11. SOLANO-COLUSA VERNAL POOL REGION

All three shrimp species occur within the Solano-Colusa Vernal Pool Region.

11.1. Vernal Pool Habitat

Approximately 45,918 acres of vernal pool grassland existed within, or immediately adjacent to, this region when the Recovery Plan was published in 2005 (see **Figure 11.1**, **Table 11.1**; Witham et al. 2013). Witham et al.'s (2013) study area did not include the small portion of this vernal pool region in Contra Costa County (**Figure 1.1**), which includes the Rodeo Creek Core Area, so there is a small amount of vernal pool habitat that has not been accounted for in this and subsequent acreage figures. Approximately 45,276 acres remained as of 2012, with 814 acres (1.8% of 2005 total) lost between 2005 and 2012 (Witham et al. 2014). However, 172 acres of new vernal pool grassland were created over that same period on vernal pool mitigation banks and other managed wetlands. Of the habitat lost, 111 acres (13.6%) were to urbanization and 703 acres (86.4%) were to agricultural conversion (49.3% to rice or row crops, 36.0% to bare plowed agricultural land, and 1.1% to agricultural residences) (Witham et al. 2014).

By 2018, approximately 44,553 acres of vernal pool grassland remained, with a total of 1,740 acres (3.8% of 2005 total) lost between 2005 and 2018 (see **Table 11.1**; Witham 2021). However, 203 acres of new vernal pool grassland were identified in the 2018 aerial imagery that were either not present or not visible on both the 2005 and 2012 aerial imagery. Of the habitat lost since 2005, 349 acres (20.0%) were to urbanization and 1,392 acres (80.0%) were to agricultural conversion (47.6% to bare plowed agricultural land, 15.4% to orchards or vineyards, 9.0% to alfalfa or irrigated pasture, 7.5% to rice or row crops, and 0.5% to agricultural residences) (see **Table 11.2**; Witham 2021). Note the changing composition of agricultural uses in this region; many areas are in the transitory state of bare plowed land, and there has been a large shift from rice and row crops in 2012 to a mix of orchards, vineyards, alfalfa, irrigated pasture, rice, and row crops in 2018.

Agricultural land conversion was the main cause of vernal pool losses, although this region did have the second lowest amount of agricultural conversions in the Central Valley, both in terms of acres lost and percentage of the 2005 baseline, second only to the Northeastern Sacramento Valley Vernal Pool Region (Witham 2021). This region also had a fairly small amount of vernal pool losses due to urbanization. However, because the total amount of vernal pool losses in this region was so low, the Solano-Colusa Vernal Pool Region actually exhibited the highest percentage of losses that were due to urbanization (20.0%). This was even greater than the percentage of losses due to urbanization in the quickly growing Southeastern Sacramento Valley Vernal Pool Region (18.4%), although the actual acreage of losses was much higher in that region (2,976 acres). These losses were concentrated around the populous cities of Vacaville and Fairfield.

Solano County had a population of approximately 459,857 in 2020, up 11.2% from 2010 (County of Solano and Solano Economic Development Corporation 2022). The cities of Vacaville and Fairfield represent approximately half the population of Solano County. The population is expected to continue growing over the next several decades, although the pace of growth is expected to slow, with a projected population of 479,372 in 2030 (4.2% increase over

10 years) (County of Solano and Solano Economic Development Corporation 2022). Thus, urbanization will likely continue to be a significant cause of habitat loss for the vernal pool fairy shrimp within this region.

As of 2018, roughly 18,347 acres of vernal pool grassland were estimated to be protected in this region, or immediately adjacent to it (see **Figure 11.1**, **Figure 11.2**, **Table 11.1**; Witham 2021; Vollmar et al. 2017). This represents 41% of the currently remaining vernal pool grassland in the region and 40% of the vernal pool grassland that existed in the region in 2005, the Recovery Plan's baseline.

11.2. Species Occurrences

11.2.1. Vernal Pool Fairy Shrimp

There are 46 occurrence records of the vernal pool fairy shrimp documented within, or immediately adjacent to, the Solano-Colusa Vernal Pool Region in the Diversity Database (see **Figure 11.3**; Diversity Database 2022). There are a wide variety of private and public landowners listed in the Diversity Database for these occurrences. All 46 occurrences are presumed extant by the Diversity Database; 31 occur within extant vernal pool habitat based on Witham's (2021) mapping efforts and 15 are outside of mapped vernal pool habitat.

The protected areas contain, at least partially, 26 of the 46 Diversity Database records (57%) for the vernal pool fairy shrimp in this region. However, this does not mean that 57% 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 11 of the 46 Diversity Database polygons (24%) 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.

11.2.2. Vernal Pool Tadpole Shrimp

There are 41 occurrence records of the vernal pool tadpole shrimp documented within the Solano-Colusa Vernal Pool Region in the Diversity Database (see **Figure 11.4**; Diversity Database 2022). There are a wide variety of private and public landowners listed in the Diversity Database for these occurrences. All 41 occurrences are presumed extant by the Diversity Database; 33 occur within extant vernal pool habitat based on Witham's (2021) mapping efforts, 1 is within extirpated vernal pool habitat, and 7 are outside of mapped vernal pool habitat.

The protected areas contain, at least partially, 35 of the 41 Diversity Database records (85%) for the vernal pool tadpole shrimp in this region. Only 17 of the 41 Diversity Database polygons (41%) 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.

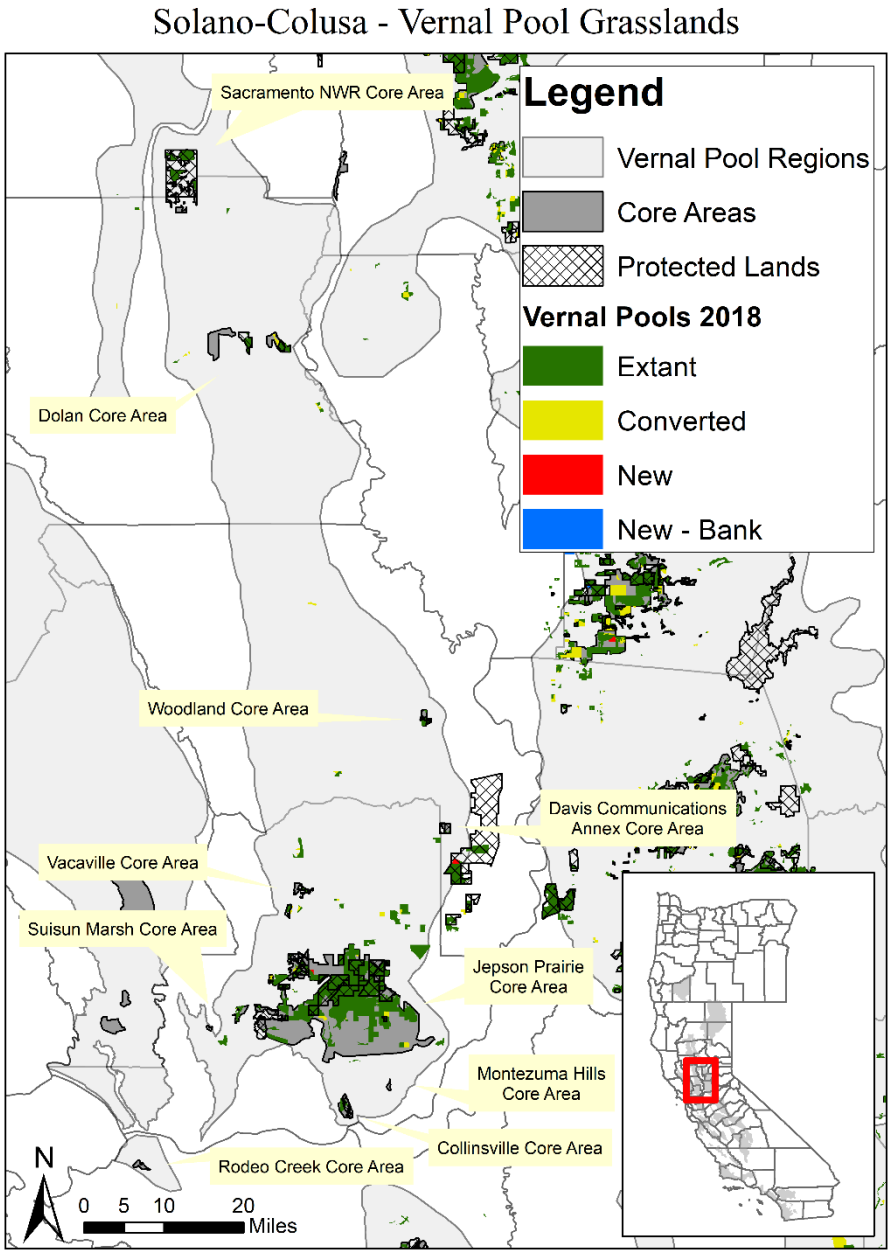

Figure 11.1. Map of vernal pool habitat within the Solano-Colusa Vernal Pool Region mapped by Witham (2021) created using aerial imagery from 2018 compared to 2005 and 2012. "New" vernal pool habitat refers to areas not seen in the 2005 or 2012 aerial imagery (either missed or restored). "New - bank" 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.

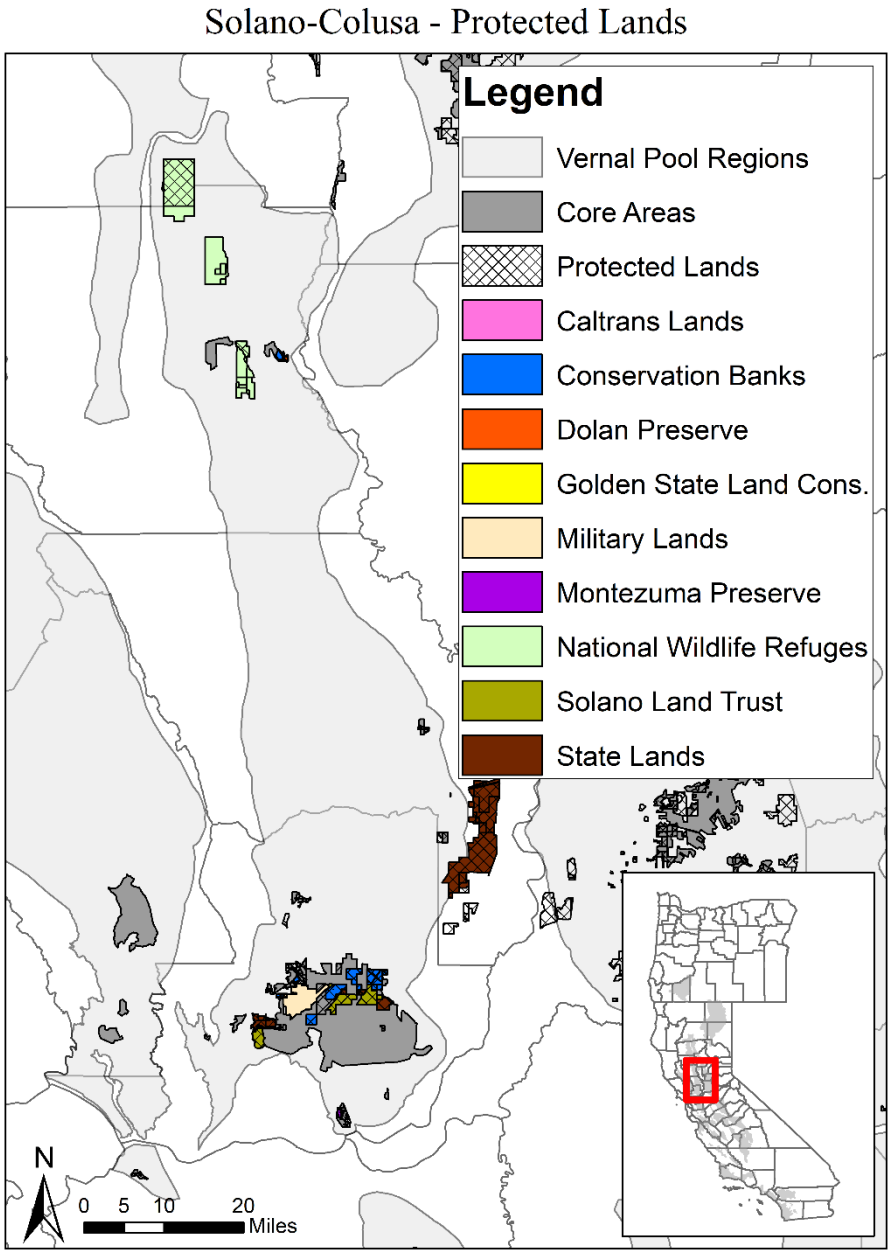

Figure 11.2. Map of protected areas that contain vernal pool grassland habitat and/or the three shrimp species within the Solano-Colusa Vernal Pool Region**.** Protected lands are based on Vollmar et al. (2017) and include various preserves. Zoom in for finer resolution.

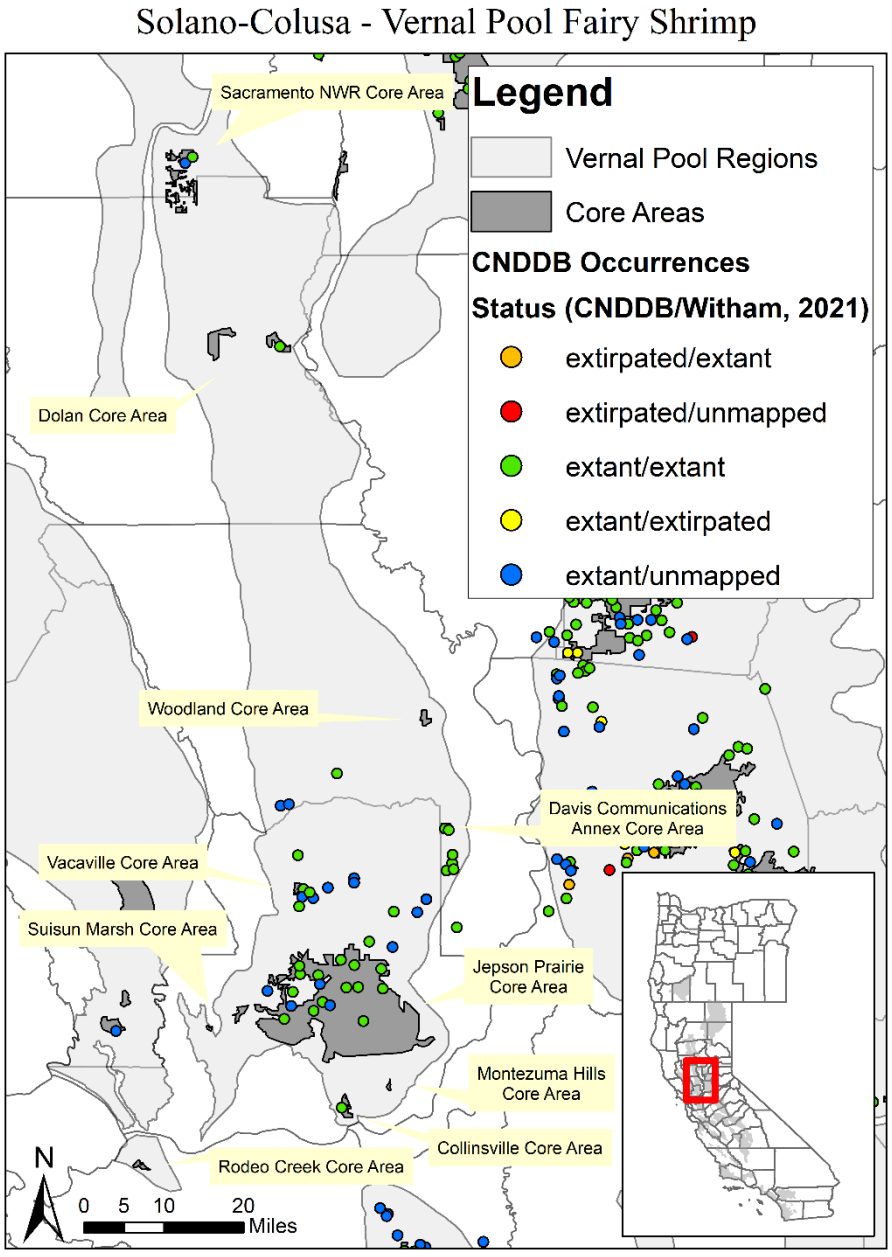

Figure 11.3. Map of known occurrences of vernal pool fairy shrimp recorded in the Diversity Database (2022) in the Solano-Colusa Vernal Pool Region. Points may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both Diversity Database occurrence records and Witham's (2021) map of vernal pool habitat. All 10 core areas in the region are displayed, though not all core areas are designated for the vernal pool fairy shrimp.

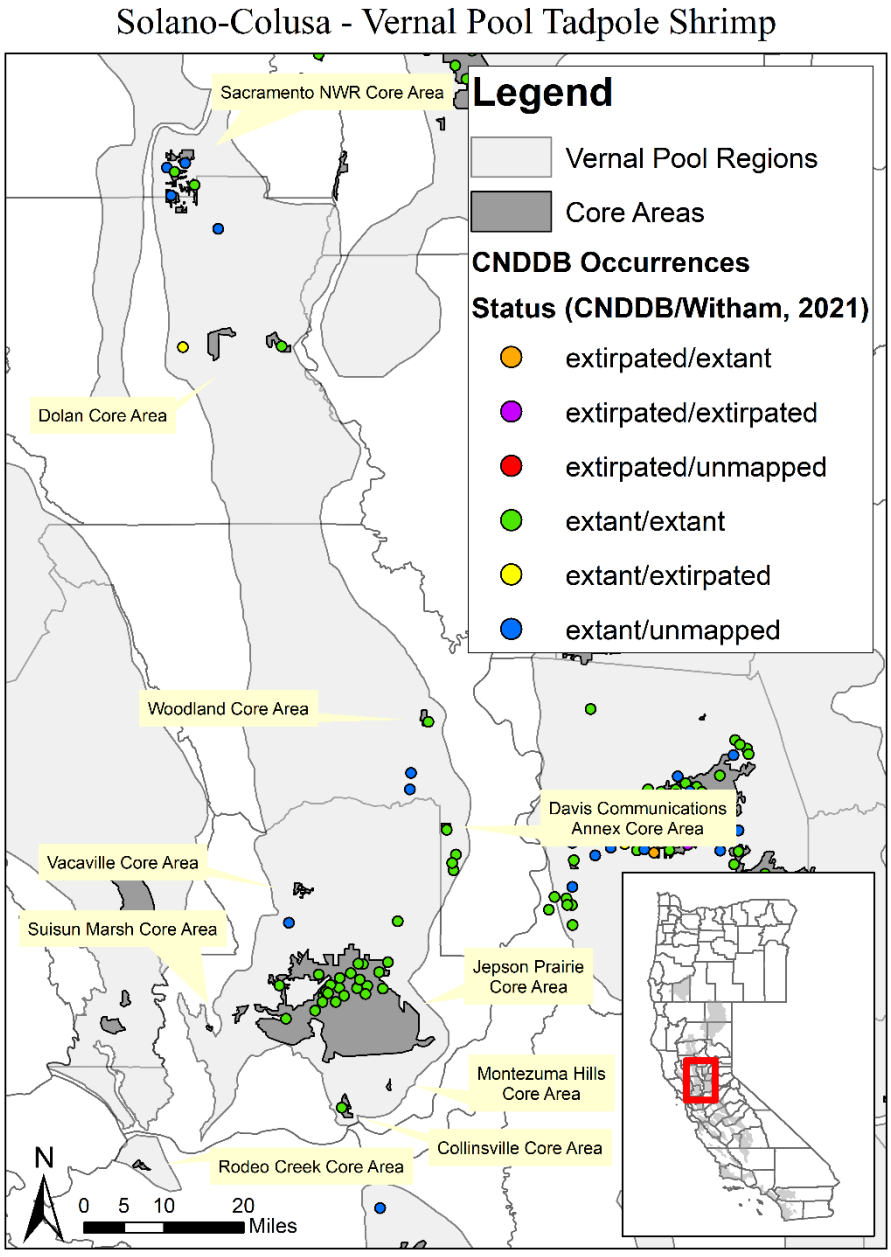

Figure 11.4. Map of known occurrences of vernal pool tadpole shrimp recorded in the Diversity Database (2022) in the Solano-Colusa Vernal Pool Region. Points may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both Diversity Database occurrence records and Witham's (2021) map of vernal pool habitat. All 10 core areas in the region are displayed, though not all core areas are designated for the vernal pool tadpole shrimp.

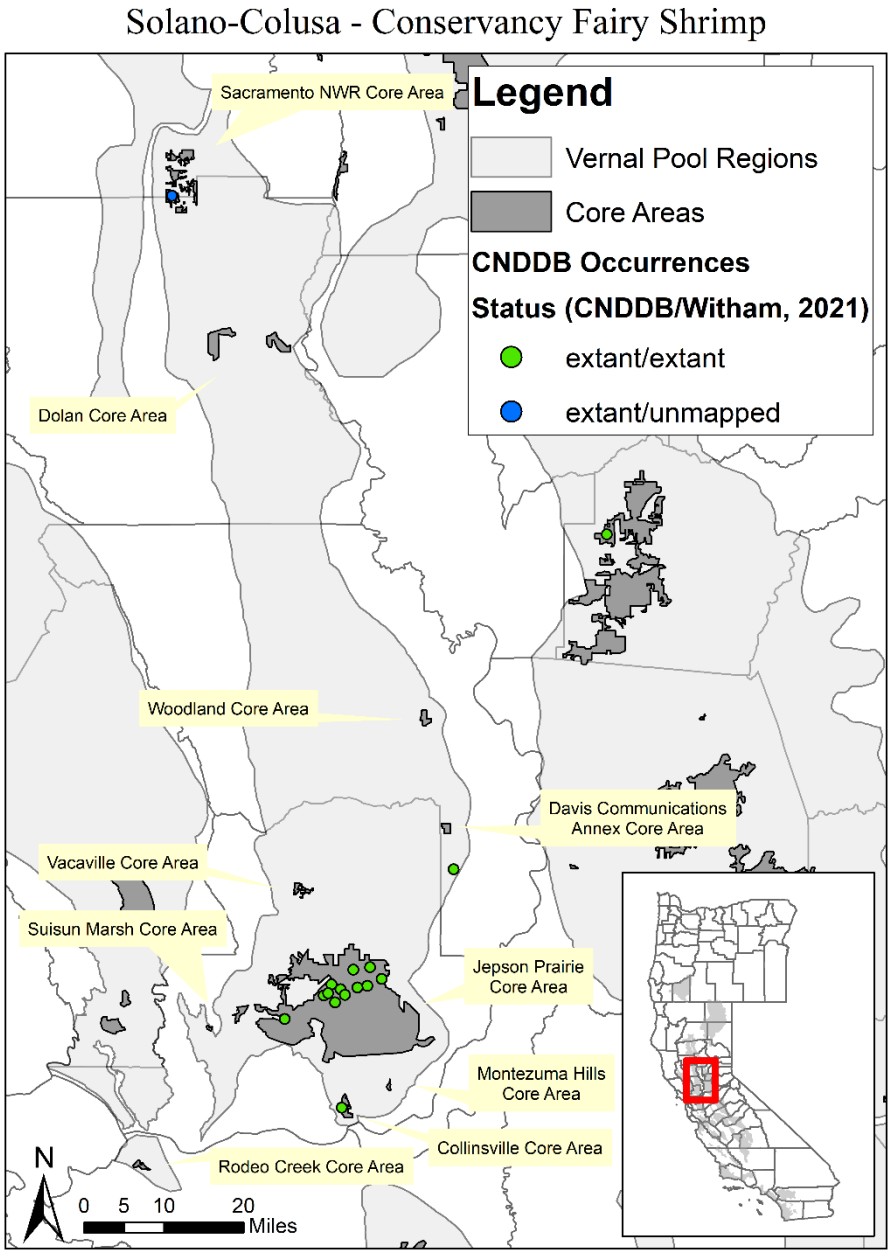

Figure 11.5. Map of known occurrences of Conservancy fairy shrimp recorded in the Diversity Database (2022) in the Solano-Colusa Vernal Pool Region. Points may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both Diversity Database occurrence records and Witham's (2021) map of vernal pool habitat. All 10 core areas in the region are displayed, though not all core areas are designated for the Conservancy fairy shrimp.

Table 11.1. Acreage of vernal pool habitat and habitat converted within the Solano-Colusa 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)
Collinsville	410.2	410.2	410.2 (100.0%)	0.0 (0.0%)	0.0 (0.0%)	154.7 (37.7%)
Davis Communications Annex	99.6	100.4	100.4 (100.0%)	0.0 (0.0%)	0.0 (0.0%)	100.0 (99.7%)
Dolan	565.5	565.5	395.1 (69.9%)	170.4 (30.1%)	0.0 (0.0%)	248.0 (43.9%)
Jepson Prairie	31,467.3	31,526.6	30,822.5 (97.8%)	506.4 (1.6%)	197.8 (0.6%)	11,203.5 (35.5%)
Sacramento National Wildlife Refuge	1,530.1	1,530.1	1,530.1 (100.0%)	0.0 (0.0%)	0.0 (0.0%)	1,530.1 (100.0%)
Vacaville	164.3	164.3	164.3 (100.0%)	0.0 (0.0%)	0.0 (0.0%)	154.6 (94.1%)
Woodland	337.7	337.7	337.7 (100.0%)	0.0 (0.0%)	0.0 (0.0%)	187.8 (55.6%)
Solano-Colusa Vernal Pool Region Total	**45,918.3**	**46,292.9**	**44,552.8 (96.2%)**	**1,391.5 (3.0%)**	**348.7 (0.8%)**	**18,346.9 (39.6%)**

Table 11.2. Acreage of vernal pool habitat losses within the Solano-Colusa 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
Collinsville	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N/A	N/A
Davis Communications Annex	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N/A	N/A
Dolan	0.0	170.4	0.0	0.0	0.0	0.0	0.0	170.4	0.0%	100%
Jepson Prairie	197.8	0.0	0.0	502.2	0.0	4.2	0.0	506.4	28.1%	71.9%
Sacramento National Wildlife Refuge	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N/A	N/A
Vacaville	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N/A	N/A
Woodland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N/A	N/A
Solano-Colusa Vernal Pool Region Total	**348.7**	**267.8**	**156.1**	**828.9**	**129.9**	**8.8**	**0.0**	**1,391.5**	**20.0%**	**80.0%**

11.2.3. Conservancy Fairy Shrimp

There are 15 occurrence records of the Conservancy fairy shrimp documented within, or immediately adjacent to, the Solano-Colusa Vernal Pool Region in the Diversity Database (see **Figure 11.5**; Diversity Database 2022). These occurrences include the Sacramento National Wildlife Refuge, Yolo Bypass Wildlife Area, and Jepson Prairie populations. The Sacramento National Wildlife Refuge and Yolo Bypass Wildlife Area occurrences are on federal and state land, respectively, and both consist of only a single vernal pool. The other 13 occurrences are all on private land, though all of these occurrences are at least partly within protected lands (Vollmar et al. 2017). All 15 occurrences are presumed extant by the Diversity Database; 14 occur within extant vernal pool habitat based on Witham's (2021) mapping efforts and 1 is outside of mapped vernal pool habitat.

The protected areas contain, at least partially, all 15 of the Diversity Database records (100%) for the Conservancy fairy shrimp in this region. Only 4 of the 15 Diversity Database polygons (27%) 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.

11.3. Federal Lands

11.3.1. National Wildlife Refuges

Within the Solano-Colusa Vernal Pool Region, vernal pool grassland complexes are known to occur on three Refuges within the Sacramento National Wildlife Refuge Complex: Colusa National Wildlife Refuge, Delevan National Wildlife Refuge, and Sacramento National Wildlife Refuge (**Figure 11.2**). The vernal pool fairy shrimp and Conservancy fairy shrimp are known to occur on the Sacramento National Wildlife Refuge, but not on the Colusa or Delevan National Wildlife Refuges. The vernal pool tadpole shrimp is known to occur throughout the Sacramento Refuge and in one vernal pool on the Delevan Refuge, but not the Colusa Refuge.

The primary purpose of the Refuge Complex is to maintain managed wetlands that support habitat for birds on the Pacific Flyway, but there are also many other habitats such as vernal pool grasslands throughout the complex given that they are some of the last large areas of undeveloped lands in an otherwise agricultural landscape. A Comprehensive Conservation Plan was prepared for these three Refuges, as well as the Sutter National Wildlife Refuge, in 2009 that included the three shrimp species (Service 2009b).

All three Refuges are located between Interstate 5 and the Sacramento River in eastern Colusa and Glenn Counties. The Colusa National Wildlife Refuge is 4,868 acres, 619 acres of which are vernal pool complexes or alkali meadows (Service 2009b). The Delevan National Wildlife Refuge is 5,877 acres, 461 acres of which are vernal pool complexes or alkali meadows (Service 2009b). The Sacramento National Wildlife Refuge is 10,819 acres, 2,941 acres of which are vernal pool complexes or alkali meadows (Service 2009b). The Sacramento National Wildlife Refuge specifically has a core area that encompasses the potential locations of vernal pool complexes on the Refuge. Witham's (2021) mapping identified only 529, 0, and 1,641 acres of

vernal pool grassland within each of the Refuges, respectively, so there is more vernal pool habitat in this region than aerial imagery indicate. Management on the Refuges consists of grassland and invasive species management through grazing, mowing, or prescribed fire, habitat restoration, and regular monitoring of plant and animal populations (Service 2009b).

A total of 11 years of vernal pool shrimp surveys have occurred within the Sacramento National Wildlife Refuge Complex between 1993 and 2017 (D'Errico, *in litt*. 2022), though likely not every Refuge or every pool was surveyed each year. On the Sacramento Refuge, the vernal pool fairy shrimp was definitively identified in 1 pool in 2004 and in 6 pools out of 45 sampled in 2017, all in the northeast of the Refuge (Helm Biological Consulting 2017; D'Errico, *in litt*. 2022). However, numerous pools throughout the Refuge were documented as having *Branchinecta* individuals that were not identified to the species level during surveys from 1993-1998; there are three other species of *Branchinecta* known within the Refuge, but it is likely that at least some of these occurrences represent the vernal pool fairy shrimp (D'Errico, *in litt*. 2022). The vernal pool tadpole shrimp was identified in 6 pools out of 45 sampled in 2017, located in the north, west, and south of the Refuge (Helm Biological Consulting 2017). The vernal pool tadpole shrimp had also previously been identified in two pools in the southeast in 1993, 1994, and 2002 (D'Errico, *in litt*. 2022). All of these pools line up with the locations of Diversity Database records within the Sacramento Refuge. The Conservancy fairy shrimp is known from just one pool in the southwest of the Refuge, where it was observed in 1993, 1994, and 2004 (D'Errico, *in litt*. 2022; Diversity Database 2022).

On the Delevan Refuge, the vernal pool tadpole shrimp was identified in one vernal pool at the northern edge of the Refuge in 1994, but it has not been observed in any subsequent surveys (Diversity Database 2022; Helm Biological Consulting 2017; D'Errico, *in litt*. 2022). The vernal pool fairy shrimp and Conservancy fairy shrimp have not been detected within the Colusa or Delevan Refuges, including in the 7 and 11 pools surveyed within each Refuge in 2017, respectively, and the vernal pool tadpole shrimp has not been detected within the Colusa Refuge (Helm Biological Consulting 2017).

11.3.2. Military Lands

The 5,137-acre Travis Air Force Base is located in Solano County east of the City of Fairfield and is owned by the Department of Defense (DOD). Over 90% of the remaining natural habitat within the Base is northern claypan vernal pool grassland complex (DOD 2022). There are 1,735 acres of annual grassland throughout the Base, and over 600 vernal pools and swales have been identified, with the highest quality pools located in the northwestern portion of the Base (**Figure 11.6**). Witham (2021) only mapped 169 acres of extant vernal pool grassland within the Base, and this was mostly located in the northwestern portion of the Base. Of the 600 pools, 256 were created as part of a long-term mitigation study; the created pools continue to exhibit similar hydrology to adjacent natural pools and the soil seed bank remains relatively dominated by native plant species (DOD 2022).

The vernal pool fairy shrimp was first identified on the Base in 2005 and has been consistently documented during survey efforts (DOD 2022). The most recent surveys, completed in 2018, found the vernal pool fairy shrimp in many vernal pools on the Base and on three offsite geographically separated units (GSUs): the 70-acre Railroad Right-of-Way GSU, the 0.23-acre

Outer Runway Marker GSU, and the 1.86-acre Middle Runway Marker GSU. The vernal pool tadpole shrimp has never been documented on the Base itself, though it was documented within one offsite GSU, the Railroad Right-of-Way GSU to the north, in 2005 (see **Figure 11.6**; DOD 2022). There are also several occurrences of the vernal pool tadpole shrimp on properties immediately adjacent to the Base (Diversity Database 2022). The Conservancy fairy shrimp has never been documented within the Base or any GSUs. Wetland management on the Base focuses on protection from human disturbance, managing the grassland and invasive plant species through grazing, mowing, and prescribed fire, and monitoring of vernal pools and endemic plant and animal species like the vernal pool fairy shrimp (DOD 2022).

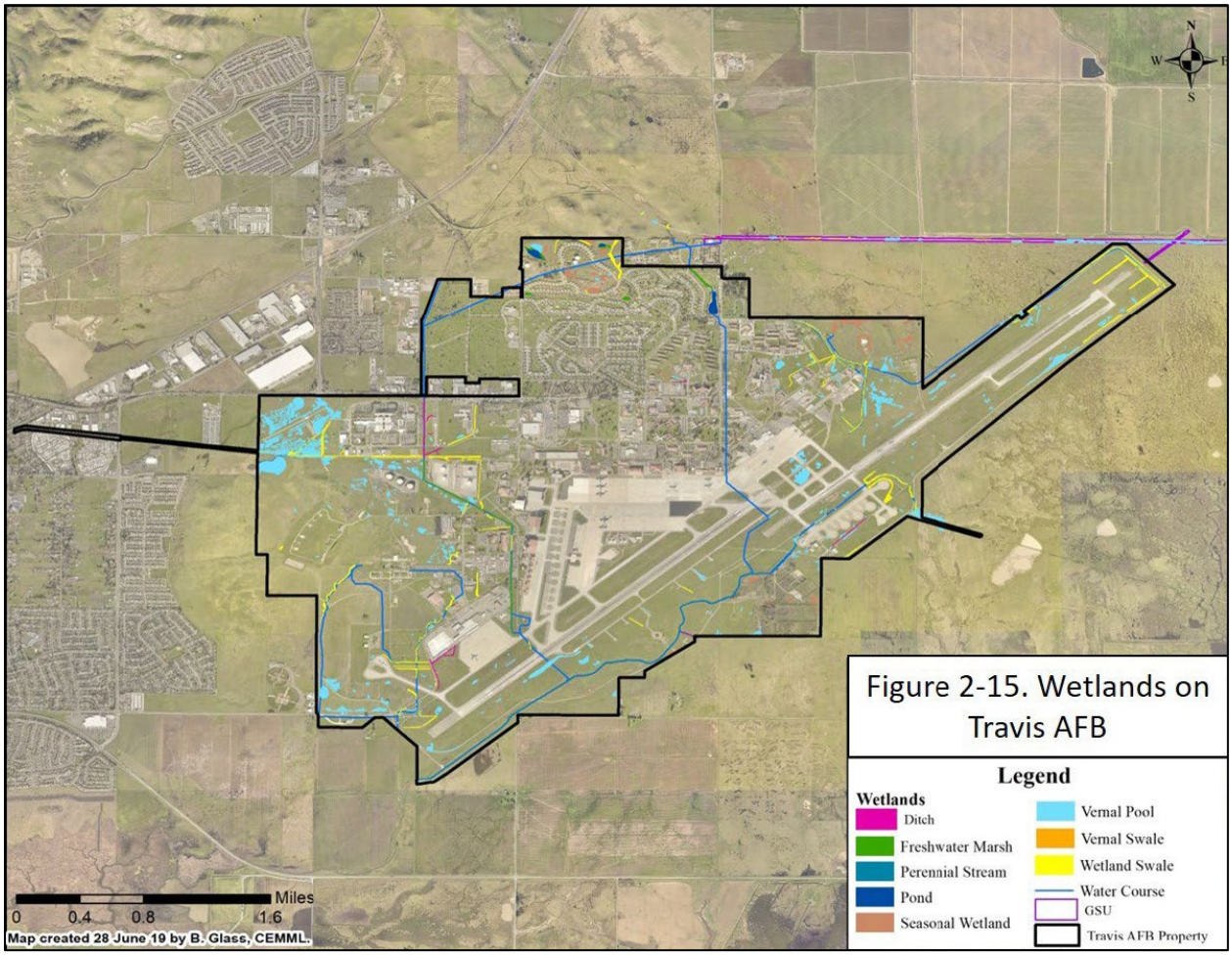

Figure 11.6. Map of vernal pools and other wetland features on Travis Air Force Base (AFB). Taken from Figure 2-15 of the 2022 Integrated Natural Resources Management Plan for Travis Air Force Base (DOD 2022).

11.3.3. Bureau of Land Management

There are no Bureau of Land Management lands with known occurrences of the three shrimp species in the Solano-Colusa Vernal Pool Region.

11.3.4. Other Federal Lands

There are no other federal lands with known occurrences of the three shrimp species in the Solano-Colusa Vernal Pool Region.

11.4. Conservation Banks

This region has the second largest number of banks and total acreage protected within banks, and it has the largest acreage of vernal pool preservation credits (acreage of the pools only, not the grassland complex). Conservation banks account for almost 30% of all protected vernal pool grasslands and 12% of all remaining extant vernal pool grasslands within this region (**Figure 11.2**). Thus, this is the region with the most significant contribution from conservation banking toward vernal pool conservation.

There are seven conservation or mitigation banks within the Solano-Colusa Vernal Pool Region that provide credits for preserved vernal pools that support the vernal pool fairy shrimp: Burke Ranch, Campbell Ranch, Dolan Ranch, Elsie Gridley, Muzzy Ranch, Noonan Ranch, and North Suisun (RIBITS 2021). These banks protect a total of 5,299 acres of land, including 961.197 acres of preserved vernal pools, 839.207 acres of which provide habitat for the vernal pool fairy shrimp (Table 6). The seven banks have sold a total of 116.424 acres of preservation credits (14%) for the vernal pool fairy shrimp (RIBITS 2021).

There are seven conservation or mitigation banks within the Solano-Colusa Vernal Pool Region that provide credits for preserved vernal pools that support the vernal pool tadpole shrimp: Burke Ranch, Campbell Ranch, Dolan Ranch, Elsie Gridley, Goldfields, Muzzy Ranch, and North Suisun (RIBITS 2021). These banks protect a total of 5,262 acres of land, including 962.217 acres of preserved vernal pools, 634.917 acres of which provide habitat for the vernal pool tadpole shrimp (Table 6). The seven banks have sold a total of 123.614 acres of preservation credits (19%) for the vernal pool tadpole shrimp (RIBITS 2021).

There are two conservation or mitigation banks within the Solano-Colusa Vernal Pool Region that provide credits for preserved vernal pools that support the Conservancy fairy shrimp: Elsie Gridley and Muzzy Ranch (RIBITS 2021). These banks protect a total of 3,126 acres of land, including 505.60 acres of preserved vernal pools, 121.99 acres of which provide habitat for the Conservancy fairy shrimp (Table 6). The two banks have sold a total of 13.044 acres of preservation credits (11%) for the Conservancy fairy shrimp (RIBITS 2021). On Elsie Gridley, the Conservancy fairy shrimp was first detected in 2008 within two large preserved pools in the northwest corner; the species was observed in 2013 in these pools again as well as six restored pools in the southeast corner, and again in 2017 in one preserved pool and three restored pools (WRA Environmental Consultants 2017; Diversity Database 2022). On Muzzy Ranch, the Conservancy fairy shrimp was first detected in 2011 within five pools and was most recently detected in 2021 within five pools (Diversity Database 2022; LSA 2022).

The Burke Ranch Conservation Bank also supports the Conservancy fairy shrimp, though it does not sell any preservation credits for the species. This bank is 960 acres and contains 273.6 acres of preserved vernal pools for the vernal pool fairy shrimp and vernal pool tadpole shrimp (RIBITS 2021). On Burke Ranch, the Conservancy fairy shrimp was first detected in 1999 and has frequently been observed within multiple pools during regular monitoring since, most recently in 2023 (Westervelt Ecological Services 2019b; Diversity Database 2022; S. O'Brien, ICF, *in litt*. 2023).

11.5. Habitat Conservation Plans

There are two regional Habitat Conservation Plans (HCPs) within the Solano-Colusa Vernal Pool Region that include the three shrimp species as Covered Species. A third HCP, the Yolo HCP, covers all of Yolo County and includes vernal pool plant species, but does not include the three shrimp species as Covered Species (ICF 2018). Vernal pool habitat will be preserved as a result of the Yolo HCP, some of which may be occupied by the three shrimp species.

11.5.1. PG&E Bay Area Operations and Maintenance HCP

See section 3.5.1 for a description of this HCP.

11.5.2. PG&E Multiple Region Operations and Maintenance HCP

See section 2.5.1 for a description of this HCP.

11.6. Other Preserves

The California Department of Fish and Wildlife (CDFW) owns three preserved areas in this region with vernal pool habitat: Yolo Bypass Wildlife Area, Calhoun Cut Ecological Reserve, and Hill Slough Wildlife Area. They also hold conservation easements over three properties: the Dixon Vernal Pools, Saxon, and Skyraker conservation easements.

The Yolo Bypass Wildlife Area consists of 16,770 acres of managed wildlife habitat and agricultural land within the Yolo Bypass, south of Interstate 80 along the Sacramento River, with the main focus of the Wildlife Area being managed wetlands for waterfowl (CDFW 2008). A survey from 2003 documented 1,600 acres of vernal pool grassland complexes within the Wildlife Area (CDFW 2008), and mapping from aerial imagery in 2018 estimated 2,016 acres of vernal pool grassland in the southern portion, mostly within Tule Ranch, and an additional 940 acres that may be vernal pool grassland or may be marsh (Witham 2021). The Land Management Plan, completed in 2008, generally states that management activities will be implemented to maintain, enhance, and/or restore vernal pool species, including following accepted scientific principles regarding grazing, prescribed fire, and herbicide use, but does not include more specific discussion of vernal pool management (CDFW 2008). Vernal pool surveys are not conducted due to the lack of funding and staffing available and because vernal pools are not the main focus of the Wildlife Area (J. Hobbs, CDFW, *in litt*. 2022). At the southern end of the Wildlife Area, there are two conservation easements held by CDFW, Saxon and Skyraker, adjacent to the Wildlife Area that slightly overlap with mapped vernal pool grassland, as well as a separate conservation easement held by the Natural Resources Conservation Service (NRCS).

There are four Diversity Database occurrences of the vernal pool fairy shrimp and three occurrences of the vernal pool tadpole shrimp within the Yolo Bypass Wildlife Area, all within Tule Ranch in the southern portion of the Wildlife Area (Diversity Database 2022). For both species, two of these occurrences were first identified in 2002 and are found along disturbed habitat associated with the railroad grade. The other occurrences, first identified in 2003 for the vernal pool tadpole shrimp and 2008 for the vernal pool fairy shrimp, were found in more natural habitat within Tule Ranch. The Conservancy fairy shrimp is known from one vernal pool on the Tule Ranch in the southern portion of the Wildlife Area (Diversity Database 2022); this single pool makes up the entirety of the Yolo Bypass Wildlife Area population. The species was first detected in 2003 and again in 2008 (Diversity Database 2022). The Service is not aware of any more recent surveys.

The Calhoun Cut Ecological Reserve is composed of the original 971-acre eastern property acquired by CDFW in 1990 and the more recently acquired 234-acre western property. The Ecological Reserve is located on either side of the Jepson Prairie Preserve and Highway 113 in Solano County. Approximately half of the eastern property and all of the western property are mapped as vernal pool grassland (Witham 2021). The Ecological Reserve is managed according to a general management plan from 1991 that mentions the importance of the vernal pool habitat and includes grazing (CDFW 1991). The three shrimp species have not been documented within the Ecological Reserve, but all three have been found immediately adjacent in the Jepson Prairie Preserve, Wilcox Ranch Preserve, and the PG&E pipeline right-of-way (Diversity Database 2022). CDFW does not monitor the vernal pools, and currently the position overseeing CDFW's Solano County vernal pool properties is vacant (B. Shelton, CDFW, *in litt*. 2022). CDFW also holds a conservation easement, known as the Dixon Vernal Pools conservation easement, over a 161-acre property on the Jepson Prairie between the Muzzy Ranch Conservation Bank and the Wilcox Ranch Preserve.

The Hill Slough Wildlife Area is located in Suisun Marsh south of Suisun City in Solano County. The primary purpose of this Wildlife Area is to protect marsh habitat, though there is a 96-acre patch of vernal pool grassland mapped by Witham (2021) in the northern portion of the Wildlife Area adjacent to Suisun City. The Hill Slough Wildlife Area is managed under the Grizzly Island Wildlife Area management plan from 1988, which does not describe management of vernal pool habitat (CDFW 1988; Shelton, *in litt*. 2022). The three shrimp species are not known to occur within the Hill Slough Wildlife Area, though all three species do occur adjacent to the southeastern corner within two mitigation sites.

There are various other protected mitigation and non-mitigation lands throughout the Solano-Colusa Vernal Pool Region, primarily within the greater Jepson Prairie area of Solano County (see **Figure 11.2**; Vollmar et al. 2017). In addition to the state lands and conservation or mitigation banks throughout the Jepson Prairie, there is a sizable amount of land preserved by the Solano Land Trust and/or The Nature Conservancy. The Solano Land Trust owns the Jepson Prairie Preserve and the Wilcox Ranch Preserve, both of which were previously acquired by The Nature Conservancy who still hold the conservation easements. The Jepson Prairie Preserve in particular has been an extremely important location for research and public education programs related to vernal pool species. The Nature Conservancy also holds conservation easements over the land east of Travis Air Force Base and west of Muzzy Ranch Conservation Bank and the Wilcox Ranch Preserve. Solano Land Trust also owns Rush Ranch in the Suisun Marsh area,

which has a small amount of mapped vernal pool grassland. One preserve not fully captured in Vollmar et al.'s (2017) database of protected lands is the Paradise Crest Wetland located in northeastern Fairfield that has a conservation easement held by the Golden State Land Conservancy. Another is the Montezuma Wetlands Project Preserve located in the Collinsville Core Area that has a conservation easement held by Solano County.

One preserve outside of Solano County not captured in Vollmar et al.'s (2017) database is the 121-acre Dolan Preserve, located adjacent to the Dolan Ranch Conservation Bank in the Dolan Core Area, Colusa County. In addition, Vollmar et al.'s (2017) and Witham's (2021) study areas did not extend to the San Francisco Bay Area, so there is a small amount of vernal pool grassland and protected land within the disconnected area of this vernal pool region in Contra Costa County that is not accounted for in their databases. Within this area, habitat that supports Contra Costa goldfields (*Lasthenia conjugens*), a vernal pool plant species, occurs within the Hercules Easement (a.k.a. State Route 4 Preserve) in the Rodeo Creek Core Area, which has a conservation easement held by Caltrans and managed by the Muir Heritage Land Trust (Service 2013). There are also various lands owned by, or with easements held by, the East Bay Regional Park District, but the Service is not aware of any vernal pool habitat that occurs within these protected lands.

11.7. Vernal Pool Core Areas

There are three Core Areas within the Solano-Colusa Vernal Pool Region that are designated in the Recovery Plan for the vernal pool fairy shrimp: Jepson Prairie, Sacramento National Wildlife Refuge, and Vacaville. There are three additional Core Areas that were not designated for the vernal pool fairy shrimp in the Recovery Plan, but that have known occurrences of the species in the Diversity Database: Collinsville, Davis Communications Annex, and Dolan (Diversity Database 2022). For the Davis Communications Annex Core Area, the vernal pool fairy shrimp was not identified until 2010, which is why this core area was not designated for the vernal pool fairy shrimp in the Recovery Plan. For the Collinsville and Dolan Core Areas, the Diversity Database occurrences includes information about surveys that occurred before December 2005, so the two core areas likely should have been designated for the vernal pool fairy shrimp in the Recovery Plan; however, it is possible that these occurrence records were not uploaded to the Diversity Database until after 2005.

There are five Core Areas within the Solano-Colusa Vernal Pool Region that are designated in the Recovery Plan for the vernal pool tadpole shrimp: Collinsville, Davis Communications Annex, Dolan, Jepson Prairie, and Sacramento National Wildlife Refuge. There is one additional Core Area that was not designated for the vernal pool tadpole shrimp in the Recovery Plan, but that has known occurrences of the species in the Diversity Database: Woodland (Diversity Database 2022). The vernal pool tadpole shrimp was not identified in the Woodland Core Area until 2011, which is why this core area was not designated for the vernal pool tadpole shrimp in the Recovery Plan.

There are three Core Areas within the Solano-Colusa Vernal Pool Region that are designated in the Recovery Plan for the Conservancy fairy shrimp: Collinsville, Jepson Prairie, and Sacramento National Wildlife Refuge.

Of these seven core areas, three have met the target amount of vernal pool habitat protected based on mapped habitat: Davis Communications Annex, Sacramento National Wildlife Refuge, and Vacaville (see **Table 11.1**; Vollmar et al. 2017; Witham 2021). However, the Vacaville Core Area likely has more vernal pool habitat than what was mapped, meaning that less than 85% is protected, and the Davis Communications Annex was mapped by Vollmar et al. (2017) as entirely protected because it is all public land, but more detailed information about the area shows that these public lands likely do not meet the requirements for protected lands in the Recovery Plan. As of 2018, one core area had lost 30% of the amount of vernal pool habitat that remained in 2005, making the targeted amount of protected habitat unattainable without habitat creation or restoration (see **Table 11.1**; Vollmar et al. 2017; Witham 2021).

11.7.1. Collinsville

This is a zone 1 core area with a goal of protecting 95% of vernal pool habitat for the vernal pool tadpole shrimp and Conservancy fairy shrimp. This core area was not designated for the vernal pool fairy shrimp in the Recovery Plan, but the species is known to occur there. The core area is located in southern Solano County north of the Sacramento River as it enters Suisun Bay.

This core area is entirely encompassed within the upland portions of the Montezuma Wetlands Project. This is a 2,400-acre tidal marsh restoration project, and the adjacent upland area with vernal pools was preserved as mitigation for the loss of vernal pools caused by Phase I of the project (C. Pinnell, Vollmar Natural Lands Consulting, pers. comm. 2022), which was completed in 2003 (Vollmar Natural Lands Consulting 2020). The tidal marsh restoration area included pockets of subsided land that had unnatural vernal pools that had developed after the marsh was dyked in the 1800's. As mitigation, the landowner preserved approximately 3.765 acres of existing vernal pools and 3.777 acres of created vernal pools on the 245-acre Montezuma Wetlands Project Preserve (**Figure 11.7**). Several pools within the preserve totaling 1.361 acres were avoided by the project but are expected to be hydrologically disturbed and thus did not count as mitigation (Pinnell, pers. comm. 2022). Also, 7.403 acres of pools (mostly one large pool) located outside of the conservation easement along the railroad tracks will be hydrologically disturbed in the future; these pools are not natural and are already highly disturbed (Pinnell, pers. comm. 2022), though they have been found to support the vernal pool fairy shrimp and vernal pool tadpole shrimp in some years (Diversity Database 2022).

There were approximately 410 acres of vernal pool grassland within this core area when the Recovery Plan was published in 2005, with another 44 acres immediately adjacent (Witham et al. 2013). As of 2018, there were still 410 acres of vernal pool grassland remaining, with no habitat losses occurring since 2005 (see **Figure 11.8**, **Table 11.1**; Witham 2021). Roughly 245 acres of vernal pool grassland are protected within the Montezuma Wetlands Project Preserve and an additional 115 acres are owned by Montezuma Wetlands, LLC and protected by a deed restriction (see **Figure 11.9**; Vollmar et al. 2017; Pinnell, *in litt*. 2022). However, only 331 acres are within the boundaries of the core area. This represents 81% of the 2005 baseline within the core area (410 acres) protected and 79% of the 2005 baseline including the habitat outside of the core area boundaries (454 acres).

11.7.1.1. Vernal Pool Fairy Shrimp Occurrences

There is one Diversity Database occurrence record for the vernal pool fairy shrimp within this core area (see **Figure 11.10**; Diversity Database 2022). As of 2018, this occurrence was partially protected within the Montezuma Wetlands Project Preserve (C. Pinnell, Vollmar Natural Lands Consulting, *in litt*. 2022). The occurrence is presumed extant by the Diversity Database and is within extant vernal pool grasslands (Witham 2021). The vernal pool fairy shrimp was first documented here in 2002 (Diversity Database 2022), and thus the Recovery Plan likely should have designated this core area for the vernal pool fairy shrimp. The vernal pool fairy shrimp has been consistently observed within multiple pools during monitoring of the preserve (Vollmar Natural Lands Consulting 2020; Diversity Database 2022).

11.7.1.1. Vernal Pool Tadpole Shrimp Occurrences

There is one Diversity Database occurrence record for the vernal pool tadpole shrimp within this core area (see **Figure 11.11**; Diversity Database 2022). As of 2018, this occurrence was partially protected within the Montezuma Wetlands Project Preserve (C. Pinnell, Vollmar Natural Lands Consulting, *in litt*. 2022). The occurrence is presumed extant by the Diversity Database and is within extant vernal pool grasslands (Witham 2021). The vernal pool tadpole shrimp was first documented here in 2000 (Diversity Database 2022) and has been consistently observed within multiple pools during monitoring of the preserve (Vollmar Natural Lands Consulting 2020; Diversity Database 2022).

11.7.1.2. Conservancy Fairy Shrimp Occurrences

There is one Diversity Database occurrence record for the Conservancy fairy shrimp within this core area (see **Figure 11.12**; Diversity Database 2022). As of 2018, this occurrence was partially protected within the Montezuma Wetlands Project Preserve (C. Pinnell, Vollmar Natural Lands Consulting, *in litt*. 2022). The occurrence is presumed extant by the Diversity Database and is within extant vernal pool grasslands (Witham 2021). The Conservancy fairy shrimp was first documented here in 2000 and has been consistently observed within multiple pools during monitoring of the preserve (Vollmar Natural Lands Consulting 2020; Diversity Database 2022). The species has been observed within 15 of the 30 vernal pools onsite: 6 natural pools, 3 enhanced pools, and 6 created pools (Diversity Database 2022). This occurrence is part of the Jepson Prairie population. Although this occurrence is 13 miles to the south of the rest of the Jepson Prairie occurrences, genetic information, along with the site's proximity and ecological similarity to the other Jepson Prairie occurrences, does support the placement of this occurrence within the Jepson Prairie population as opposed to its own distinct population (Kieran and Finger 2020).

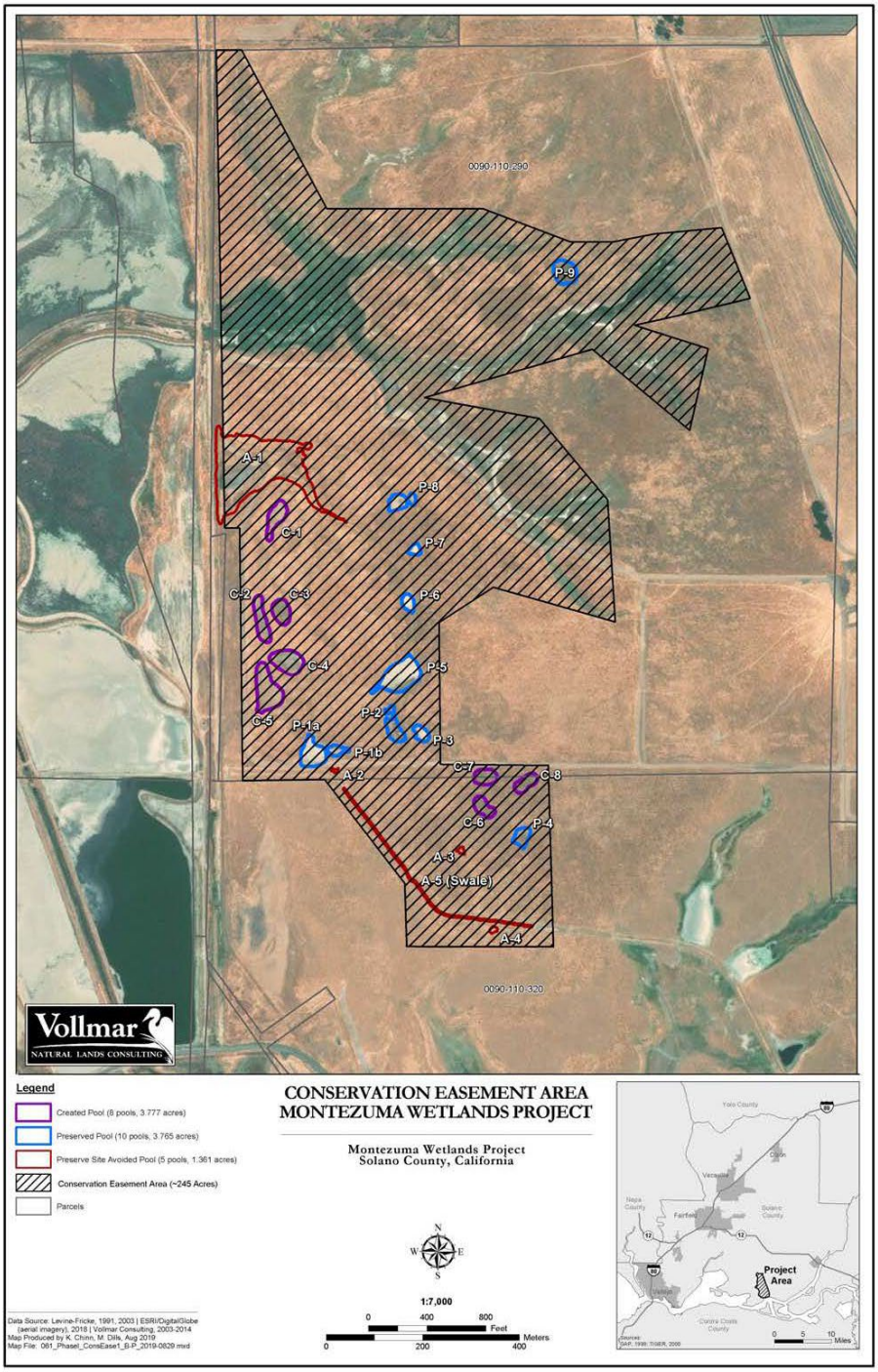

Figure 11.7. Map of the conservation easement and vernal pools within the Montezuma Wetlands Project Preserve provided by Vollmar Natural Lands Consulting (Pinnell, *in litt*. 2022).

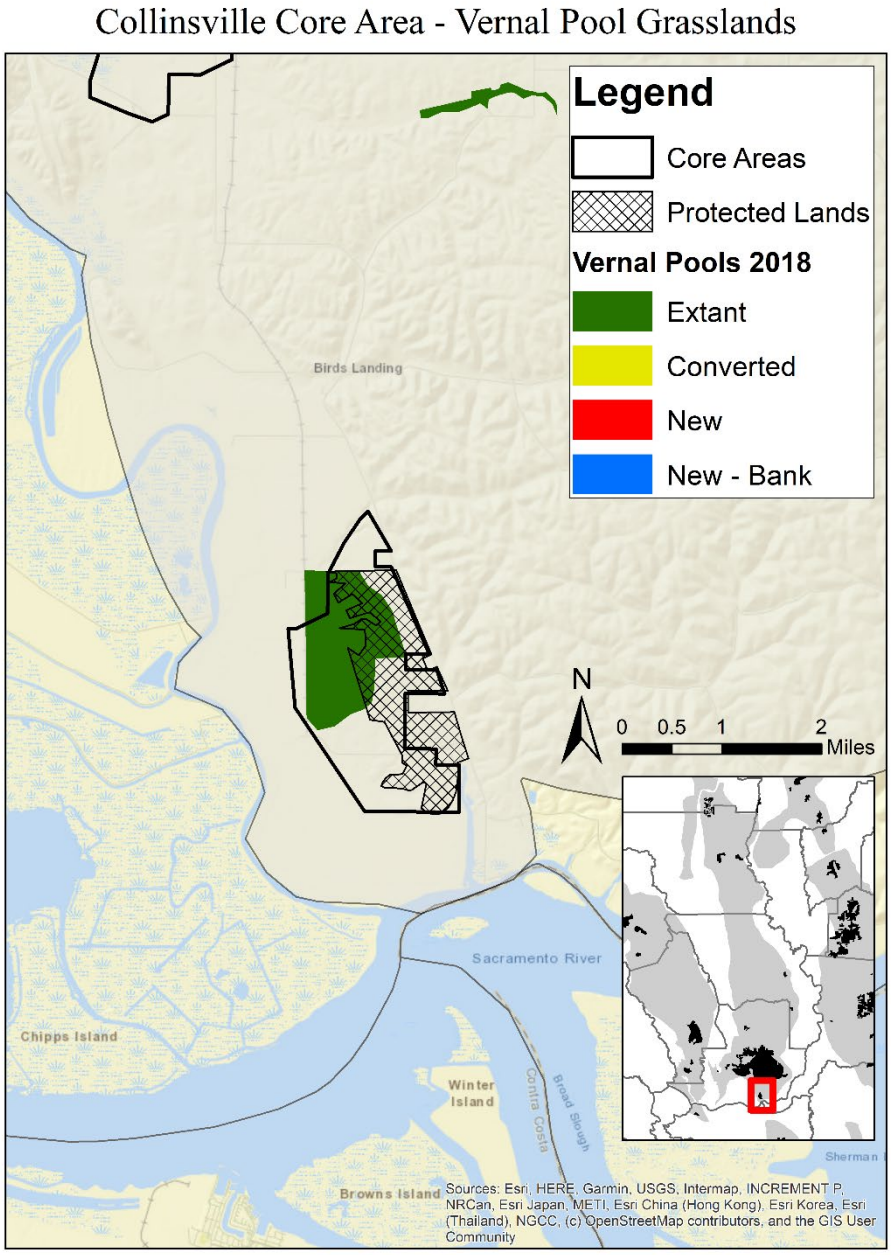

Figure 11.8. Map of vernal pool grassland habitat within the Collinsville Core Area mapped by Witham (2021) created using aerial imagery from 2018 compared to 2005 and 2012. "New" vernal pool habitat refers to areas not seen in the 2005 or 2012 aerial imagery (either missed or restored). "New - bank" 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.

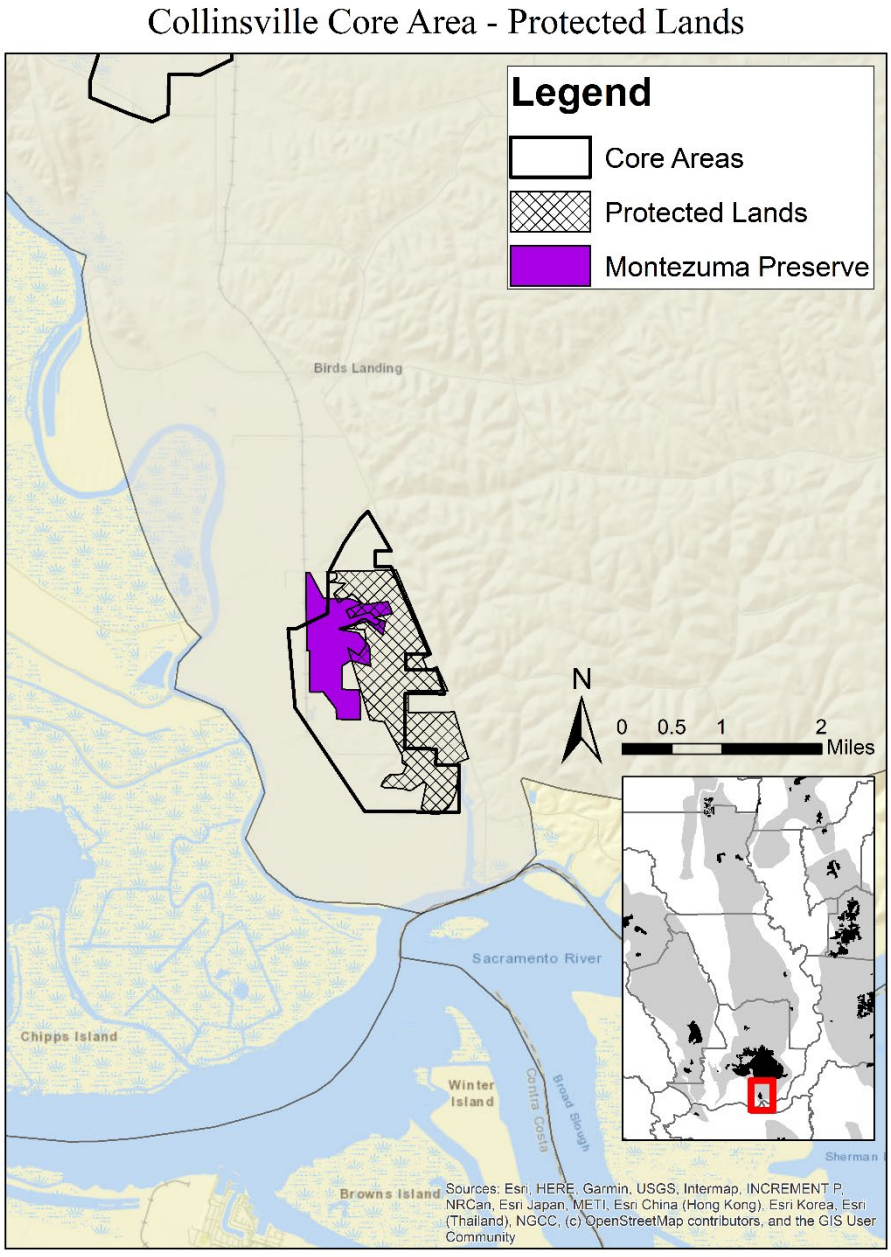

Figure 11.9. Map of protected areas within the Collinsville Core Area**.** Protected lands are based on Vollmar et al. (2017). Montezuma Wetlands Project Preserve boundary provided by Vollmar Natural Lands Consulting (Pinnell, *in litt*. 2022).

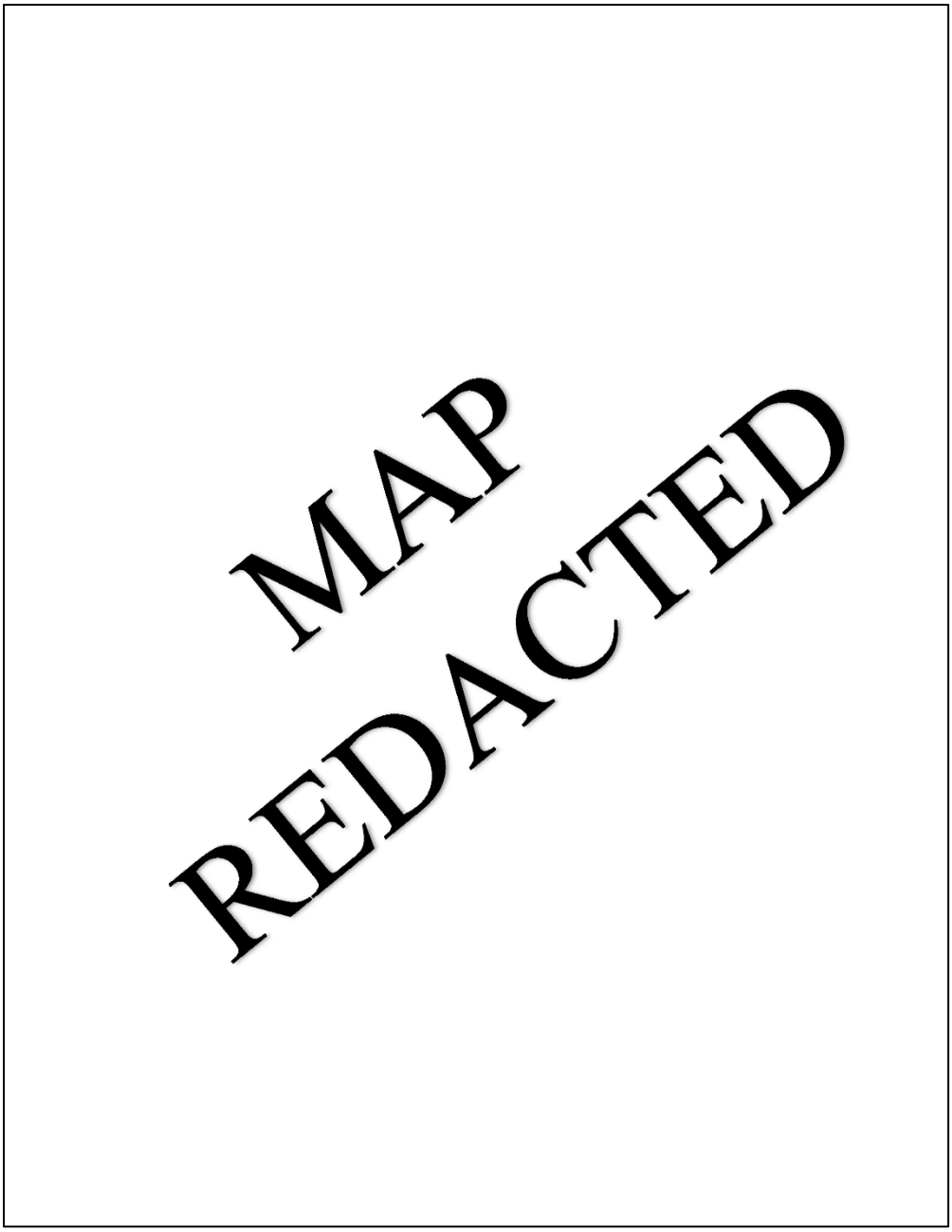

Figure 11.10. Map of known occurrences of vernal pool fairy shrimp recorded in the Diversity Database (2022) within the Collinsville Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

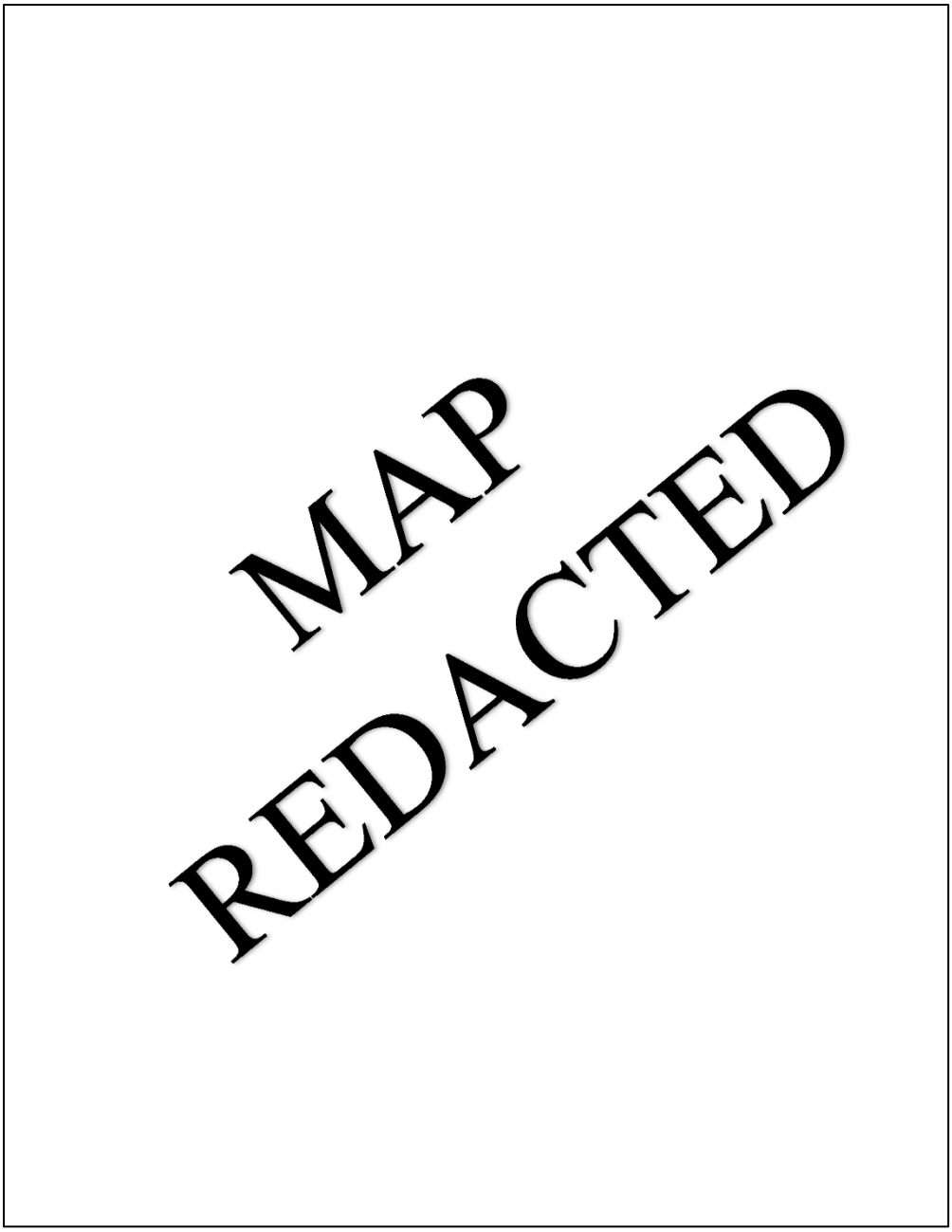

Figure 11.11. Map of known occurrences of vernal pool tadpole shrimp recorded in the Diversity Database (2022) within the Collinsville Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

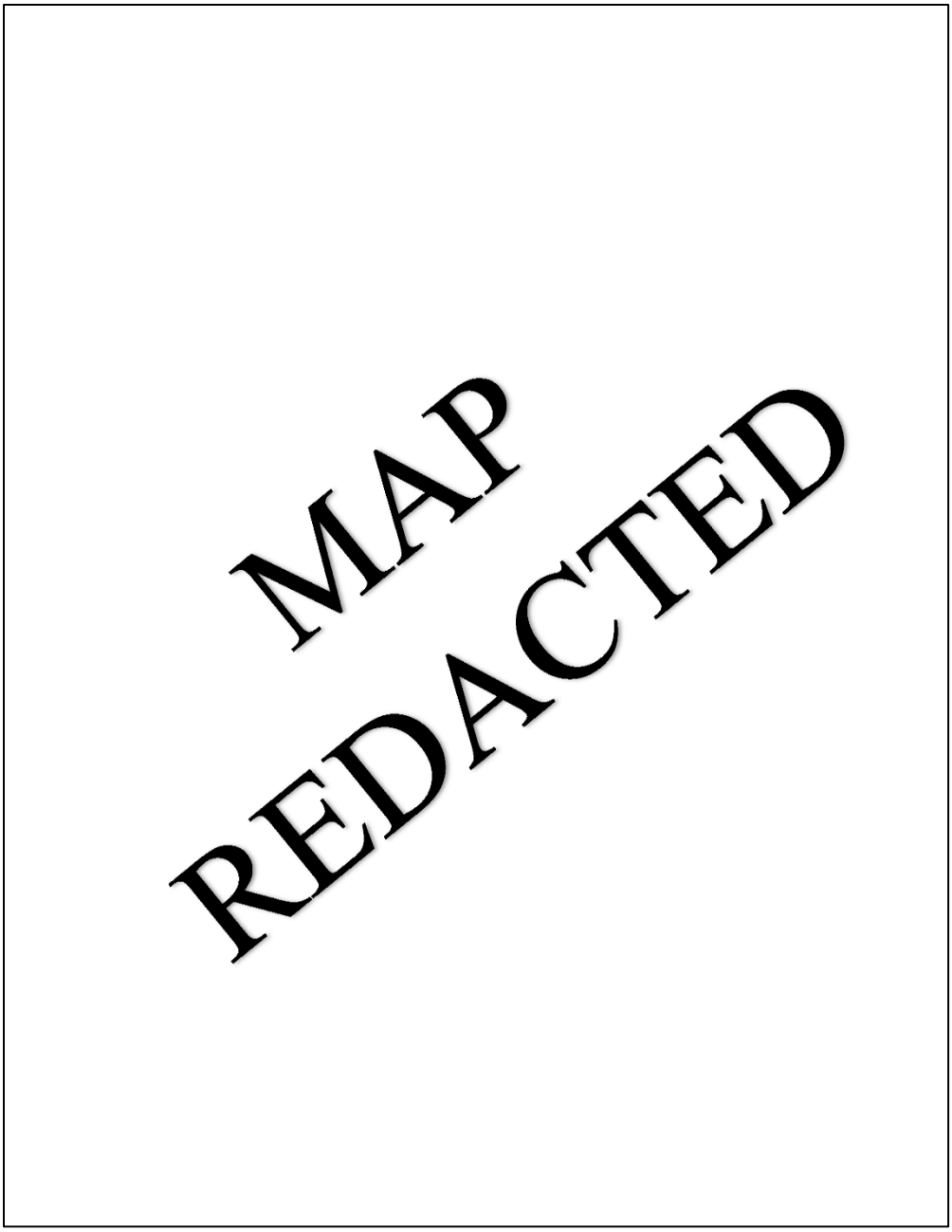

Figure 11.12. Map of known occurrences of Conservancy fairy shrimp recorded in the Diversity Database (2022) within the Collinsville Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

11.7.2. Davis Communications Annex

This is a zone 1 core area with a goal of protecting 95% of vernal pool habitat for the vernal pool tadpole shrimp. This core area was not designated for the vernal pool fairy shrimp in the Recovery Plan, but the species is known to occur there. The core area is located in southern Yolo County south of the City of Davis.

The 1-square mile (640-acre) area east of Mace Boulevard between County Road 35 and County Road 36 is composed of the Yolo County Grasslands Regional Park on the west and the former Davis Communications Site on the east. The Davis Communications Annex Core Area is 440 acres in size and is composed of the entire former Davis Communications Site and the northeastern portion of Grasslands Regional Park. The Davis Communications Site was part of McClellan Air Force Base, which closed in 2003. As part of the base closure, this site was transferred to the National Park Service as an intermediary, with the eventual plan to transfer the entire site to Yolo County and for Yolo County to place a 173-acre conservation easement over the portion of the property with vernal pools (Service 2004). However, conservation easements cannot be placed on former military lands per federal regulations, so the National Park Service and Yolo County are now considering a deed restriction as an alternative mechanism to protect the site (K. Berry and A. Stewart, Service, pers. comm. 2019). Yolo County assumed management responsibility over the former Davis Communications Site in 2007 as they were awaiting transfer of ownership, and the site is currently managed as part of Grasslands Regional Park (Helm Biological Consulting 2010).

There were approximately 102 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 102 acres of vernal pool grassland remaining, with no habitat losses occurring in the mapped areas since 2005 (see **Figure 11.13**; Witham 2021). However, a 30-acre solar development was built in 2013 that partially overlaps the northwestern corner of the core area, and there were concerns at the time that the wetland feature filled during construction may have provided habitat for vernal pool species (C. Mustin, Service, *in litt*. 2013). A wetland delineation conducted in 2010 identified approximately 11.6 acres of vernal pools throughout the core area, including five small created vernal pools (Helm Biological Consulting 2010) that were created in 2007–2008 (Yolo County Parks, *in litt*. 2023). The locations of the vernal pools generally line up with Witham's (2021) mapped vernal pool grasslands; the area of created pools is noticeable as a distinct separate patch of habitat (**Figure 11.13**). This core area is generally highly disturbed, both from historical uses (agricultural and military development) and recent activities (grassland enhancement and demolition activities) (Helm Biological Consulting 2010).

Vollmar et al. (2017) mapped the entire core area as being protected as all public lands counted as "preserved" in their study. However, due to the historic disturbance of the core area, the current lack of a mechanism to protect the vernal pool grasslands in perpetuity, and concerns that Yolo County does not have sufficient funds to establish an endowment once the Davis Communications Site is protected (K. Berry, Service, *in litt*. 2017), the Grasslands Regional Park and former Davis Communications Site do not currently meet the requirements for protected habitat outlined in the Recovery Plan's recovery criteria.

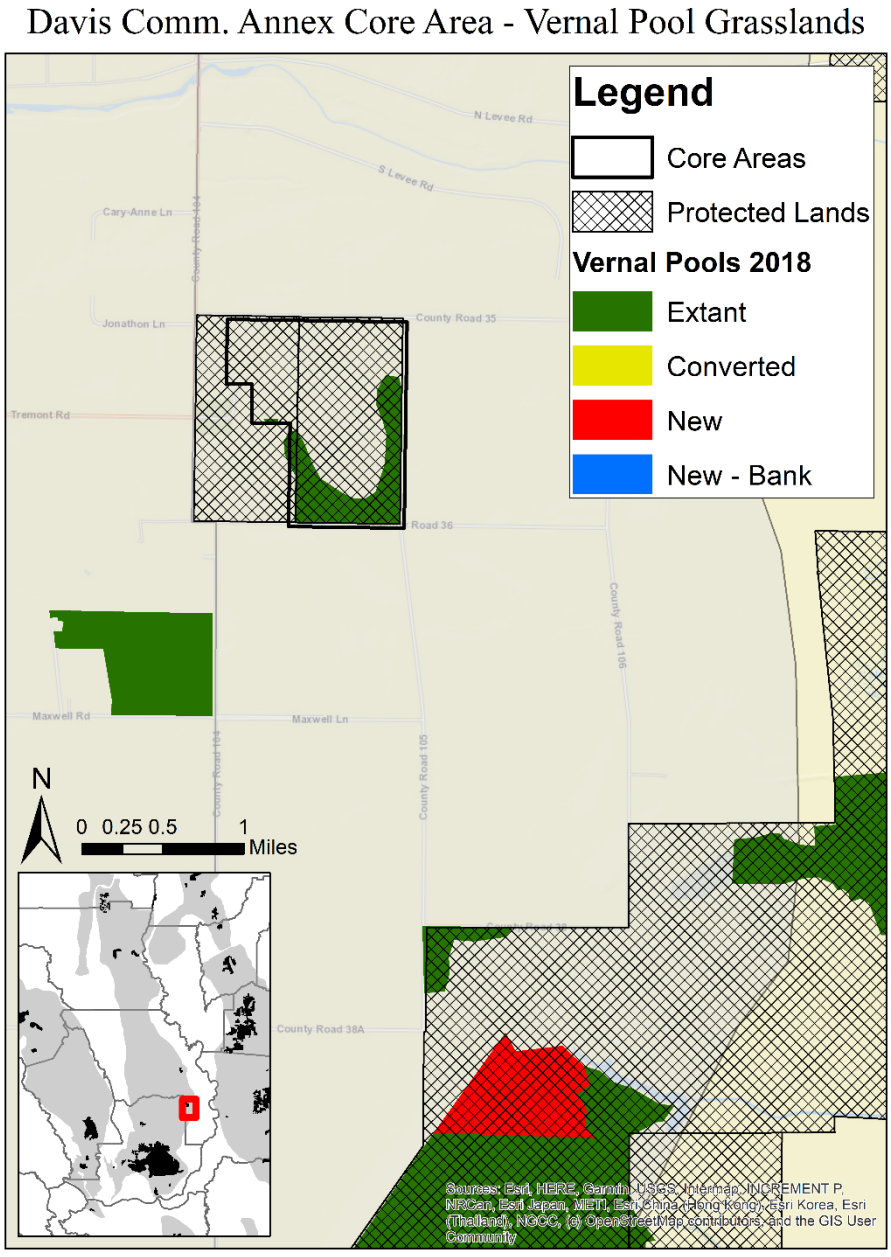

Figure 11.13. Map of vernal pool grassland habitat within the Davis Communications Annex Core Area mapped by Witham (2021) created using aerial imagery from 2018 compared to 2005 and 2012. "New" vernal pool habitat refers to areas not seen in the 2005 or 2012 aerial imagery (either missed or restored). "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.

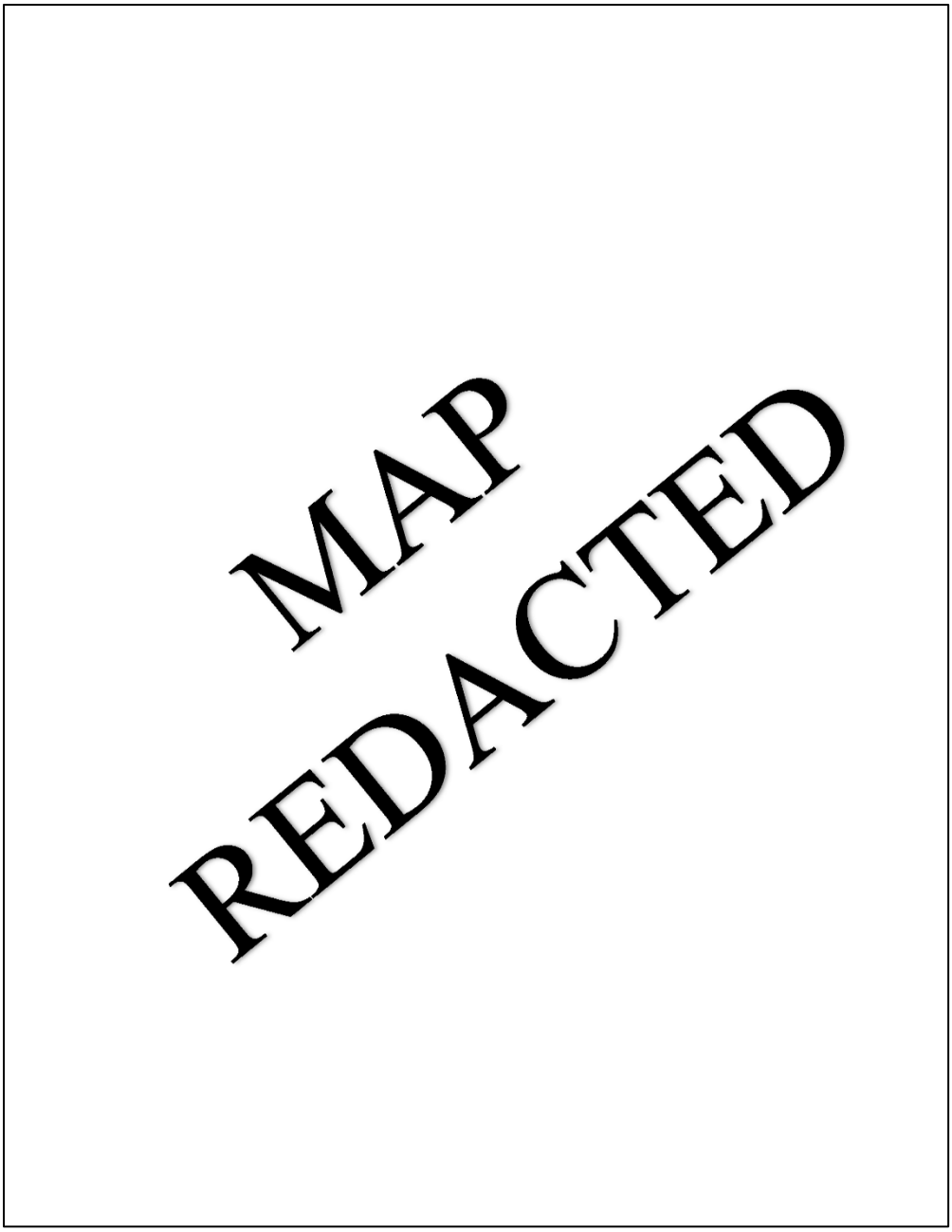

Figure 11.14. Map of known occurrences of vernal pool fairy shrimp recorded in the Diversity Database (2022) within the Davis Communications Annex Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

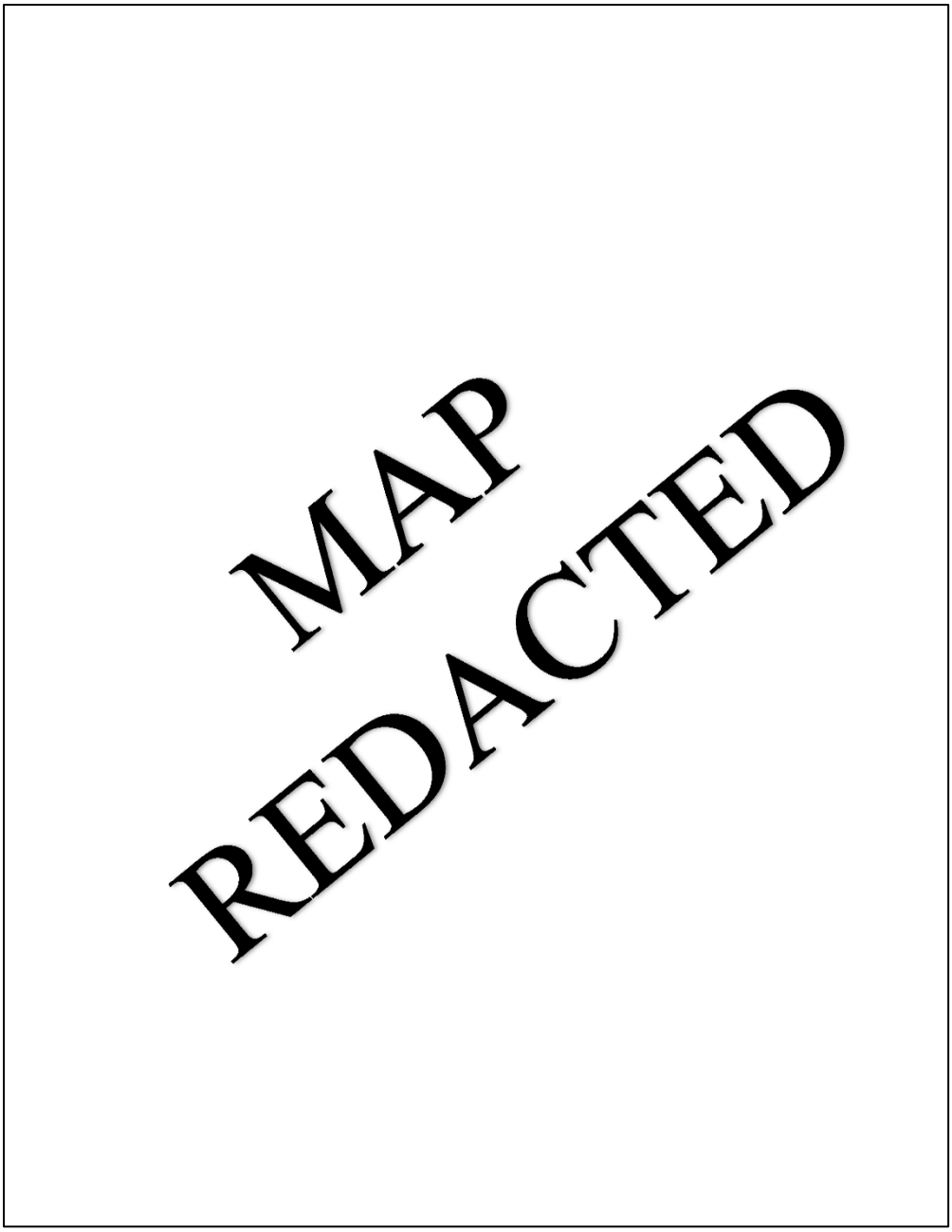

Figure 11.15. Map of known occurrences of vernal pool tadpole shrimp recorded in the Diversity Database (2022) within the Davis Communications Annex Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

11.7.2.1. Vernal Pool Fairy Shrimp Occurrences

There are two Diversity Database occurrence records for the vernal pool fairy shrimp within this core area (see **Figure 11.14**; Diversity Database 2022). As of 2018, both occurrences were entirely protected within the former Davis Communications Site (Vollmar et al. 2017). The occurrences are presumed extant by the Diversity Database and are within extant vernal pool grasslands (Witham 2021). The vernal pool fairy shrimp was first documented here in 2010 (Diversity Database 2022), after the Recovery Plan was published. The Service is not aware of any monitoring that has occurred since 2010.

11.7.2.2. Vernal Pool Tadpole Shrimp Occurrences

There is one Diversity Database occurrence record for the vernal pool tadpole shrimp within this core area (see **Figure 11.15**; Diversity Database 2022). As of 2018, the occurrence was entirely protected within the former Davis Communications Site (Vollmar et al. 2017). The occurrence is presumed extant by the Diversity Database and is within extant vernal pool grasslands (Witham 2021). The vernal pool tadpole shrimp was first documented here in 1993 and was most recently observed in 2010 (Diversity Database 2022). The Service is not aware of any monitoring that has occurred since 2010.

11.7.3. Dolan

This is a zone 2 core area with a goal of protecting 85% of vernal pool habitat for the vernal pool tadpole shrimp. This core area was not designated for the vernal pool fairy shrimp in the Recovery Plan, but the species is known to occur there. The core area is located in eastern Colusa County on either side of the Colusa National Wildlife Refuge.

There were approximately 566 acres of vernal pool grassland within this core area when the Recovery Plan was published in 2005, all mapped within the eastern unit of the core area (Witham et al. 2013). As of 2018, there were 395 acres of vernal pool grassland remaining (see **Figure 11.16**, **Table 11.1**; Witham 2021). Approximately 170 acres had been lost since the Recovery Plan's 2005 baseline, with all losses due to agricultural conversion to orchards (see **Table 11.2**; Witham 2021). This represents a loss of more than 15% of the amount of vernal pool habitat that remained in 2005, making the 85% target unattainable without habitat creation or restoration. Roughly 248 acres of vernal pool grassland were protected within this core area as of 2017 (Vollmar et al. 2017), representing 44% of the 2005 baseline.

Protected areas within this core area include the Dolan Ranch Conservation Bank and the Dolan Ranch Preserve (**Figure 11.17**).

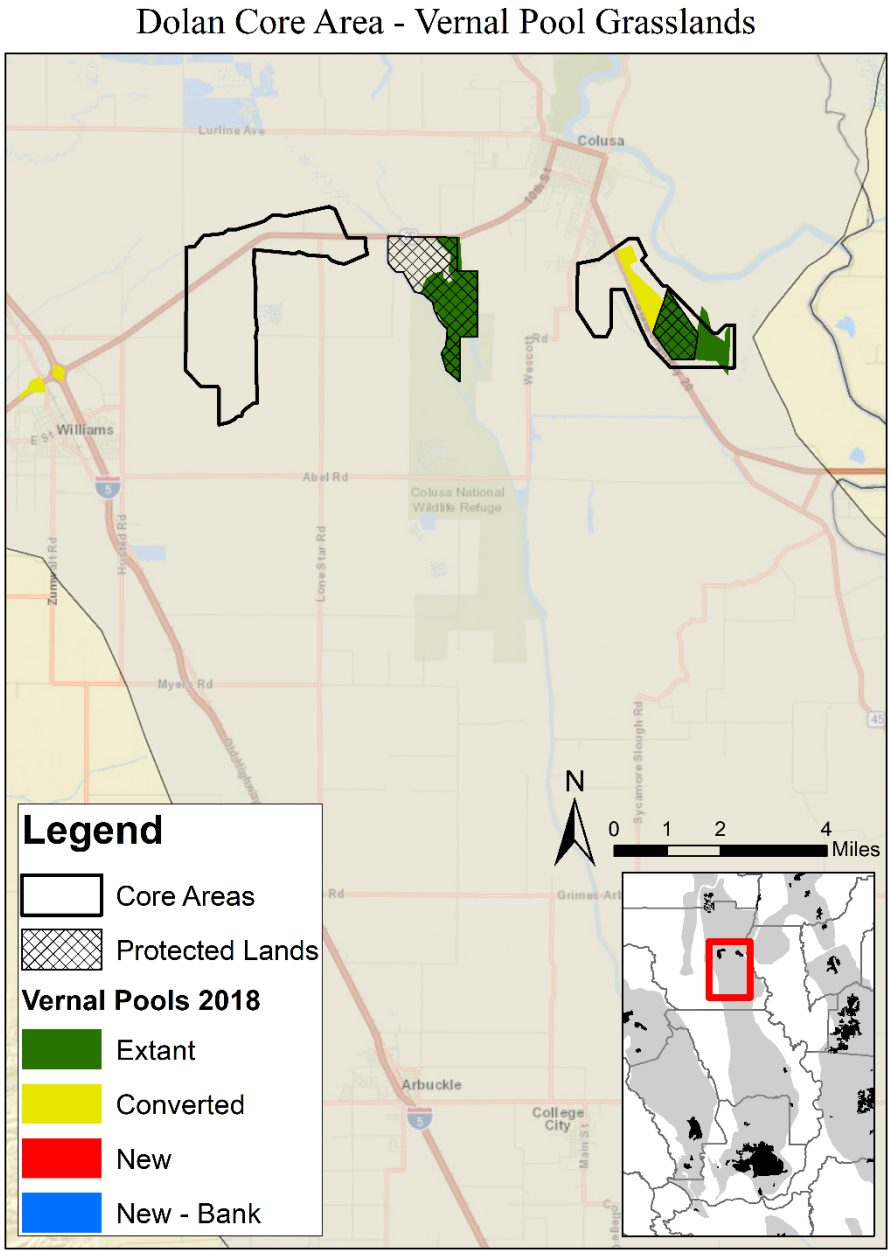

Figure 11.16. Map of vernal pool grassland habitat within the Dolan Core Area mapped by Witham (2021) created using aerial imagery from 2018 compared to 2005 and 2012. "New" vernal pool habitat refers to areas not seen in the 2005 or 2012 aerial imagery (either missed or restored). "New - bank" refers 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.

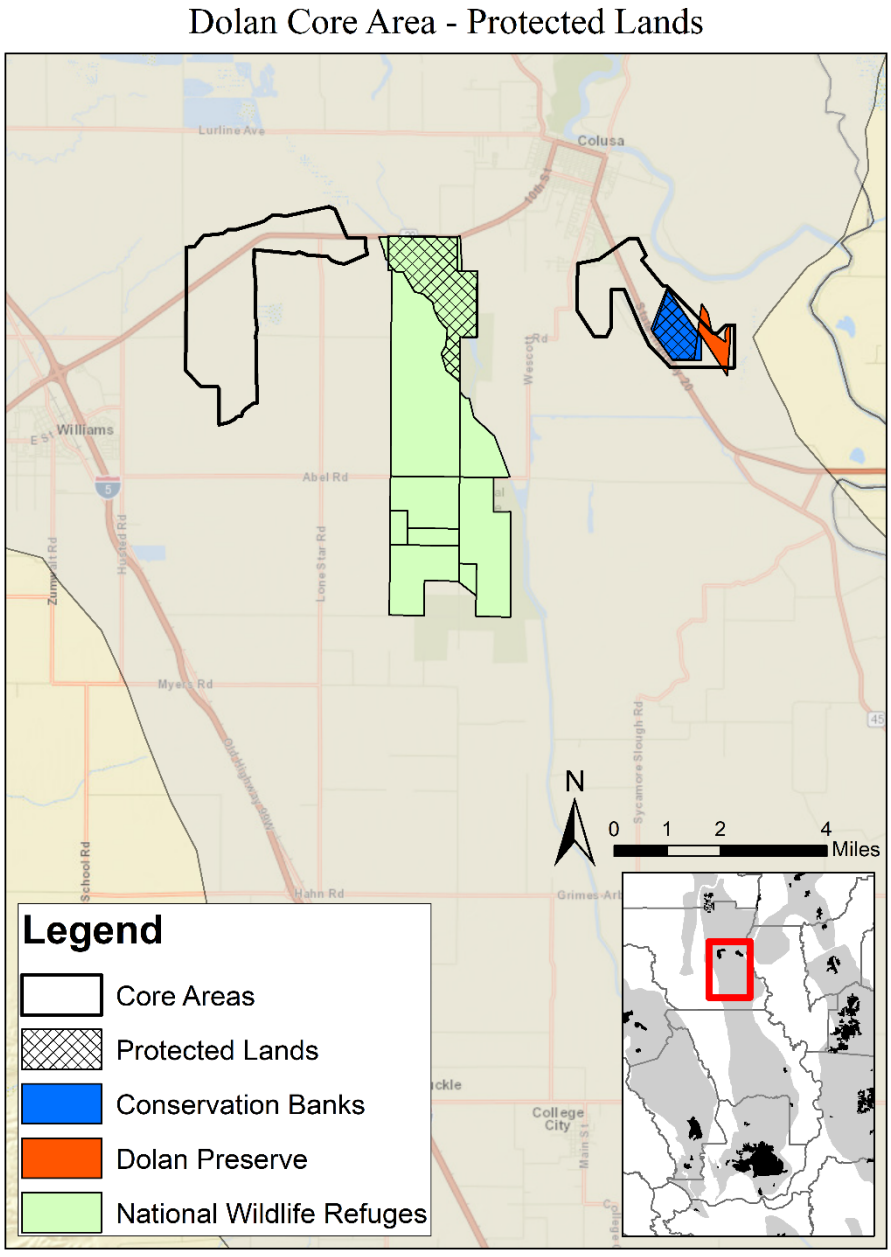

Figure 11.17. Map of protected areas within the Dolan Core Area**.** Protected lands are based on Vollmar et al. (2017) and include various preserves.

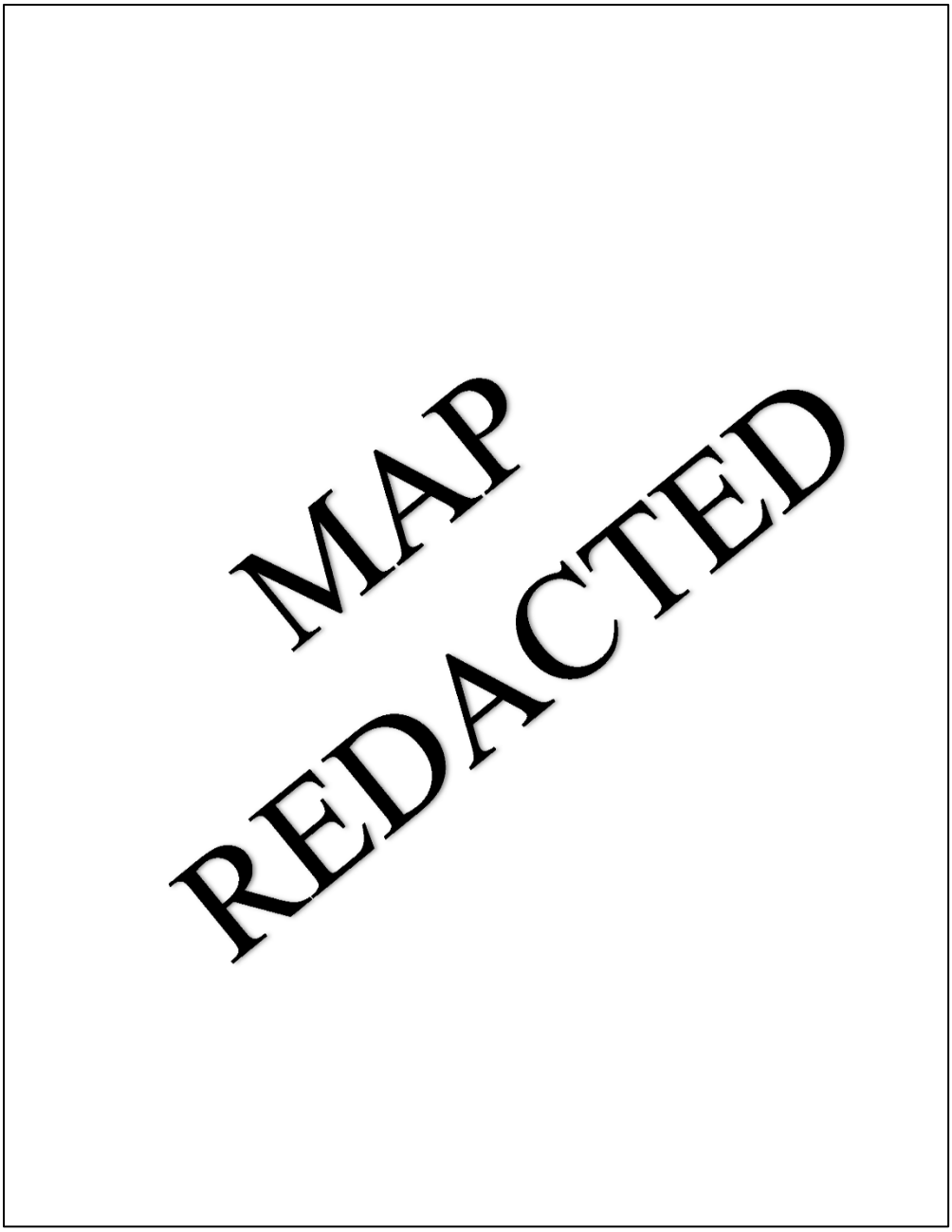

Figure 11.18. Map of known occurrences of vernal pool fairy shrimp recorded in the Diversity Database (2022) within the Dolan Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

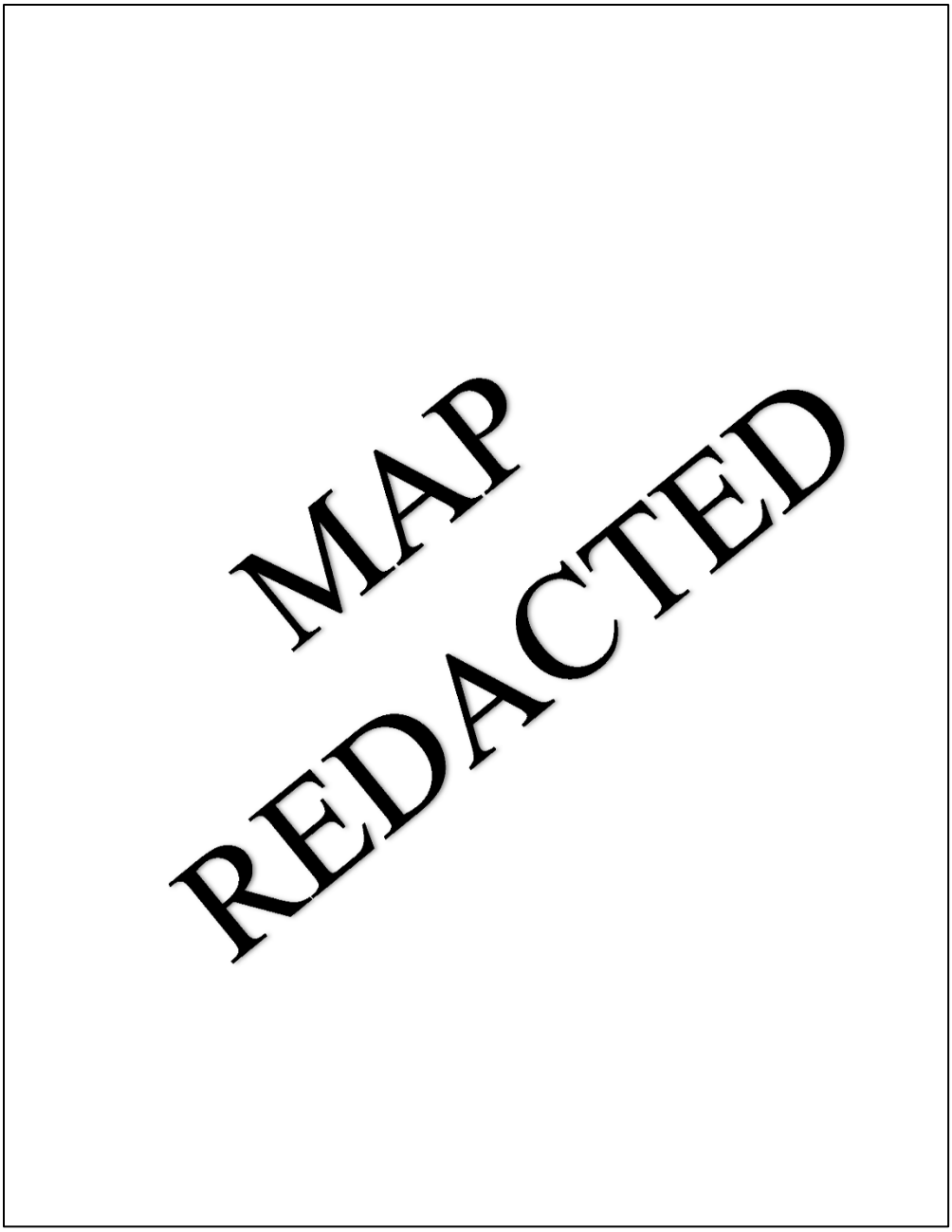

Figure 11.19. Map of known occurrences of vernal pool tadpole shrimp recorded in the Diversity Database (2022) within the Dolan Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

11.7.3.1. Vernal Pool Fairy Shrimp Occurrences

There is one Diversity Database occurrence record for the vernal pool fairy shrimp within this core area (see **Figure 11.18**; Diversity Database 2022). As of 2018, this occurrence was entirely protected within the Dolan Ranch Conservation Bank (Vollmar et al. 2017). The occurrence is presumed extant by the Diversity Database and is within extant vernal pool grasslands (Witham 2021). The vernal pool fairy shrimp was first documented here in January 2005 (Diversity Database 2022), and thus the Recovery Plan likely should have designated this core area for the vernal pool fairy shrimp. The vernal pool fairy shrimp was identified again in 2012, 2017, and 2022 during regular 5-year monitoring on the bank (Wildlands 2017a; Diversity Database 2022; Resource Environmental Solutions 2022).

11.7.3.2. Vernal Pool Tadpole Shrimp Occurrences

There is one Diversity Database occurrence record for the vernal pool tadpole shrimp within this core area (see **Figure 11.19**; Diversity Database 2022). As of 2018, this occurrence was entirely protected within the Dolan Ranch Conservation Bank (Vollmar et al. 2017). The occurrence is presumed extant by the Diversity Database and is within extant vernal pool grasslands (Witham 2021). The vernal pool tadpole shrimp was first documented here in 2002 (Diversity Database 2022). The species was identified again in 2017 and 2022 during regular 5-year monitoring on the bank (Wildlands 2017a; Resource Environmental Solutions 2022).

11.7.4. Jepson Prairie

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 central Solano County east of the City of Fairfield. The greater Jepson Prairie area is the last remaining large, mostly contiguous stretch of vernal pool grasslands within the Solano-Colusa Vernal Pool Region, representing over half of all extant vernal pool habitat in this region.

There were approximately 31,467 acres of vernal pool grassland within this core area when the Recovery Plan was published in 2005, which represents 68.5% of all vernal pool grasslands mapped within the Solano-Colusa Vernal Pool Region (Witham et al. 2013). As of 2018, there were 30,823 acres of vernal pool grassland remaining (see **Figure 11.20**, **Table 11.1**; Witham 2021). Approximately 704 acres had been lost since the Recovery Plan's 2005 baseline, though 16 additional acres were created on banks that were not previously mapped as vernal pool grassland in 2005 and 43 acres were identified that were either new or missed in previous mapping efforts. The majority of losses were attributable to agricultural conversions (502 acres [71.3%] to bare plowed agricultural land and 4 acres [0.6%] to agricultural residences), though a significant amount of the losses were caused by urbanization (198 acres, 28.1%), mostly on the outskirts of Fairfield (**Table 11.2**). Roughly 11,204 acres of vernal pool grassland were protected within this core area as of 2017 (Vollmar et al. 2017), representing 35.6% of the 2005 baseline. The protected lands within this core area represent 61% of all protected habitat within the vernal pool region.

There are seven conservation banks with vernal pool fairy shrimp or vernal pool tadpole shrimp preservation credits in this core area: Burke Ranch, Campbell Ranch, Elsie Gridley, Goldfields, Muzzy Ranch, Noonan, and North Suisun (**Figure 11.21**). Other protected areas within this core area include CDFW's Calhoun Cut Ecological Reserve, Dixon Vernal Pools conservation easement, and part of the Hill Slough Wildlife Area; the Solano Land Trust's Jepson Prairie Preserve, Wilcox Ranch Preserve, and part of Rush Ranch; the Golden State Land Conservancy's Paradise Crest Wetland preserve; a small part of Travis Air Force Base (most of the Base was purposefully excluded from the core area); the County-owned land with a conservation easement held by The Nature Conservancy to the east of Travis Air Force Base; and six other mitigation sites that have been protected, likely as part of proposed conservation measures during Section 7 interagency consultations (see **Figure 11.21**; Vollmar et al. 2017).

11.7.4.1. Vernal Pool Fairy Shrimp Occurrences

There are 15 Diversity Database occurrence records for the vernal pool fairy shrimp within this core area (see **Figure 11.22**; Diversity Database 2022). As of 2018, 12 of these occurrences were at least partially within protected areas (Vollmar et al. 2017). All occurrences are presumed extant by the Diversity Database; 13 are within extant mapped vernal pool grasslands and 2 are outside of mapped vernal pool grasslands (Witham 2021). Vernal pool fairy shrimp were first detected within this core area in 1993 and new Diversity Database records were consistently reported up through 2009 (Diversity Database 2022). Of the 15 records, 1 was known at the time of listing in 1994 and 9 were known at the time the Recovery Plan was published in 2005; these records are located throughout the core area. The six newer records are mostly located near older records, with two newer records on the eastern boundary of the core area. This confirms that most vernal pool grasslands in this core area are occupied by the vernal pool fairy shrimp.

11.7.4.2. Vernal Pool Tadpole Shrimp Occurrences

There are 22 Diversity Database occurrence records for the vernal pool tadpole shrimp within this core area (see **Figure 11.23**; Diversity Database 2022). As of 2018, all 22 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 mapped vernal pool grasslands (Witham 2021). Vernal pool tadpole shrimp were first detected within this core area in 1980 and new Diversity Database records were consistently reported up through 2012 (Diversity Database 2022). Of the 22 records, 5 were known at the time of listing in 1994 and 14 were known at the time the Recovery Plan was published in 2005; these records are located throughout the northern and western parts of the core area. The eight newer records are mostly located near older records, though two of the records fill in significant gaps in the species distribution that had existed in the center of the core area. This confirms that the majority of vernal pool grasslands in this core area are occupied by the vernal pool tadpole shrimp.

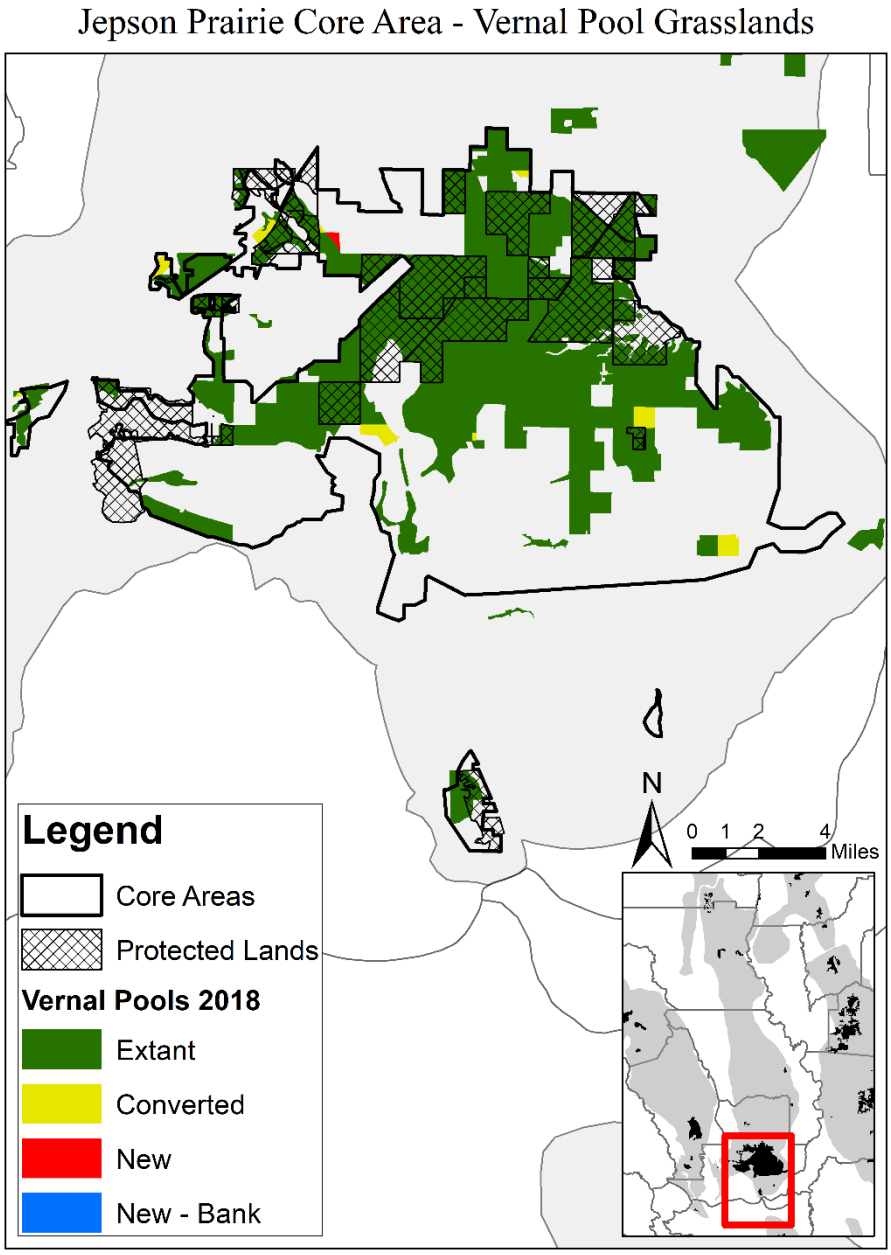

Figure 11.20. Map of vernal pool grassland habitat within the Jepson Prairie Core Area mapped by Witham (2021) created using aerial imagery from 2018 compared to 2005 and 2012. "New" vernal pool habitat refers to areas not seen in the 2005 or 2012 aerial imagery (either missed or restored). "New - bank" 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.

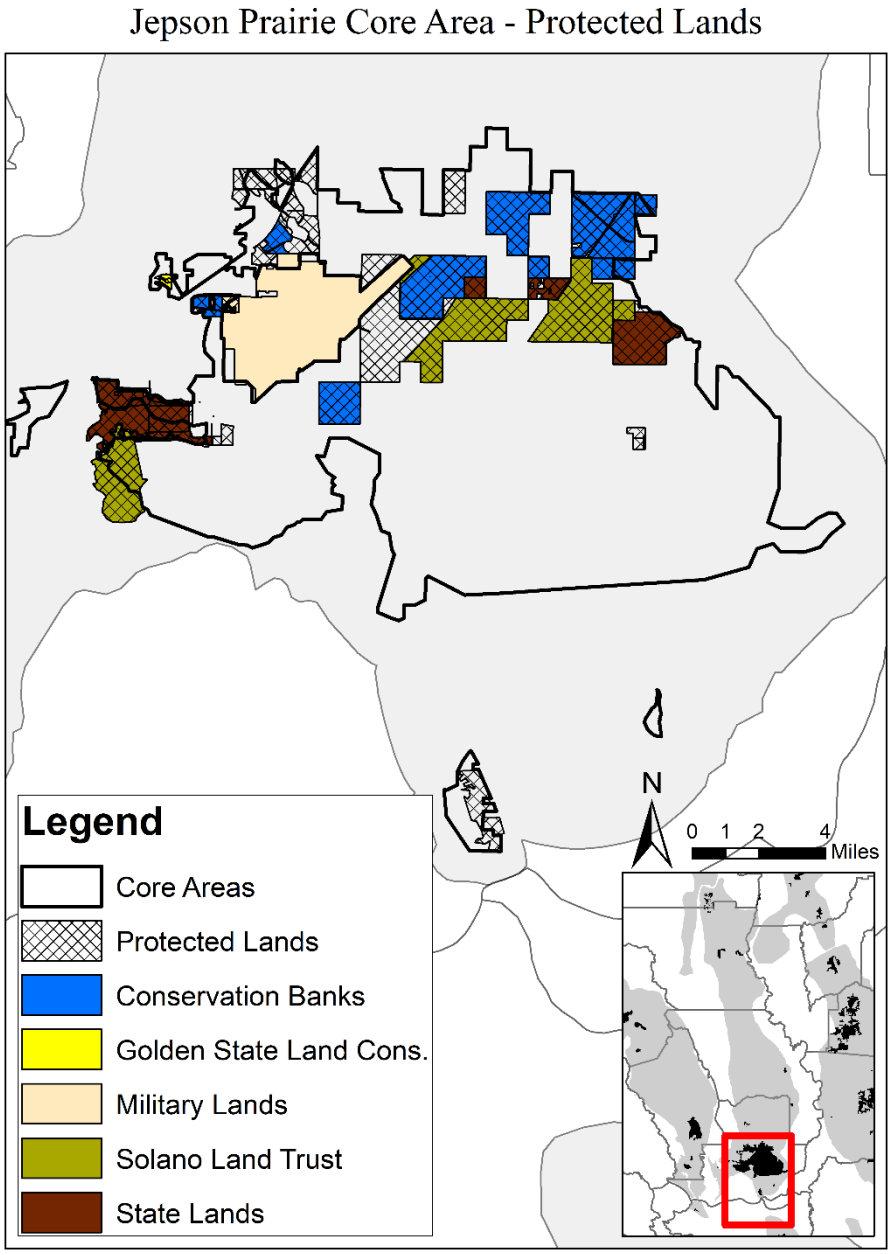

Figure 11.21. Map of protected areas within the Jepson Prairie Core Area**.** Protected lands are based on Vollmar et al. (2017) and include various preserves.

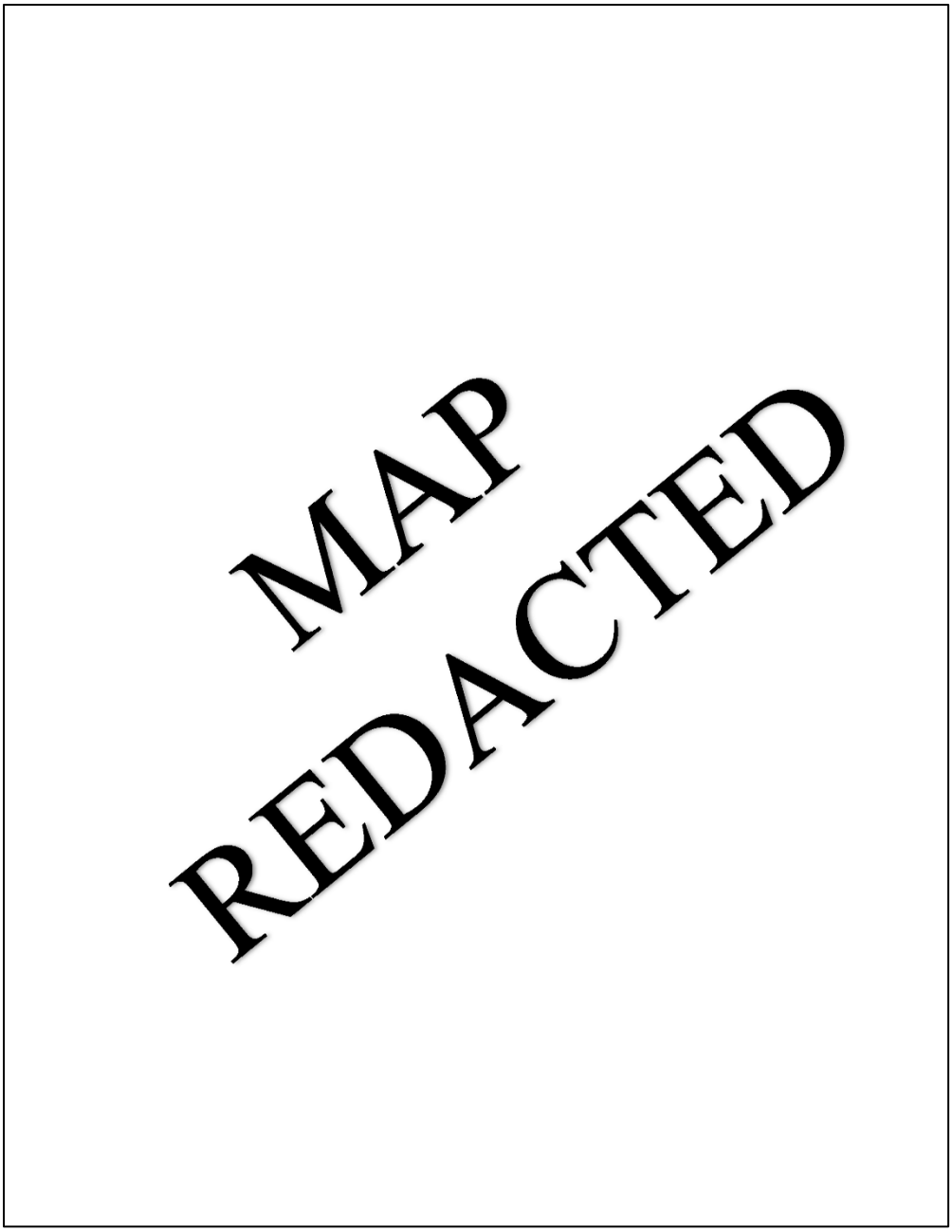

Figure 11.22. Map of known occurrences of vernal pool fairy shrimp recorded in the Diversity Database (2022) within the Jepson Prairie Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

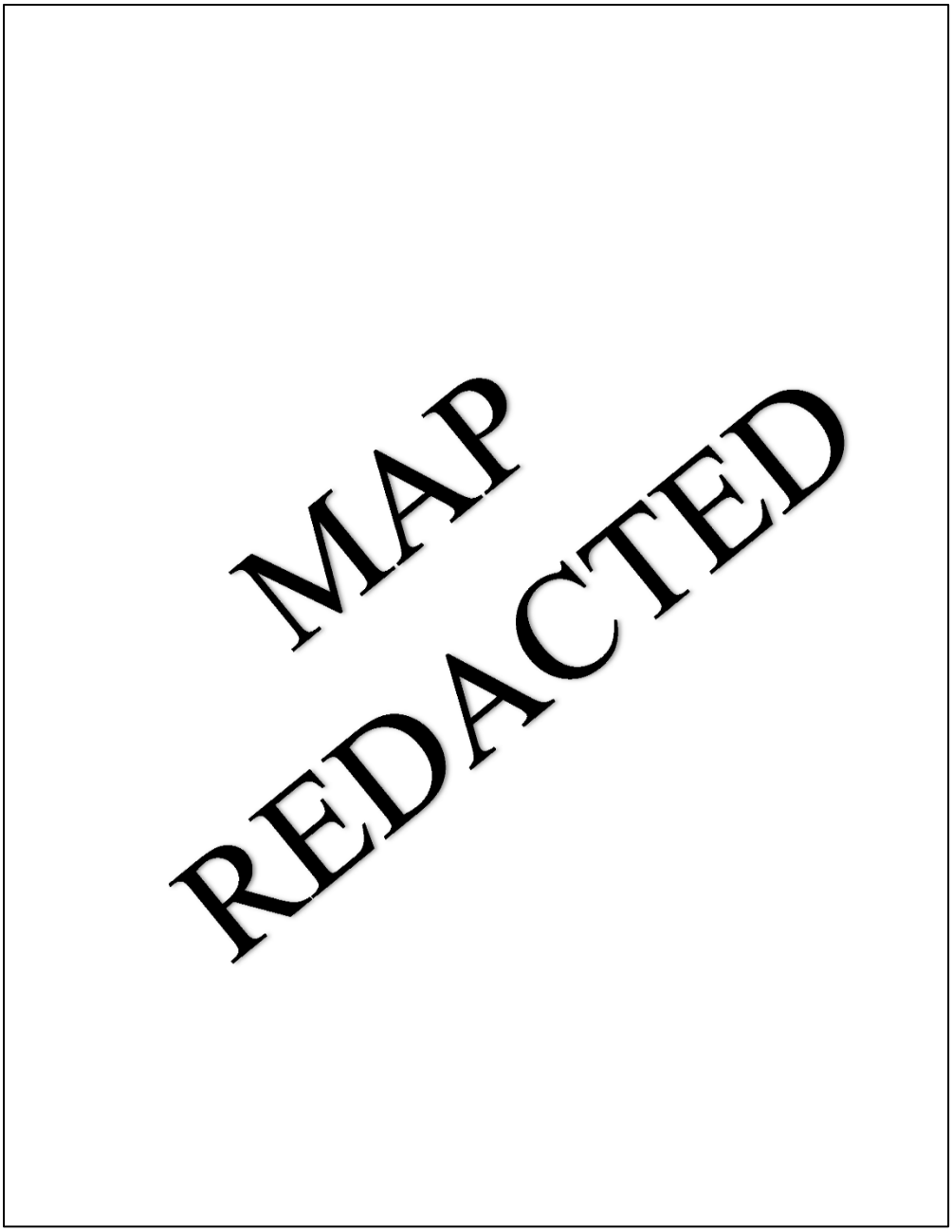

Figure 11.23. Map of known occurrences of vernal pool tadpole shrimp recorded in the Diversity Database (2022) within the Jepson Prairie Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

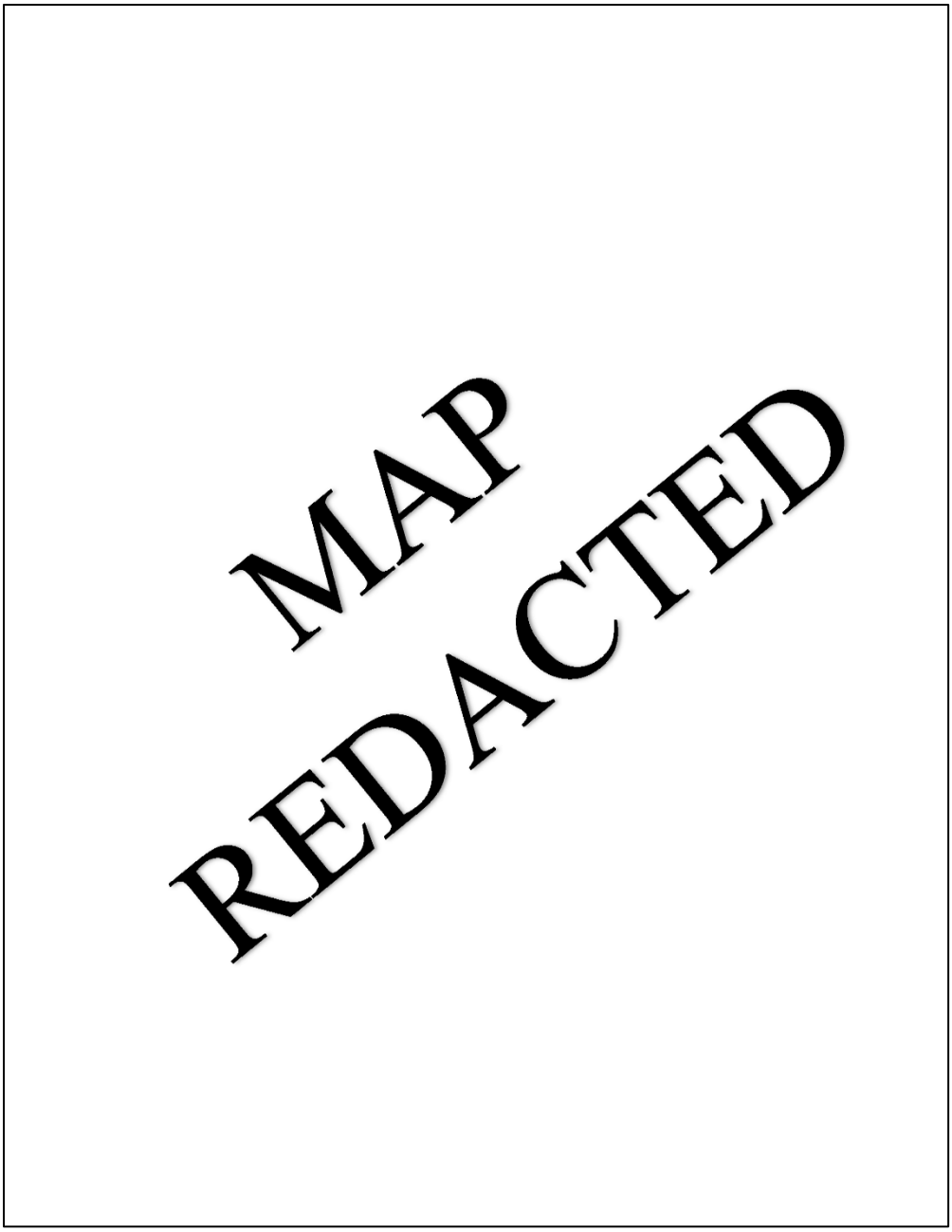

Figure 11.24. Map of known occurrences of Conservancy fairy shrimp recorded in the Diversity Database (2022) within the Jepson Prairie Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

11.7.4.3. Conservancy Fairy Shrimp Occurrences

There are 12 Diversity Database occurrence records for the Conservancy fairy shrimp within this core area (see **Figure 11.24**; Diversity Database 2022). As of 2018, all 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 mapped vernal pool grasslands (Witham 2021). The Conservancy fairy shrimp was first detected within this core area in 1979 in Olcott Lake; this is the largest vernal pool in California and the type locality for the Conservancy fairy shrimp (Diversity Database 2022). Of the 12 records, 1 was known at the time of listing in 1994 and 9 were known at the time the Recovery Plan was published in 2005; these records are located throughout the north of the core area and one in the southwest. The three newer records are located near older records, with two in the northeast within Burke Ranch Conservation Bank and one in the center within Muzzy Ranch Conservation Bank.

11.7.5. Sacramento National Wildlife Refuge

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 entirely within the Sacramento National Wildlife Refuge in Colusa and Glenn Counties.

Witham et al.'s (2013) mapping effort estimated that there were 1,530 acres of vernal pool grassland within this core area when the Recovery Plan was published in 2005, and as of 2018 no habitat losses were estimated to have occurred (see **Figure 11.25**, **Table 11.1**; Witham 2021). However, the Comprehensive Conservation Plan prepared for this Refuge in 2009 identified 2,941 acres of vernal pool complexes or alkali meadows within the Refuge (Service 2009b). All of these vernal pool grassland complexes are protected within the Sacramento National Wildlife Refuge (**Figure 11.26**).

11.7.5.1. 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 Sacramento National Wildlife Refuge (see **Figure 11.27**; Diversity Database 2022). All occurrences are presumed extant by the Diversity Database; one is within extant mapped vernal pool grasslands and one is outside of mapped vernal pool grasslands (Witham 2021). A total of 11 years of vernal pool shrimp surveys have occurred on the Sacramento National Wildlife Refuge between 1993 and 2017 (D'Errico, *in litt*. 2022), though it is possible that not every pool was surveyed each year. The vernal pool fairy shrimp was definitively identified in one pool in 2004 and in six pools out of 45 sampled in 2017, all in the northeast of the Refuge (Helm Biological Consulting 2017; D'Errico, *in litt*. 2022). However, numerous pools throughout the Refuge were documented as having *Branchinecta* individuals that were not identified to the species level during surveys from 1993-1998; there are three other species of *Branchinecta* known within the Refuge, but it is likely that at least some of these occurrences represent the vernal pool fairy shrimp (see **Figure 11.28**; D'Errico, *in litt*. 2022).

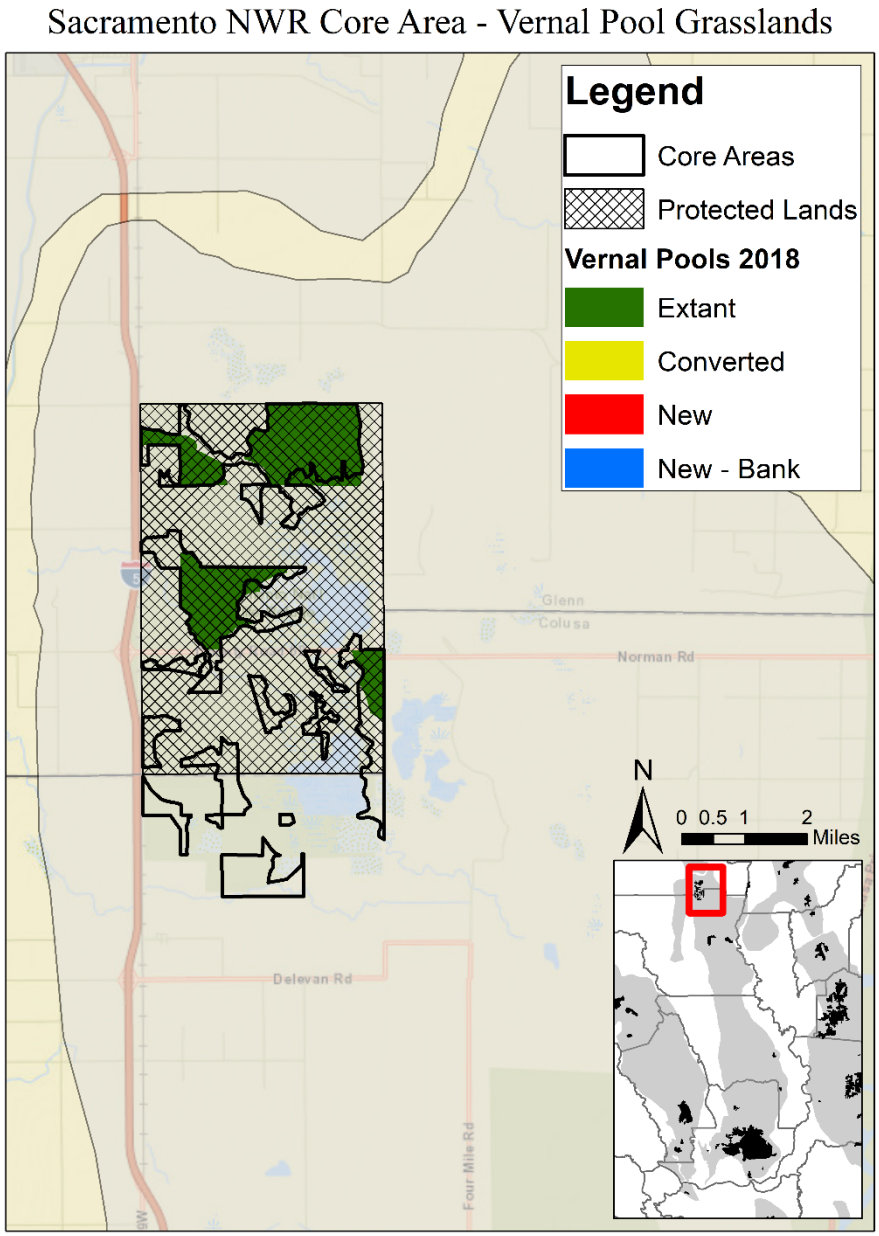

Figure 11.25. Map of vernal pool grassland habitat within the Sacramento National Wildlife Refuge (NWR) Core Area mapped by Witham (2021) created using aerial imagery from 2018 compared to 2005 and 2012. "New" vernal pool habitat refers to areas not seen in the 2005 or 2012 aerial imagery (either missed 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.

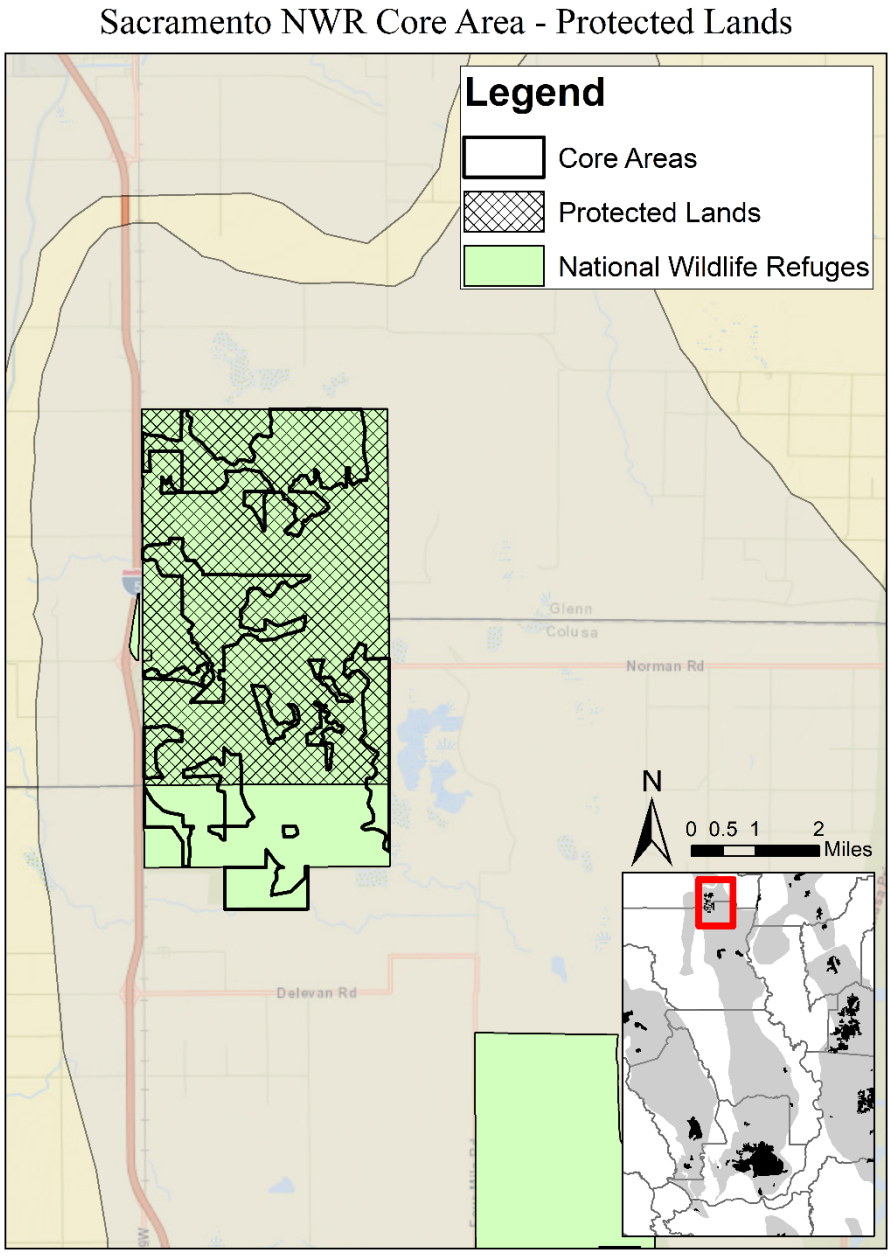

Figure 11.26. Map of protected areas within the Sacramento National Wildlife Refuge (NWR) Core Area**.** Protected lands are based on Vollmar et al. (2017) and include various preserves.

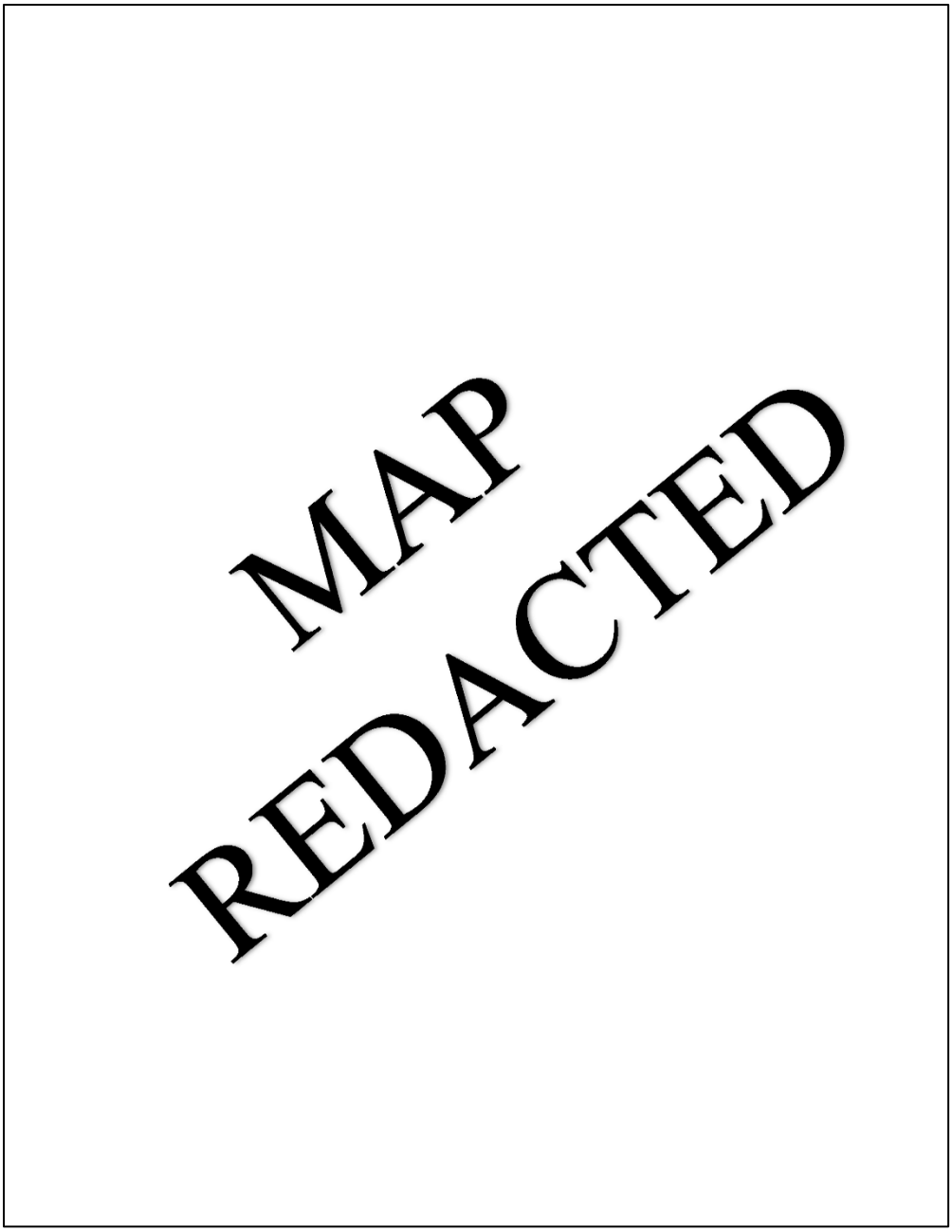

Figure 11.27. Map of known occurrences of vernal pool fairy shrimp recorded in the Diversity Database (2022) within the Sacramento National Wildlife Refuge (NWR) Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

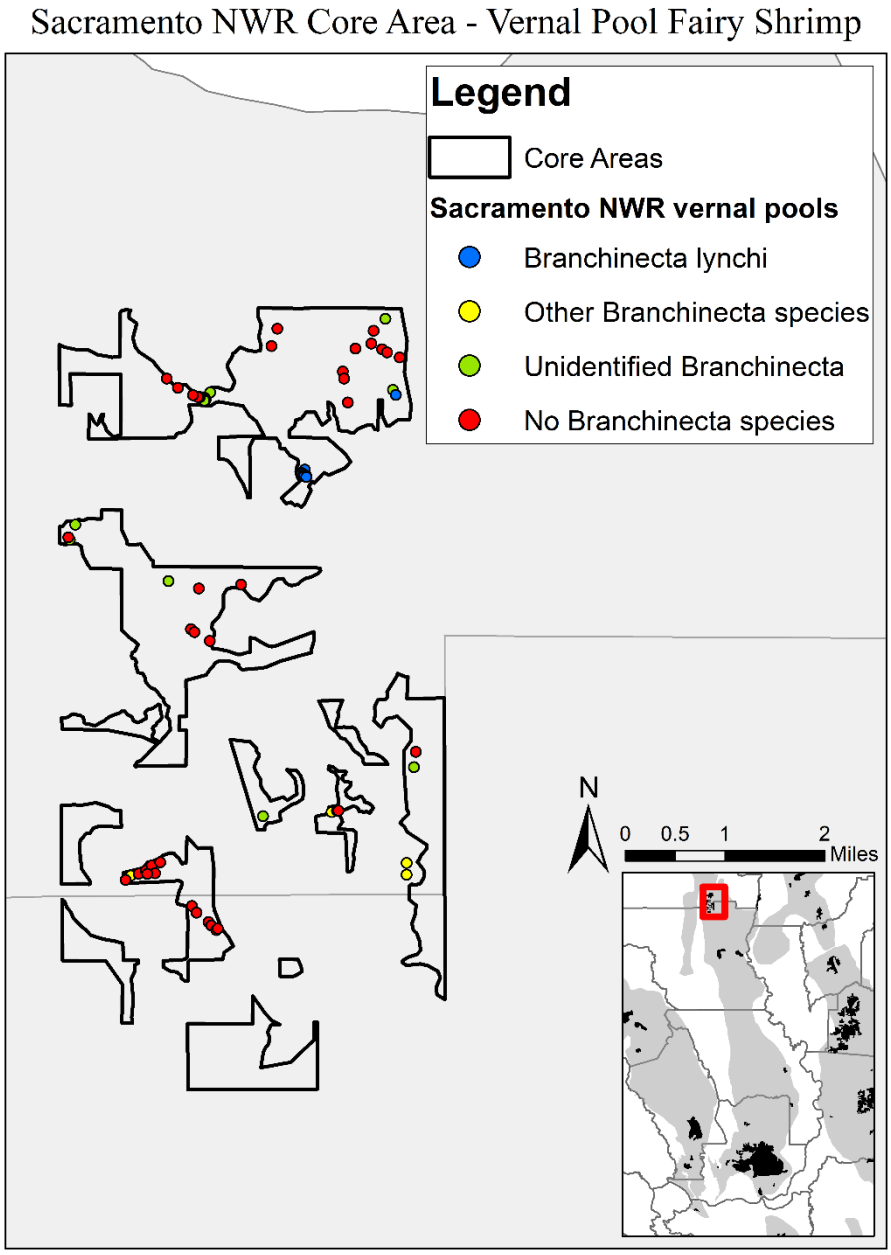

Figure 11.28. Map of known occurrences of vernal pool fairy shrimp (*Branchinecta lynchi*) and other *Branchinecta* species based on Sacramento National Wildlife Refuge (NWR) surveys from 1993 to 2017 (D'Errico, *in litt*. 2022). Pools where the vernal pool fairy shrimp has ever been definitively identified are in blue. Pools where the vernal pool fairy shrimp has not been definitively identified but where some surveys observed *Branchinecta* that were not identified to the species level are in green. Pools where only other *Branchinecta* species have been identified (with no unidentified records) are in yellow. Pools that have never contained any *Branchinecta* species are in red.

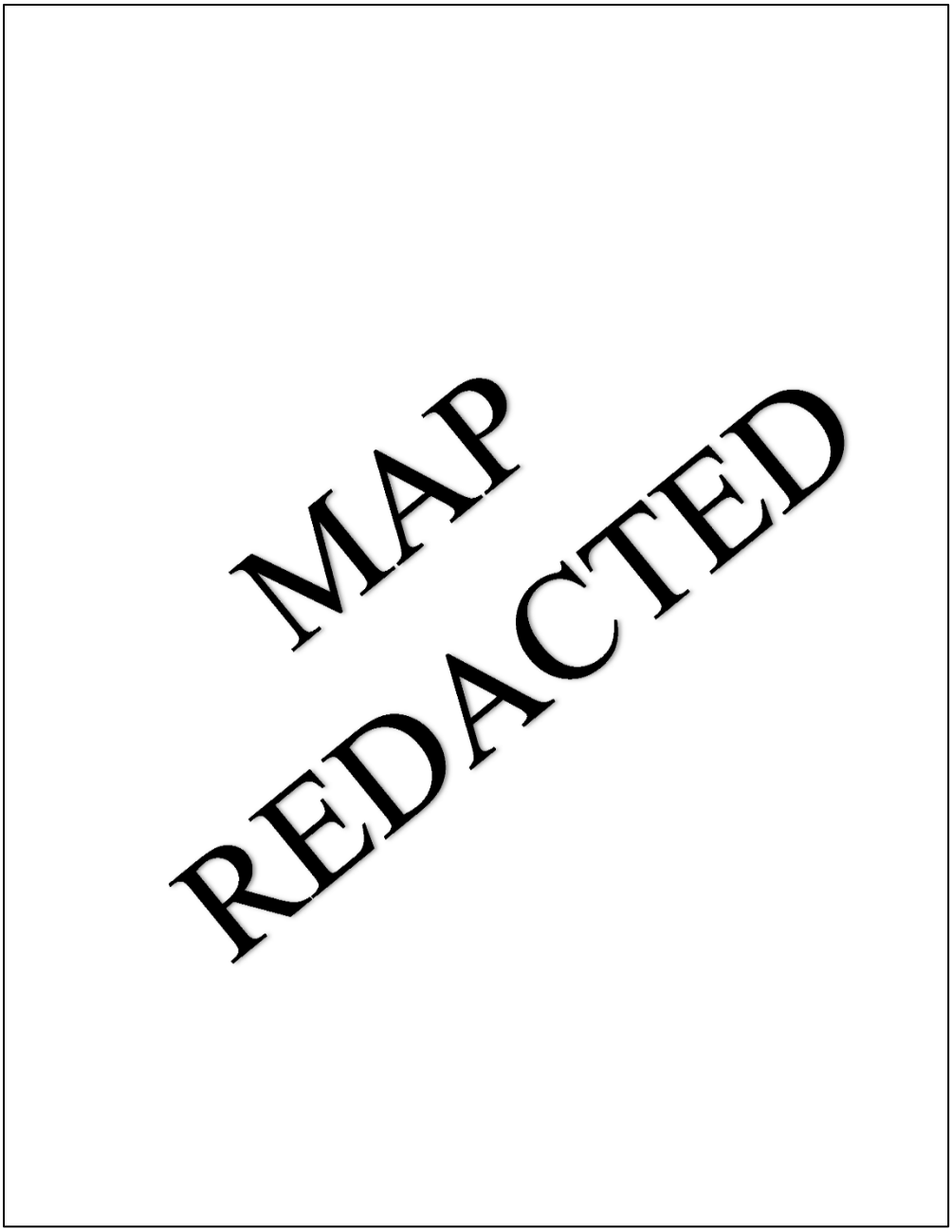

Figure 11.29. Map of known occurrences of vernal pool tadpole shrimp recorded in the Diversity Database (2022) within the Sacramento National Wildlife Refuge (NWR) Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

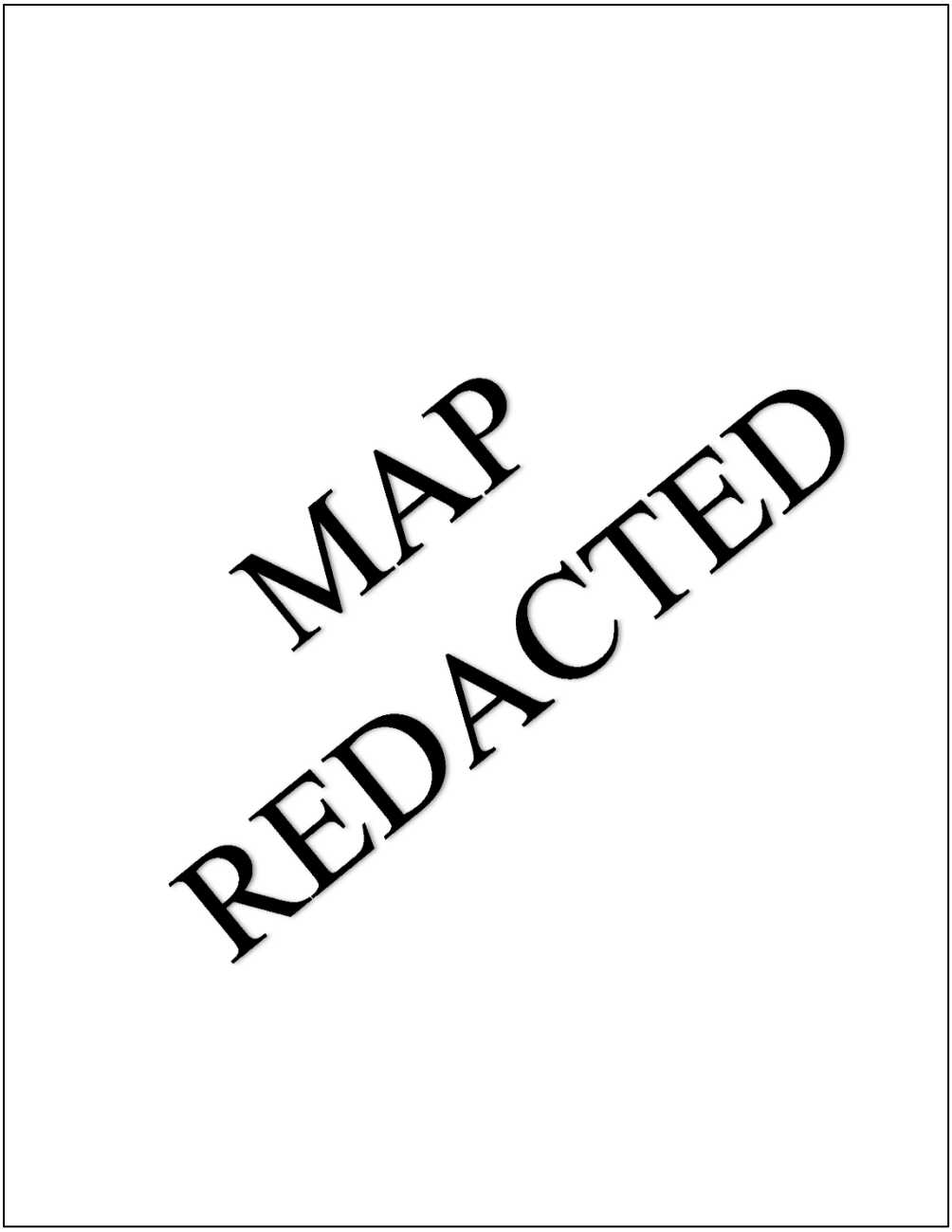

Figure 11.30. Map of known occurrences of Conservancy fairy shrimp recorded in the Diversity Database (2022) within the Sacramento National Wildlife Refuge (NWR) Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

11.7.5.2. Vernal Pool Tadpole Shrimp Occurrences

There are five Diversity Database occurrence records for the vernal pool tadpole shrimp within this core area, all of which are entirely protected within the Sacramento National Wildlife Refuge (see **Figure 11.29**; Diversity Database 2022). All occurrences are presumed extant by the Diversity Database; two are within extant mapped vernal pool grasslands and three are outside of mapped vernal pool grasslands (Witham 2021). A total of 11 years of vernal pool shrimp surveys have occurred on the Sacramento National Wildlife Refuge between 1993 and 2017 (D'Errico, *in litt*. 2022), though it is possible that not every pool was surveyed each year. The vernal pool tadpole shrimp was identified in 6 pools out of 45 sampled in 2017, located in the north, west, and south of the Refuge (Helm Biological Consulting 2017). The vernal pool tadpole shrimp had also previous been identified in two pools in the southeast in 1993, 1994, and 2002 (D'Errico, *in litt*. 2022). All of these pools line up with the locations of Diversity Database records within the Sacramento Refuge.

11.7.5.3. Conservancy Fairy Shrimp Occurrences

There is one Diversity Database occurrence records for the Conservancy fairy shrimp within this core area, which is entirely protected within the Sacramento National Wildlife Refuge (see **Figure 11.30**; Diversity Database 2022). The occurrence is presumed extant by the Diversity Database and is outside of mapped vernal pool grasslands (Witham 2021). A total of 11 years of vernal pool shrimp surveys have occurred on the Sacramento National Wildlife Refuge between 1993 and 2017 (D'Errico, *in litt*. 2022), though it is possible that not every pool was surveyed each year. The Conservancy fairy shrimp is known from just one pool in the southwest of the Refuge, where it was observed in 1993, 1994, and 2004 (D'Errico, *in litt*. 2022; Diversity Database 2022). This single pool represents the entirety of the Sacramento National Wildlife Refuge population.

11.7.6. Vacaville

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 the City of Vacaville in Solano County on either side of Interstate 505 near the intersection with Interstate 80.

Witham et al.'s (2013) mapping effort estimated that there were 164 acres of vernal pool grassland within this core area when the Recovery Plan was published in 2005, and as of 2018 no habitat losses were estimated to have occurred (see **Figure 11.31**, **Table 11.1**; Witham 2021). All of the vernal pool grasslands mapped by Witham (2021) are within protected lands, as the entire core area east of Interstate 505 is within the North Preserve unit of the Michael Remy Vernal Pool Preserve. However, any unmapped vernal pool grasslands that may exist west of Interstate 505 are not within protected lands, so the true percentage of the 2005 baseline that is protected may be closer to around 50%. No vernal pool shrimp species have been identified west of Interstate 505, but there is an occurrence record of bearded popcorn flower (*Plagiobothrys hystriculus*) that confirms that some vernal pool habitat not mapped by Witham (2021) does exist west of Interstate 505, at least as recently as 2016 (Diversity Database 2022).

The only protected land within this core area is the North Preserve unit of the Michael Remy Vernal Pool Preserve. This 220-acre preserve was protected in 2004 as mitigation for the surrounding North Village residential development project (CNLM 2022b), and the irregular shape of the core area east of Interstate 505 was designed to contain this preserve. The Center for Natural Lands Management (CNLM) holds the conservation easement and manages the preserve. Numerous vernal pools and non-vernal pool palustrine wetlands are scattered throughout the North Preserve, and 17.86 acres of seasonal wetlands have been created within the preserve (see **Figure 11.32**; CNLM 2022b). There are no protected lands in the portion of the core area west of Interstate 505.

11.7.6.1. Vernal Pool Fairy Shrimp Occurrences

There are three Diversity Database occurrence records for the vernal pool fairy shrimp within this core area; there is also one occurrence that very slightly overlaps the core area due to the large margin of error of the record, but it most likely does not occur within the core area (see **Figure 11.33**; Diversity Database 2022). As of 2018, all three occurrences were at least partially within protected areas (Vollmar et al. 2017). All occurrences are presumed extant by the Diversity Database; two are within extant mapped vernal pool grasslands and one is outside of mapped vernal pool grasslands (Witham 2021). Of the three records in the core area, none were known at the time of listing in 1994 (though the nearby imprecise record was) and two were known at the time the Recovery Plan was published in 2005. The one newer record is located in the North Preserve unit of the Michael Remy Vernal Pool Preserve in the easternmost section of the core area. This confirms that the entire portion of the core area east of Interstate 505 is occupied by the vernal pool fairy shrimp. CNLM monitors 22 natural pools and 22 created pools on the North Preserve every 5 years; in 2021-2022, the vernal pool fairy shrimp was observed in 4 natural pools and 8 created pools (see **Figure 11.32**; CNLM 2022b). No vernal pool shrimp species have been identified west of Interstate 505, but there is an occurrence record of bearded popcorn flower (*Plagiobothrys hystriculus*) that confirms that some vernal pool habitat not mapped by Witham (2021) does exist west of Interstate 505, at least as recently as 2016 (Diversity Database 2022).

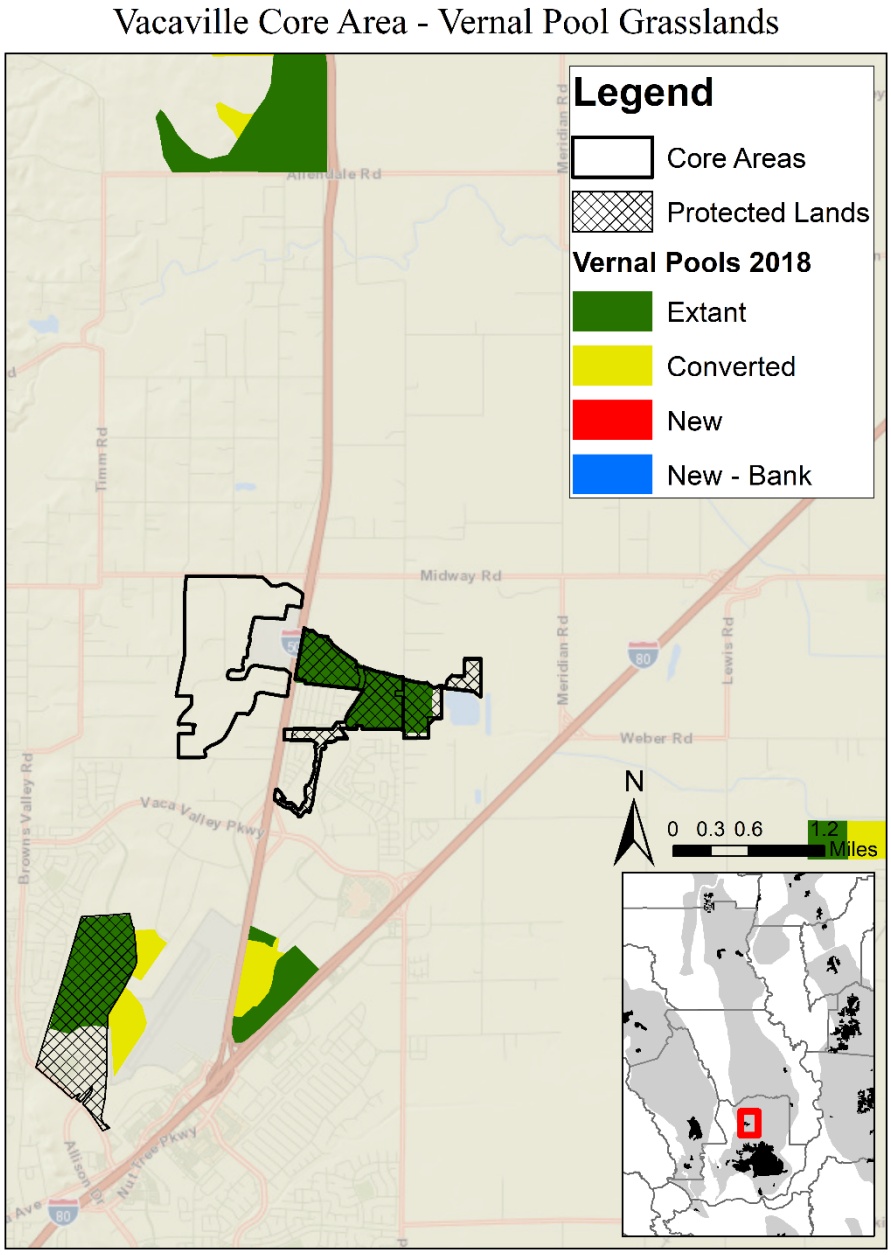

Figure 11.31. Map of vernal pool grassland habitat within the Vacaville Core Area mapped by Witham (2021) created using aerial imagery from 2018 compared to 2005 and 2012. "New" vernal pool habitat refers to areas not seen in the 2005 or 2012 aerial imagery (either missed or restored). "New - bank" refers 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.

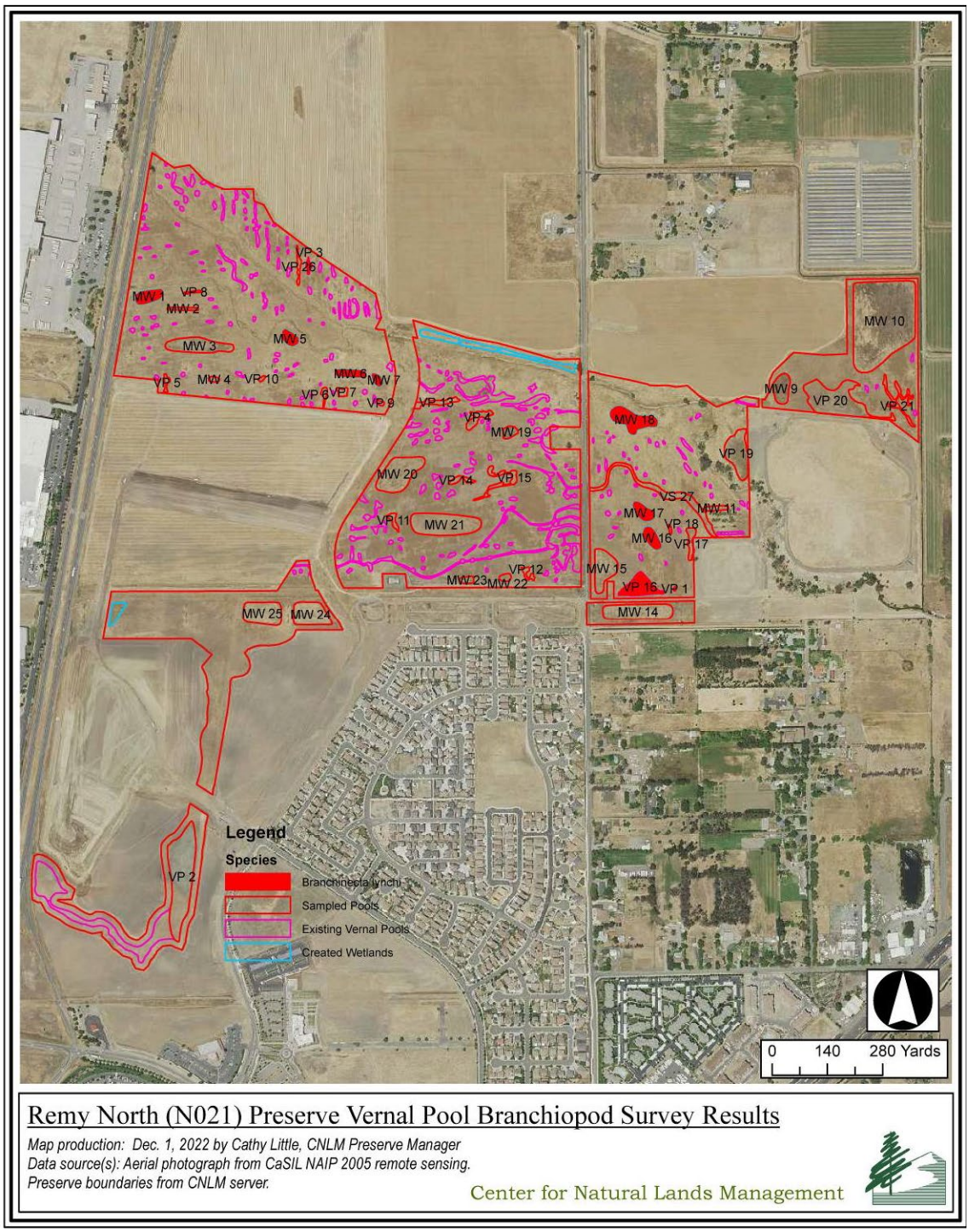

Figure 11.32. Map of natural vernal pools, existing vernal pools, and created wetlands within the North Preserve unit of the Michael Remy Vernal Pool Preserve in Vacaville, Solano County, including results of 2022 surveys for the vernal pool fairy shrimp. Taken from Figure 7 of the 2022 Annual Report for the preserve (CNLM 2022b).

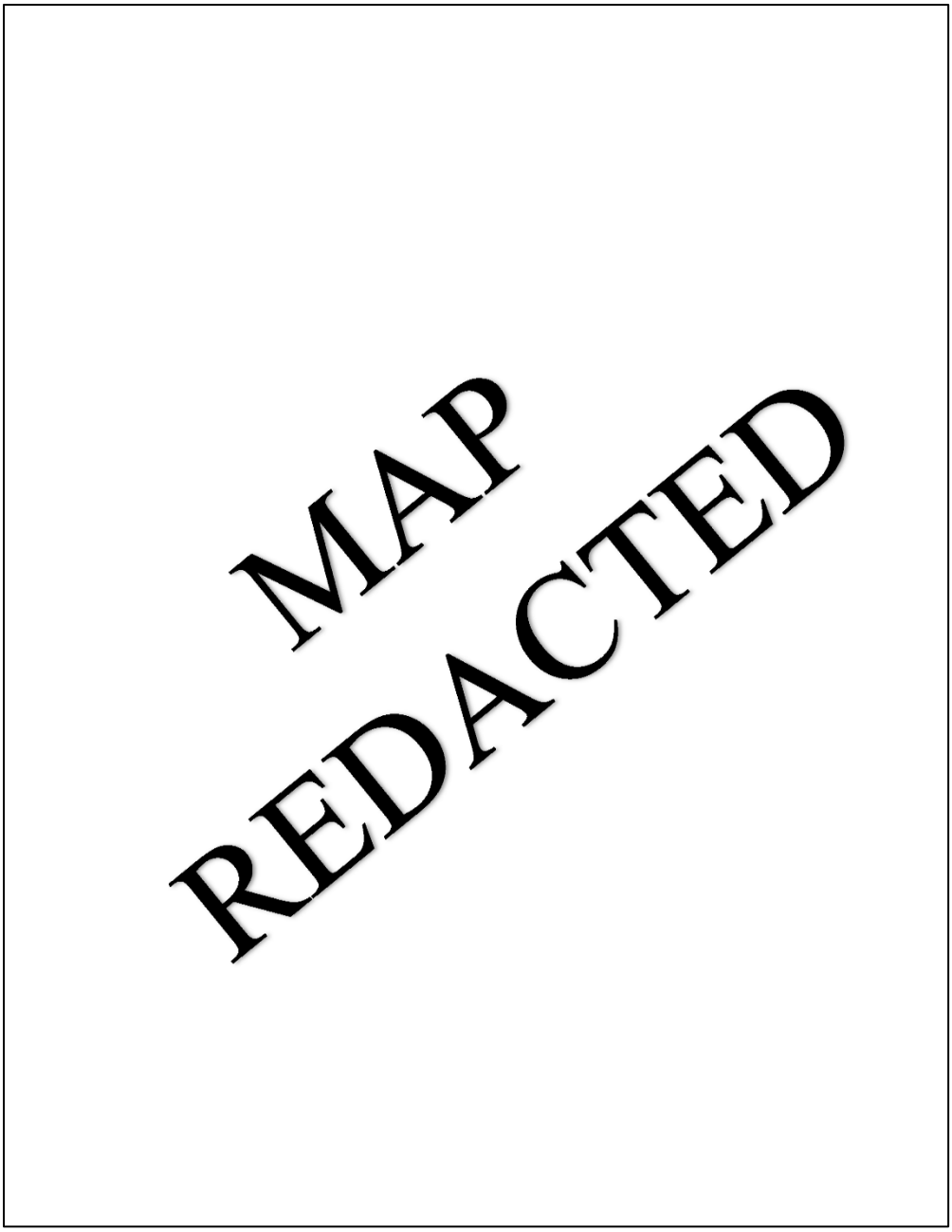

Figure 11.33. Map of known occurrences of vernal pool fairy shrimp recorded in the Diversity Database (2022) within the Vacaville Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.

11.7.7. Woodland

This is a zone 2 core area, but it was not designated for the vernal pool tadpole shrimp in the Recovery Plan. It was designated for alkali milk vetch (*Astragalus tener* var. *tener*) with a goal of protecting 85% of vernal pool habitat. The core area is located east of County Road 102 in the City of Woodland, Yolo County.

There were approximately 338 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 338 acres of vernal pool grassland remaining, with no habitat losses occurring since 2005 (see **Figure 11.34**, **Table 11.1**; Witham 2021). Roughly 188 acres of vernal pool grassland were protected within this core area as of 2017 within the Alkali Grasslands Preserve (Vollmar et al. 2017), representing 56% of the 2005 baseline.

There is one protected land within this core area: the Alkali Grasslands Preserve. This 180-acre preserve is located in the center of the core area on either side of County Road 25 and is composed of four units. The northern three units are owned by the City of Woodland and the southern unit is privately owned. These parcels were preserved as mitigation for several projects, and a conservation easement was recorded in 2005 (CNLM 2022c). The Center for Natural Lands Management (CNLM) is the easement holder and the land manager. The preserve is dominated by alkali grassland habitat intermixed with alkali scalds, meadows, pools, and swales, with nine pools mapped onsite (CNLM 2022c). Witham (2021) mapped the entire preserve as extant vernal pool grassland. Management on the preserve includes grazing, monitoring thatch levels, invasive species management, and various biotic surveys, primarily for rare plants (CNLM 2022c).

11.7.7.1. Vernal Pool Tadpole Shrimp Occurrences

There is one Diversity Database occurrence record for the vernal pool tadpole shrimp within this core area (see **Figure 11.35**; Diversity Database 2022). As of 2018, this occurrence was entirely protected within the Alkali Grasslands Preserve (Vollmar et al. 2017). The occurrence is presumed extant by the Diversity Database and is within extant vernal pool grasslands (Witham 2021). The vernal pool tadpole shrimp was first documented here in 2011 (Diversity Database 2022), after the Recovery Plan was published. Wet-season surveys are conducted on the preserve annually (CNLM 2022c), and the vernal pool tadpole shrimp was observed in most years that had sufficient ponding for the species, including 2011, 2012, 2013, 2016, and 2017 (CNLM, *in litt*. 2021b; Diversity Database 2022).

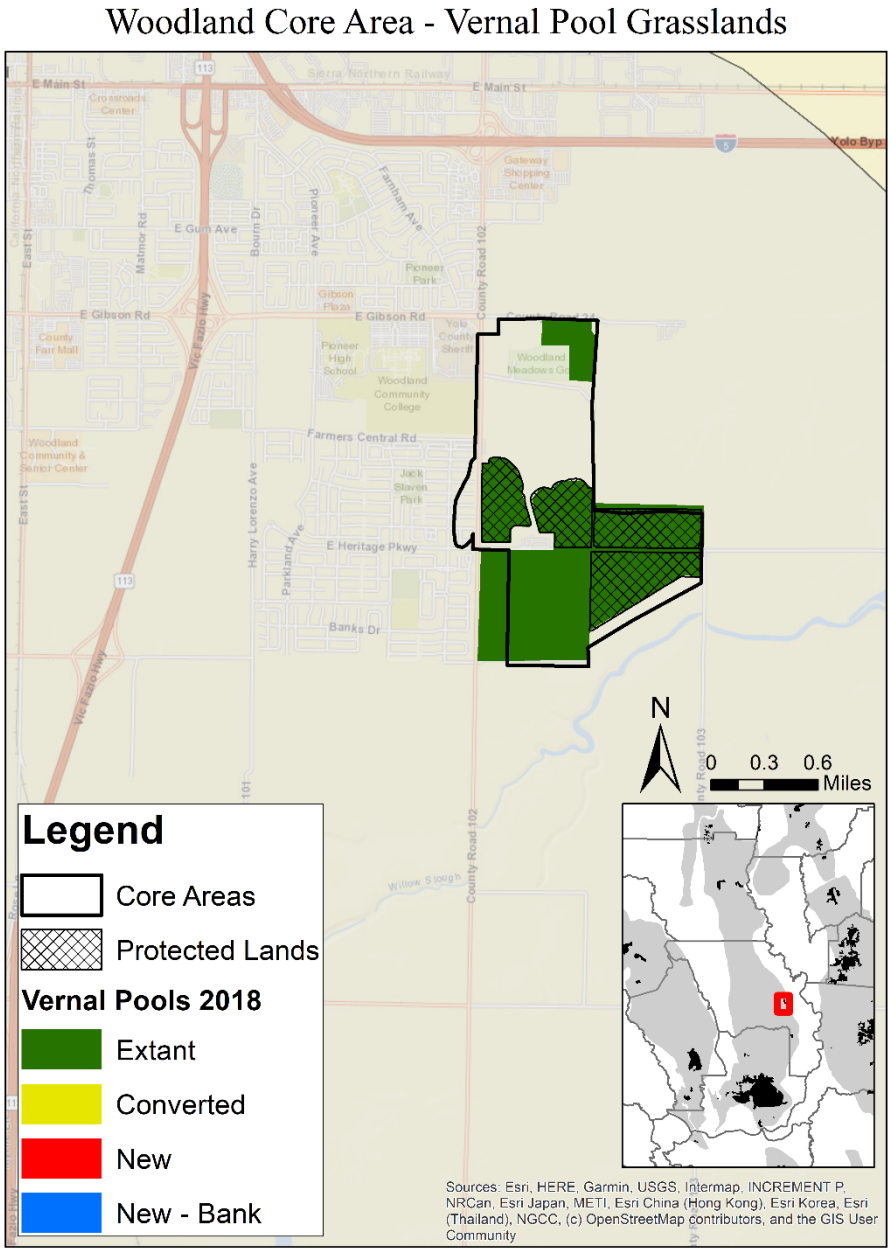

Figure 11.34. Map of vernal pool grassland habitat within the Woodland Core Area mapped by Witham (2021) created using aerial imagery from 2018 compared to 2005 and 2012. "New" vernal pool habitat refers to areas not seen in the 2005 or 2012 aerial imagery (either missed or restored). "New - bank" refers 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.

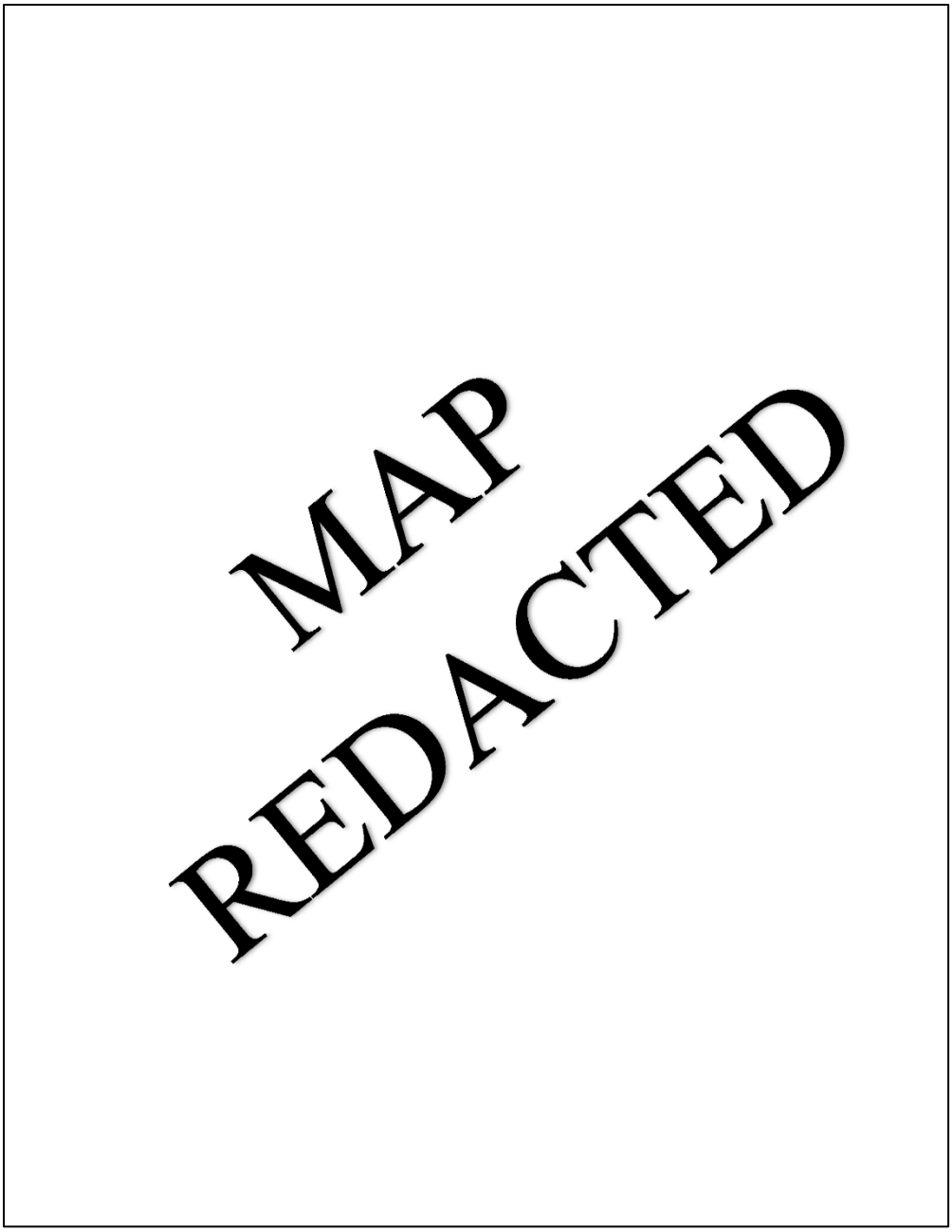

Figure 11.35. Map of known occurrences of vernal pool tadpole shrimp recorded in the Diversity Database (2022) within the Woodland Core Area. Polygons may represent individual pools, multiple pools, whole properties, or entire vernal pool grassland complexes. Occurrences are color coded as extant or extirpated based on both the Diversity Database and Witham's (2021) map of vernal pool habitat.