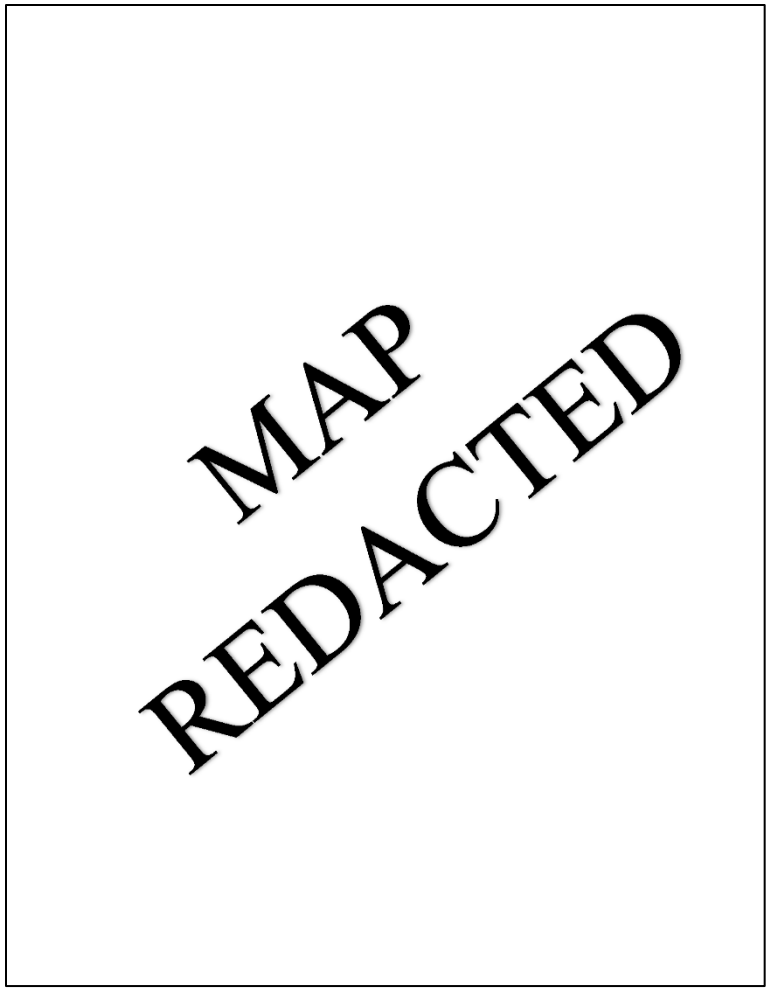

Figure 9.22. Map of known occurrences of vernal pool tadpole shrimp recorded in the Diversity Database (2022) within the Grassland Ecological Area Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

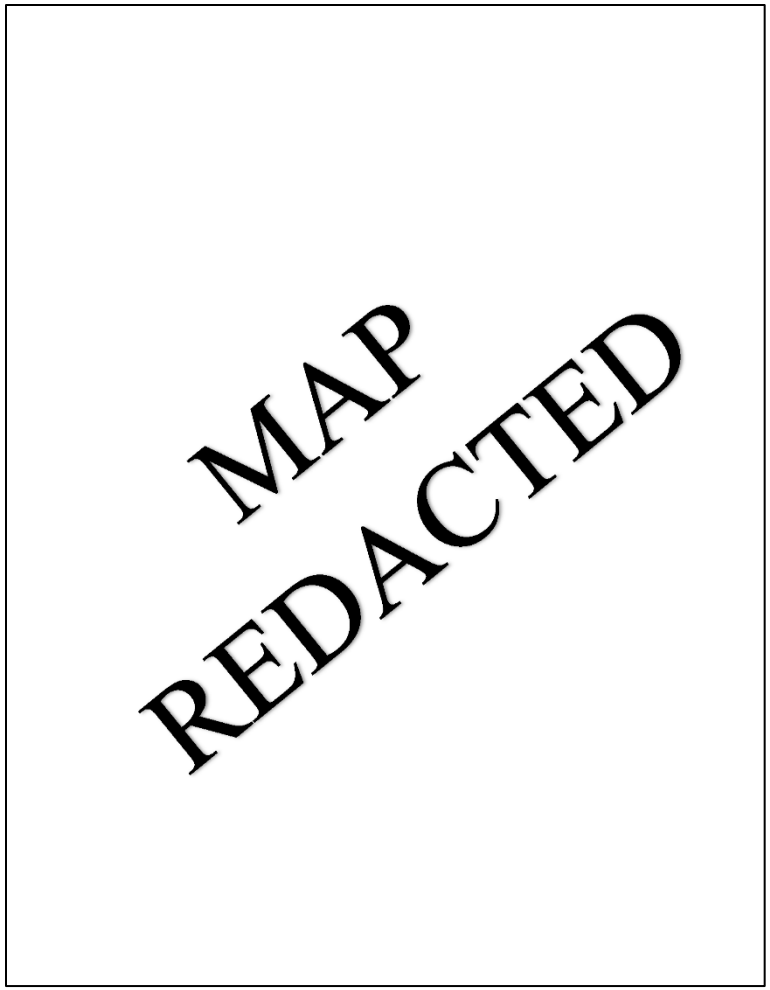

Figure 9.23. Map of known occurrences of Conservancy fairy shrimp recorded in the Diversity Database (2022) within the Grassland Ecological Area Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

9.7.4. Pixley

This is a zone 2 core area with a goal of protecting 85% of vernal pool habitat for the vernal pool fairy shrimp. The core area is located in southwestern Tulare County between Highway 99 and Highway 43 around the Pixley National Wildlife Refuge.

There were approximately 10,745 acres of vernal pool grassland within this core area when the Recovery Plan was published in 2005 (Witham et al. 2013). As of 2018, there were 10,476 acres of vernal pool grassland remaining (see **Figure 9.24**, **Table 9.1**; Witham 2021). Approximately 270 acres had been lost since 2005. All losses were due to agricultural conversion, primarily to bare plowed agricultural land (195.4 acres, 72.5%) and rice, row crops, or dairies (70.1 acres, 26.0%) (see **Table 9.2**; Witham 2021). These numbers were based on aerial imagery, which identified almost all of Pixley National Wildlife Refuge as vernal pool grassland. However, the 2021 Natural Resources Management Plan for the refuge only identifies four units within the central portion of the refuge as containing vernal pools (Service 2021a). Other units of the refuge may not contain the vernal pools suggested by the aerial imagery, or vernal pools may be present and not documented. Vollmar et al. (2017) estimated that there were roughly 5,173 acres of vernal pool grassland protected within this core area as of 2017 (Vollmar et al. 2017), representing 48.1% of the 2005 baseline. There are 44 small parcels totaling 276 acres on Pixley National Wildlife Refuge that are almost entirely mapped as vernal pool grassland but not included in Vollmar et al.'s database. This means a total of 5,449 acres of vernal pool grassland area are protected, representing 50.7% of the 2005 baseline.

Protected areas within this core area include Pixley National Wildlife Refuge, part of CDFW's Allenworth Ecological Reserve, and 10 very small mitigation parcels owned by CDFW adjacent to Pixley National Wildlife Refuge (**Figure 9.25**).

9.7.4.1.Vernal Pool Fairy Shrimp Occurrences

There are four Diversity Database occurrence records for the vernal pool fairy shrimp within this core area (see **Figure 9.26**; Diversity Database 2022). As of 2018, two of these occurrences were within protected areas (Vollmar et al. 2017). All occurrences are presumed extant by the Diversity Database and overlap extant vernal pool grasslands, although one of the occurrences is centered over an area that was not mapped as vernal pool grassland (Witham 2021). All four occurrence were known at the time of listing in 1994. The northern two occurrences are located on private land, and the southern two occurrences are located on the central portion of Pixley National Wildlife Refuge. In 2022, six vernal pools within the Centerfield unit of Pixley National Wildlife Refuge (the area with the Diversity Database occurrences) were surveyed; the vernal pool fairy shrimp was identified in five of the pools (Jimenez, *in litt*. 2023).

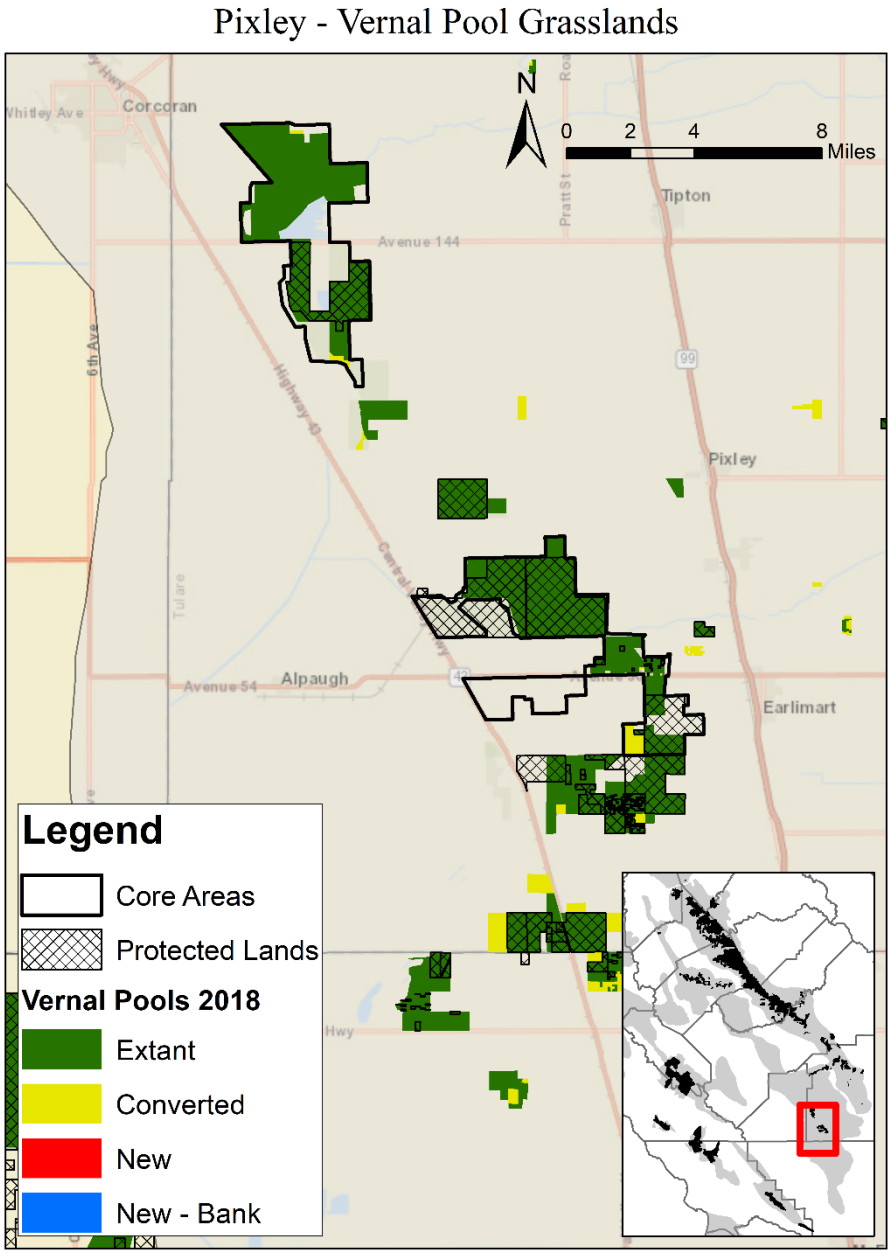

Figure 9.24. Map of vernal pool grassland habitat within the Pixley Core Area mapped by Witham (2021) created using aerial imagery from 2018 compared to 2005 and 2012. "New" vernal pool habitat refers to areas not seen in the 2005 or 2012 aerial imagery (either missed or restored). "New - bank" refers to newly created vernal pool habitat on mitigation lands. Converted habitat refers to vernal pool habitat that was seen in 2005 or 2012 aerial imagery and by 2018 was converted to other land uses. Modified habitat as described by Witham (2021) was altered but still provides suitable vernal pool habitat (e.g., mitigation banks, lands managed for waterfowl), and so is mapped as extant. Zoom in for finer resolution.

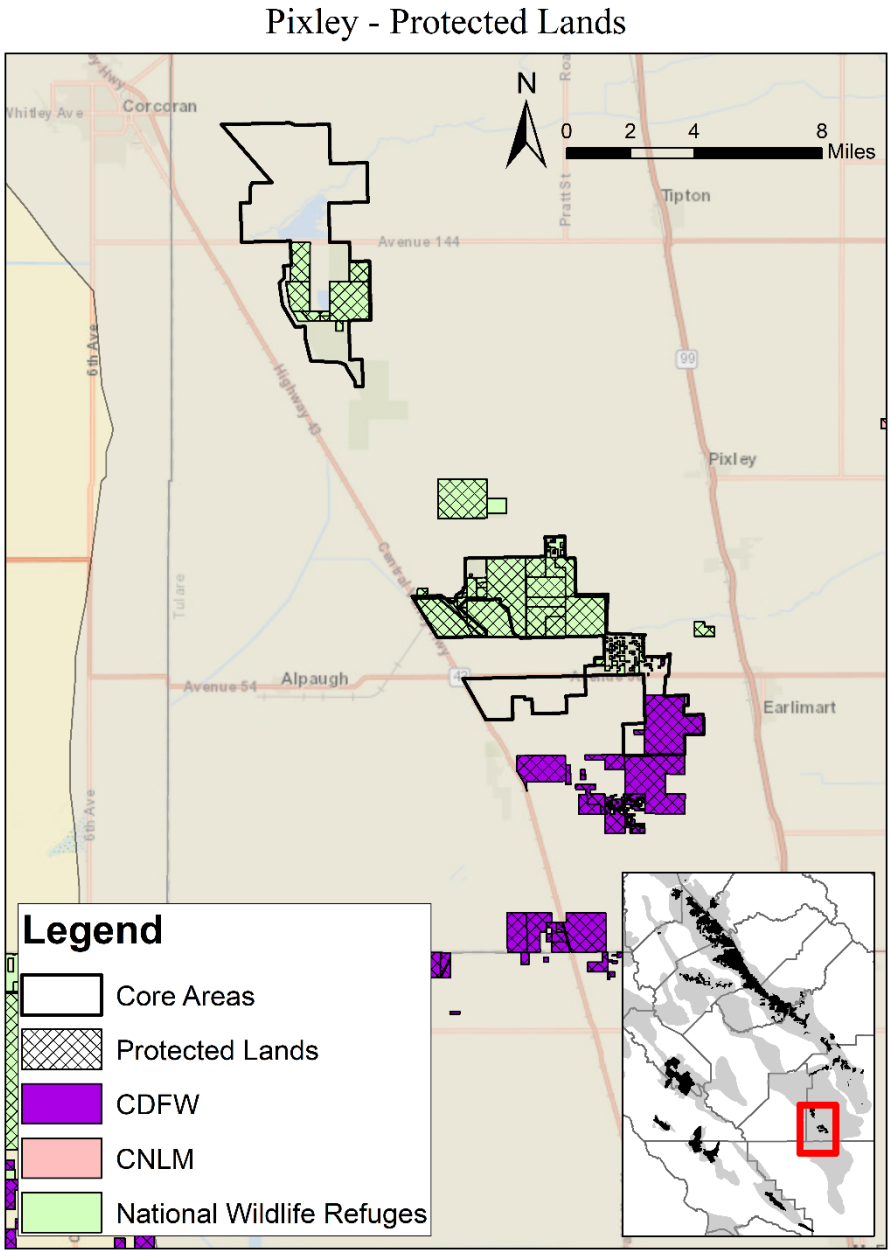

Figure 9.25. Map of protected areas within the Pixley Core Area**.** Protected lands are based on Vollmar et al. (2017) and include various preserves. CDFW = California Department of Fish and Wildlife, CNLM = Center for Natural Lands Management.

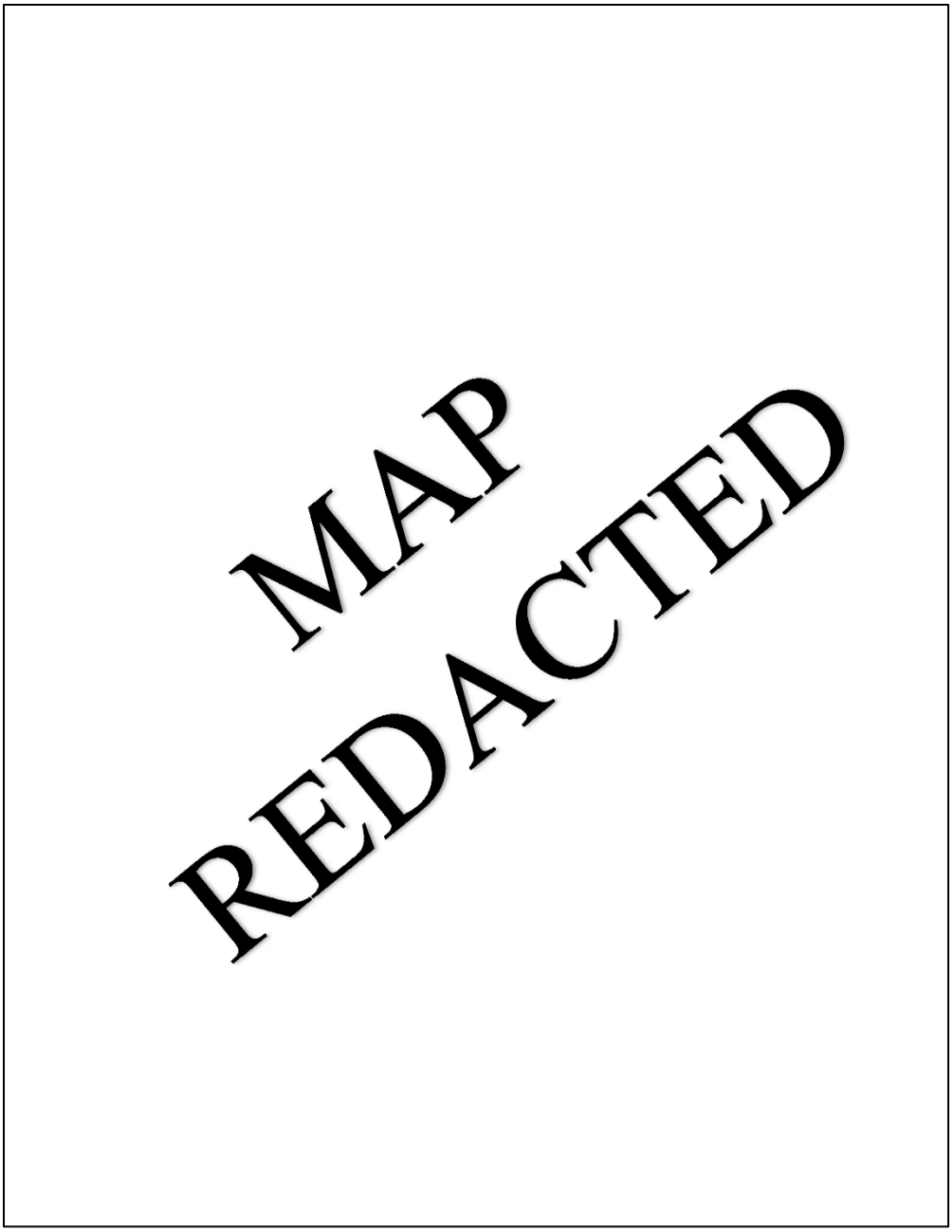

Figure 9.26. Map of known occurrences of vernal pool fairy shrimp recorded in the Diversity Database (2022) within the Pixley Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.