

5-YEAR REVIEW

Colusa Grass (*Neostapfia colusana*)

GENERAL INFORMATION:

Species: Colusa Grass (*Neostapfia colusana*)

Date listed: March 26, 1997

Federal Register (FR) citation: 62 FR 14338 (Service 1997)

Classification: Threatened

State listing:

Colusa grass was listed as endangered by the State of California in 1979.

BACKGROUND:

Species overview:

As summarized in the Recovery Plan (Service 2005, pp. II-55–II-58), Colusa grass is an annual plant in the grass family (Poaceae) and is in the Orcuttieae taxonomic tribe, which also includes species of the *Orcuttia* and *Tuctoria* genera. Grasses of the Orcuttieae tribe are endemic to California vernal pool habitat. Unlike terrestrial grasses, grasses in the Orcuttieae tribe have pith-filled stems, lack distinct leaf sheaths (parts of a grass leaf that encircles the stem) and ligules (thin outgrowths at the junction of leaf and leafstalk), and produce exudate (fluid secretions). Population sizes of Colusa grass can vary widely from year to year. Long-term inundation of approximately three months is required for seed germination, and it appears that deeper vernal pools and stock ponds are most likely to provide the long inundation period required. Colusa grass has one of the broadest ecological range among the Orcuttieae tribe, as it occurs on the rim of alkaline basins in the Sacramento and San Joaquin Valleys, on acidic soils of alluvial fans and stream terraces along the eastern margin of the San Joaquin Valley and into the adjacent foothills, as well as in Northern Claypan and Northern Hardpan vernal pool types. Colusa grass is found in the Solano-Colusa, San Joaquin Valley, and Southern Sierra Foothills vernal pool regions within Yolo, Solano, Merced, and Stanislaus counties.

Most recent status review:

[Service] U.S. Fish and Wildlife Service. 2008. Colusa Grass (*Neostapfia colusana*). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Sacramento, California. 27 pp.

We did not recommend a status change in the 2008 status review.

FR notice citation announcing this status review:

[Service] U.S. Fish and Wildlife Service. 2022. Endangered and Threatened Wildlife and Plants; Initiation of 5-Year Status Reviews of 40 Species in California and Nevada. Federal Register 87:5832–5834.

We did not receive information from the public regarding Colusa grass in response to the notice.

ASSESSMENT:

Information acquired since the last status review:

This 5-year review was conducted by the U.S. Fish and Wildlife Service's (Service) Sacramento Fish and Wildlife Office. Data for this review were solicited from interested parties through a Federal Register notice announcing this review on February 2, 2022. We also contacted species experts and other partners to request any data or information we should consider in our review. Additionally, we conducted a literature search, reviewed information in our files, and obtained data from an occurrence search of the California Natural Diversity Database (Diversity Database) maintained by the California Department of Fish and Wildlife.

Since our last 5-year review, a range-wide genetic analysis was completed for Colusa grass (discussed in **Genetics**). Seven new occurrences of Colusa grass, which are located in proximity to previously known occurrences, have been added to the Diversity Database. Colusa grass has become fully extirpated from the Farmington and Waterford core areas in Stanislaus County (discussed in **Distribution**). Although current abundance estimates remain unavailable for Colusa grass throughout the range of the species, 30 out of the 45 extant occurrences of the species have been surveyed since the last 5-year review. Survey and monitoring reports suggest the number of plants at each site varies greatly from year to year (discussed in **Abundance**). Updates on threats and progress towards the recovery criteria are addressed in the **Threats and Recovery Criteria** sections, respectively.

Genetics:

New genetic research shows that Colusa grass exhibits significant genetic variation and population structure across the species range (Gordon *et al.* 2012, entire). Gordon *et al.* concluded that the detection of allele richness and heterozygosity in Colusa grass suggests a long-lived and persistent seed bank that can at least temporarily protect the species from the detrimental effects associated with small and fragmented populations (Gordon *et al.* 2012, p. 126). Additionally, the study further identified two genetically distinct regions in the north and the south (Gordon *et al.* 2012, pp. 121–123). The observed patterns of population structure between the two regions support the boundaries of the vernal pool regions delineated in the Recovery Plan (Service 2005, pp. I-83–I-85). As such, the northern region encompasses Colusa grass populations found within the Solano-Colusa vernal pool region, and the southern region encompasses all Colusa grass populations found in the San Joaquin Valley and Southern Sierra Foothill vernal pool regions. Additionally, the study found strong support for genetic distinction between Yolo and Solano counties in the north region and between Stanislaus and Merced counties in the south region (Gordon *et al.* 2012, pp. 125, 127). Therefore, the authors suggest the need to preserve unique genetic varieties within each region in the north and south (Gordon *et al.* 2012, pp. 125–126). To minimize the risk of outbreeding depression, Gordon *et al.* recommend restricting plant translocation to areas within the natural range of wind-driven seed dispersal range and thereby preserving the natural gene pools detected within each region (Gordon *et al.* 2012, p. 127). The results of this study provide important information for informing future recovery efforts (seed collection and introduction programs) and meeting the delisting criteria for the species as detailed in the Vernal Pool Recovery Plan (Service 2005, pp. I-87–I-120; Table 3).

Distribution:

Colusa grass is known to occur within three of the vernal pool regions that are delineated in the Recovery Plan (Service 2005, pp. I-8–I-12), including the Solano-Colusa, San Joaquin Valley, and Southern Sierra Foothill vernal pool regions. Within these regions, Colusa grass was historically located within eight core areas, including the Davis Communication Annex, Jepson Prairie, Grasslands Ecological Areas, Farmington, Madera, Merced, Turlock, and Waterford (Table 1; Service 2005, pp. I-8 – I-12).

Table 1. Vernal pool regions and associated core areas within each county for which Colusa grass historically occurred as identified in the Recovery Plan (Service 2005, pp. I-8–I-12).

County	Vernal Pool Region	Core Area	Number of extant occurrences as of 2023
Colusa ¹	Solano-Colusa	Not within a designated core area	0 (Extirpated by 1997)
Yolo	Solano-Colusa	Davis Communication Annex	3
Solano	Solano-Colusa	Jepson Prairie	4
Merced	San Joaquin Valley	Grasslands Ecological Areas	3
Merced	Southern Sierra Foothills	Madera	25
Merced and Stanislaus	Southern Sierra Foothills	Turlock	0 (Extirpated by 2008)
Merced and Stanislaus	Southern Sierra Foothills	Merced	10
Stanislaus	Southern Sierra Foothills	Farmington	0 (Extirpated by 2023)
Stanislaus	Southern Sierra Foothills	Waterford	0 (Extirpated by 2023)

¹ The historical occurrence in Colusa County was extirpated prior to listing in 1997 (Service 1997, p. 14339), so it was not identified as a core area in the Recovery Plan for Colusa grass; however, the record is included in the table to provide historical context.

At the time of listing in 1997, Colusa grass had become fully extirpated from Colusa County and 40 occurrences remained extant in Yolo, Solano, Merced, and Stanislaus counties (Service 1997, p. 14339; Table 1). By 2008, when the previous 5-year review was conducted, the number of known extant occurrences reported in the Diversity Database had slightly increased to 43 occurrences, but the species had been extirpated from the Turlock core area (Service 2008, pp. 9, 14).

Currently, there are 45 presumed extant occurrences of Colusa grass distributed across the same four counties (Yolo, Solano, Merced, and Stanislaus) (Diversity Database 2023; Figure 1; Table 1). The most recent documented visits to known occurrences of Colusa grass occurred in 2023 and Colusa grass has been confirmed at 12 occurrences since 2017. Overall, there have been seven new occurrences (occurrence # 72–78) added to the Diversity Database (2023) since 2008. These new occurrences are within the known extent of the species range and are located in proximity to previously known occurrences. Three occurrences (occurrence #15, #40, and #51)

that were listed as extirpated or presumed extirpated in 2008 are now listed as extant due to detections during recent site visits. Seven additional occurrences (occurrence #11, #20, #47, #56, #57, #64, and #65) are now listed as extirpated in the Diversity Database, of which six have been extirpated due to habitat conversion to crop fields based on satellite imagery (Diversity Database 2023). Details of all presumed extant occurrences and recently extirpated occurrences are summarized in **Appendix A**.

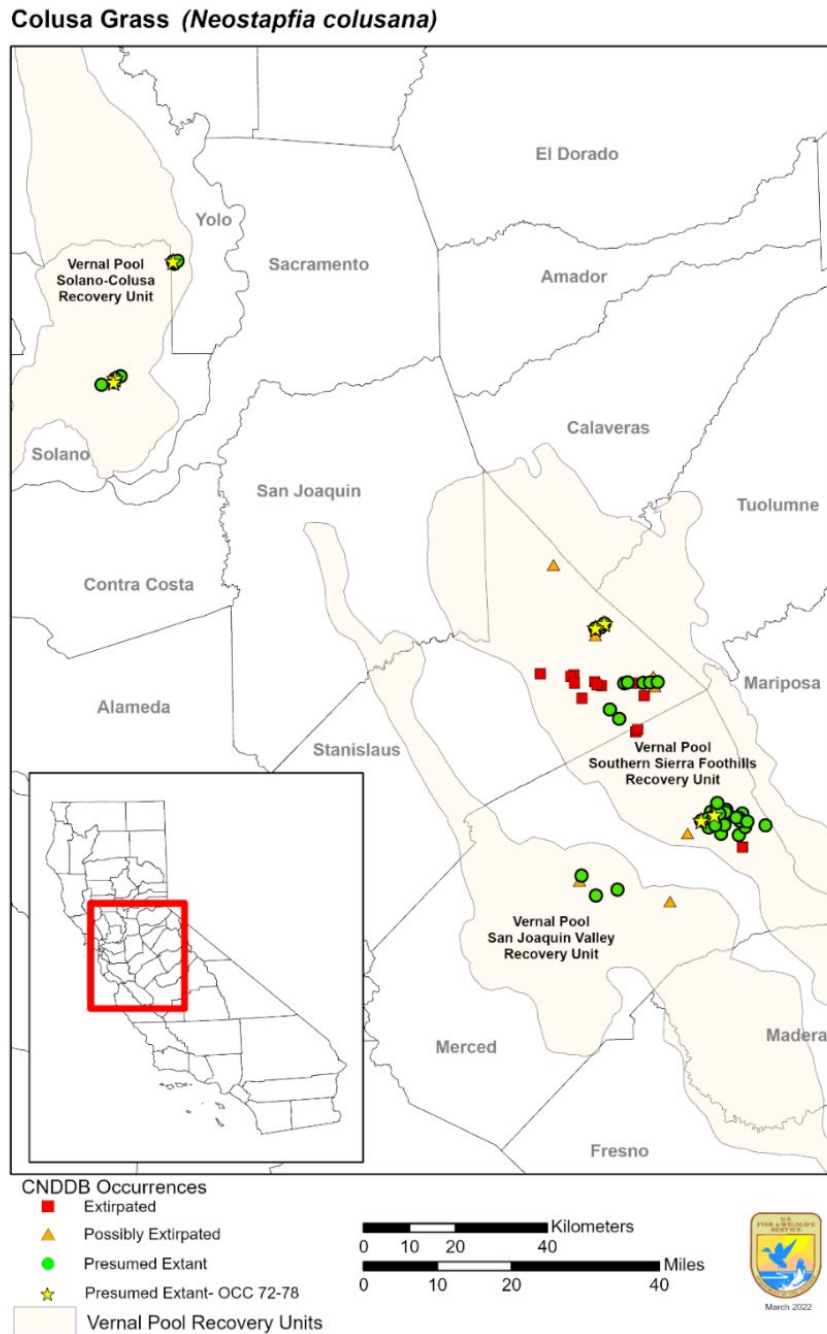


Figure 1. Colusa grass Diversity Database occurrence records (Diversity Database 2023), showing county, vernal pool region (Service 2005), and the seven occurrences identified since the 2008 5-year review (occurrence #72–78).

Colusa grass remains presumed extant in each of the vernal pool regions, but Diversity Database occurrences are currently found in only five of the eight core areas. Since the 2008 5-year review, all Diversity Database occurrences of Colusa grass in the Farmington and Waterford core areas in Stanislaus County are now described as fully extirpated as a result of habitat loss (occurrence #47, #56, #64, and #65). The vast majority (84%) of the known extant Diversity Database occurrences are still found in the southern portion of the species range on privately owned lands in Merced and Stanislaus counties (Figure 1). Currently, there are 28 presumed extant Diversity Database occurrences in Merced County. Although two new occurrences (occurrence #75 and #76) have been added to the Diversity Database in Stanislaus County, the number of presumed extant occurrences in Stanislaus County has declined from 16 to 10 occurrences since 2008. All known Diversity Database occurrences continue to persist in Solano and Yolo Counties (Figure 1). However, occurrence #48 in Solano County is reported as presumed extant in the Diversity Database but has not been detected since 1986 despite multiple survey efforts between 1989–2010. Two new occurrences (occurrence #72 and #73) have been added since 2014 in the Jepson Prairie core area and both are on private land adjacent to the Jepson Prairie Reserve. In addition, conservation efforts to seed nearby pools in Yolo County (occurrence #74) were completed in 2009 (Witham *et al.* 2013, p. 39). However, Colusa grass was not detected during a survey of the pools in 2020 (Stone 2020, p. 4). The survey report suggested the artificially created pools may only provide suitable conditions to support Colusa grass growth and reproduction during years with exceptional rainfall (Stone 2020, p. 4).

Abundance:

Colusa grass populations can vary greatly in size from year to year in response to environmental conditions (Service 2005, p. II-50; Service 2008, p. 20). Population sizes have been observed to vary by one to four orders of magnitude among successive years and to return to previous levels even after 3 to 5 consecutive years when no mature plants were present (Service 2008, p. 20). Current standardized abundance surveys are not known to occur for Colusa grass, and the Service is not aware of a range-wide survey taking place for Colusa grass. Since developing the Recovery Plan informal site visits confirming presence of the species have been conducted, but standardized survey protocols are still lacking so accurate estimates of current abundances across the range of the species are not available. According to the Diversity Database (2023), 30 out of the 45 extant occurrences have been visited since the previous 5-year review in 2008 (**Appendix A**).

In recent surveys from 2017–2022 abundance varied greatly from as few as two individuals to as many as 100,000 individuals. Fifty or fewer individuals were found at more than half of the occurrences surveyed during this period. The current status of nine occurrences (occurrence #01, #17, #32, #34, #37, #48, #50, #58, #74; **Appendix A**) is presumed extant although the species was not detected during the most recent surveys at those localities. Annual abundance of vernal pool plants is known to vary greatly with precipitation (Service 2008, pp. 381–382) and surveys at these sites were conducted following periods of significant prolonged drought in California (Mount *et al.* 2021, pp. 1–2; Water Resources 2020, pp. 63–93). In addition, the current status of 15 presumed extant occurrences has not been reassessed in several decades (**Appendix A**) and areas with habitat that may support this species remain to be surveyed. Thus, reliable estimates of the abundance and population trends of Colusa grass and suitable habitat remain unknown for most of the species' range.

Vernal pools have been annually surveyed on the Merced Vernal Pools and Grassland Reserve since 2015 (LAS 2023, entire). Colusa grass has been detected in 13 of the 22 vernal pools on the reserve since 2015 (LAS 2023, p. 12, Appendix A). However, the most recent surveys conducted in 2023 detected Colusa grass in only five vernal pool locations (LAS 2023, p. 4; Table 2). The number of plants detected per pool ranged from as few as three plants to as many as 100,000 plants (LAS 2023, p. 5, Table 2). The Lame Cow Pond remains the most stable population on the reserve (Table 2). The Lame Cow Pond is a stock pond that can retain water for a longer duration compared to other vernal pools on the property. For this reason, the Lame Cow Pond can support Colusa grass even during periods of prolonged drought. The Southern Playa Pool supports one of the largest populations of Colusa grass currently known throughout the species range. Although the population has declined since 2016 when 1.2 million plants were detected, the population is considered stable overall (LAS 2023, p. 12).

Table 2. Colusa grass abundance estimates from 2015 to 2023 on the Merced Vernal Pools and Grassland Reserve in Merced County (LAS 2023, p. 12, adapted from Appendix A).

Vernal Pool	2015	2016	2017	2018	2019	2020	2021	2022	2023
Hercules Powder Pond	5	1	0	0	0	0	0	0	3
Lame Cow Pond	10,000	400	500–700	100–300	500–1,000	500	3,000–4,000	3,000–4,000	1,500–4,000
Location A	0	0	-	30	0	0	0	0	3
Southern Playa Pool	0	1.2 million	1 million	0	100,000+	0	0	0	50,000–100,000
Northwestern Vernal Pool	0	5+	37	0	0	0	0	0	16

Resource managers on the Merced National Wildlife Refuge in Merced County have periodically monitored Colusa grass populations since 1987 (Service 2022, p. 3; Figure 2). Estimated yearly counts range from 0 to 3,043 individuals, with a median count of 38.5 individuals detected each year. The number of plants counted on the refuge peaked in 1992 and 1993 with 2,000 and 3,043 plants detected, respectively. The number of Colusa grass detected following these surveys remained below 100 individuals before increasing again to 884 plants in 2017 and 1,313 plants in 2019. Five plants were detected in 2020 and then Colusa grass was not detected on the refuge during surveys in 2021 and 2022. However, the refuge population seems to demonstrate the natural variation in year-to-year abundance (and even presence) that is typical of annual vernal pool plant species. As such, following record-breaking rainfall in 2023, refuge staff reported the greatest number of Colusa grass detected in the vernal pools on the refuge since monitoring was initiated in 1987 (F. Takahashi, San Luis National Wildlife Refuge Complex, *in litt.* 2024).

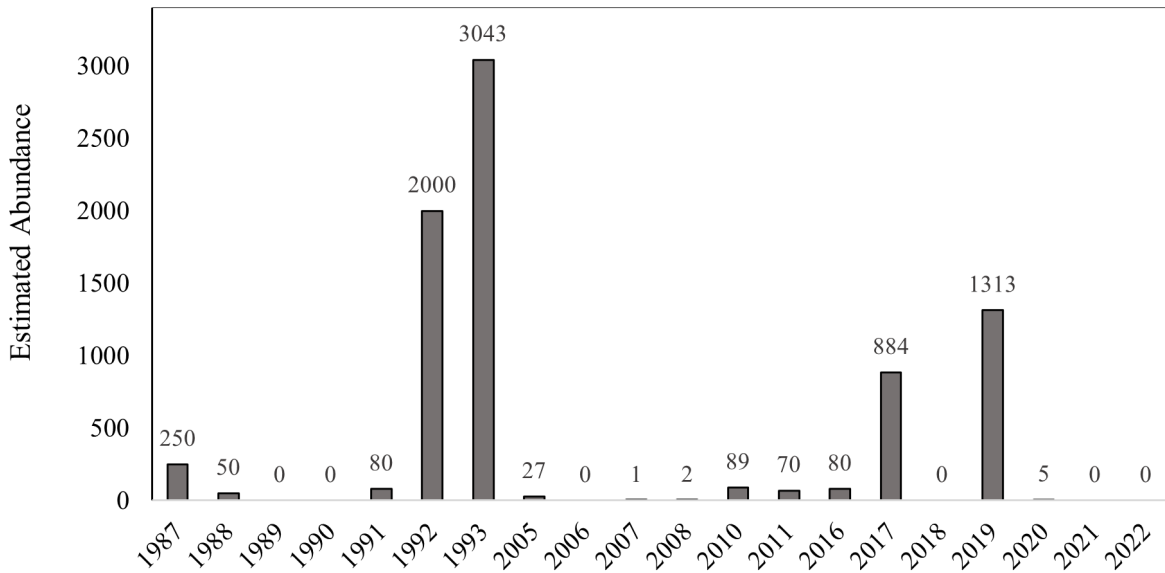


Figure 1. Estimated number of Colusa grass detected during vernal pool surveys conducted from 1987 to 2022 on the Merced National Wildlife Refuge in Merced County (Service 2022, entire). Numbers from 2023 are not included in the figure, but early survey results indicate that abundance was high in 2023 (Takahashi *in litt.* 2024).

Annual monitoring of vernal pools has also occurred on the Jepson Prairie Reserve in Solano County since 1988 (C. Witham, Biological Consultant, *in litt.* 2023). However, this data has not been processed and remains in its raw format on datasheets, so it was unavailable for this review.

Threats:

At the time of listing, multiple threats to Colusa grass were identified: habitat loss and degradation due to urbanization, agricultural land conversion; livestock grazing; off-highway vehicle use; a flood control project; a highway project; mining projects; altered hydrology, landfill projects; and competition from weedy nonnative plants (Service 1997, p. 14338). These threats continued to act on the species at the time of our 2008 5-year review, with climate change and drought and small population size identified as additional threats to the species (Service 2008, pp. 19–20). However, recent genetic analysis suggests the negative consequences of small population size (e.g., inbreeding and genetic drift) may be less of a threat to Colusa grass than previously thought (Gordon *et al.* 2012, p. 126; see **Genetics**). The other threats identified at the time of listing and our 2008 5-year review continue to act on the species with pesticide use identified as a new threat. The following sections summarize new information related to the ongoing threats of habitat loss and climate change, and the threat of pesticides.

Habitat loss

The 1997 listing rule described Colusa grass habitat as having been reduced and fragmented throughout its historical range (Service 1997, pp. 14346–14347) and the Recovery Plan lists habitat loss and fragmentation as the primary threat to survival and recovery of this species (Service 2005, p. I–16). Primary causes attributed to the reduction and fragmentation of habitat include agricultural land conversion and urbanization (Service 2008, p. 15).

Between the listing of the species in 1997 and the development of the Recovery Plan in 2005, approximately 36,068 acres (7.7% of mapped extent) of vernal pool habitat within the current range of the species (Stanislaus, Merced, Solano, and Yolo Counties) were converted to urban or agricultural land uses (Holland 2009, p. 8). Updated mapping of vernal pool habitat across California's Central Valley shows a net loss of 70,482 acres between 2005 and 2018, or approximately 5,848 acres per year of natural vernal pool habitat converted to other land uses (Witham 2021, p. 5). Most of this habitat loss is from conversion to agriculture, specifically the conversion to orchards, which total 56.6% of mapped acres lost (Witham 2021, p. 1). By contrast, habitat loss to urban or industrial development total 6.65% of mapped acres lost (Witham 2021, p. 1). Currently, no vernal pool habitat remains in the Waterford core area (Witham 2021, geodatabase). Potential future urban development includes the California Forever proposed development project near the Jepson Prairie Preserve (J. Westbrook, Solano Land Trust, *pers. comm.* 2023; California Forever 2024, p. entire). The project proposes to construct an approximately 17,500-acre new community in Solano County (California Forever 2024, p. 1) that could potentially affect known Diversity Database occurrences in the area (Witham *in litt.* 2023; Westbrook *pers comm.* 2023) (see **Appendix A**).

Climate change

California's Fourth Climate Change Assessment was published in 2018 (Thorne *et al.* 2018, entire) and has included subsequent regional reports focused on the different regions of California, including the Sacramento Valley and San Joaquin Valley (Fernandez-Bou *et al.* 2021, entire; Houlton and Lund 2018, entire). These regions of California encompass the core range of the Colusa grass and are expected to experience significant impacts from climate change. In both regions, the projected annual average temperature is expected to increase by the end of the century under both of the considered emission scenarios (RCP 4.5 and RCP 8.5) (Fernandez-Bou *et al.* 2021, p. 19; Houlton and Lund 2018, p. 18). In addition, models of projected future precipitation in both regions show a similar trend towards fewer but more intense precipitation events each year (Fernandez-Bou *et al.* 2021, p. 8; Houlton and Lund 2018, p. 6). Natural wetlands may experience extended periods of drought, floods, increased water temperatures, and higher evaporation rates (Fernandez-Bou *et al.* 2021, p. 10).

Wetlands (including vernal pools) are expected to be more sensitive to climate change because precipitation is often their main water source (Winter 2000, p. 307), so alterations to precipitation regimes are likely to disproportionately affect these ecosystems. Pyke (2004, pp. 3–4) reported that climate change and reduced frequency of suitable habitat might represent the greatest threat to vernal pool species. Modeling of vernal pool hydrology and plant community composition in northern California show that vernal pools will have shorter inundation times with little change in maximum depth under projections of altered climate change conditions (Montrone *et al.* 2019, p. 1010). However, this model was developed based on data from an isolated, snow-fed pool in the Modoc Plateau Vernal Pool Region, so the results may not be directly applicable to rain-fed pools throughout most of California (Montrone *et al.* 2019, p. 6). Vernal pool specialists are highly sensitive to inundation time, so shortened inundation time due to climate change is expected to cause declines in the number of vernal pool specialist species. While extended periods of drought are not expected to reduce seed bank viability (C. Witham, Biological Consultant, *pers. comm.* 2022), variation in annual weather exacerbated by climate change can contribute to changes in vernal pool plant abundance and community composition, often allowing invasion by non-native exotic species that can competitively exclude sensitive

vernal pool species (Javornik and Collinge 2016, p. 66). For this reason, threatened or endangered vernal pool obligate plant species, such as Colusa grass, may experience increased risk from environmental and ecological changes from climate change (Bauder 2005, p. 2134).

Pesticides

Research over the last 20 years has shown that contaminants may threaten vernal pool ecosystems and pose a significant risk to threatened and endangered vernal pool species within the agricultural matrix of the Central Valley (Johnson 2006, p. 11). Pesticides from agricultural runoff, drift, precipitation, and/or aerial deposition can contaminate vernal pools. Due to the ephemeral nature of vernal pools, contaminants may concentrate in vernal pools during the dry-down phase, potentially exacerbating the ecological impacts of these contaminants (Cahill *et al.* 2001, p. 822). Modeling of pesticide concentrations in vernal pool habitats in Merced County within the San Joaquin Valley of California shows that vernal pools are under a high risk of pesticide inputs via agricultural runoff from the surrounding landscape (Sinnathamby *et al.* 2020, p. 9). The actual concentrations of pesticides in vernal pools are not well-known because of the difficulty of accurately sampling these highly seasonal habitats. However, higher concentrations are typically observed in pools directly adjacent to agricultural lands. A study of vernal pools and streams found that atrazine and glyphosate (both herbicides) are detected in concentrations above the freshwater aquatic life standard even when the vernal pools themselves were located on protected lands (Battaglin *et al.* 2009, p. 301). It is unknown the extent to which pesticides (including insecticides, herbicides, and fungicides) may affect Colusa grass, but best management practices for weed control state that “if endangered grasses such as Sacramento Orcutt grass (*Orcuttia viscida*) are also present, a grass-specific herbicide should never be used” and to avoid broadcast application of glyphosate to control invasive plants in vernal pools (DiTomaso and Kyser 2013, p. 2, Waxy Mannagrass section). There is also evidence that fungicides may inhibit germination of *Orcuttia* seeds, as demonstrated by Keeley (1988, p. 1088), which indicated that fungicide inhibited germination of California Orcutt grass (*O. californica*) seeds but did not affect Greene’s tuctoria (*Tuctoria greenei*) seeds. Detailed germination studies have not been conducted for Colusa grass.

The Environmental Protection Agency (Agency) recently released final biological evaluations assessing the effects of labeled uses of three neonicotinoid pesticides on listed species (Agency 2022a, entire; Agency 2022b, entire; Agency 2022c, entire). The three pesticides (clothianidin, imidacloprid, and thiamethoxam) are registered for use on a variety of agricultural crops; there are also some non-agricultural applications. The three pesticides target insect species by acting on their neurotransmitters to cause excessive nervous stimulation, paralysis, and death. The overall importance of pollinating insects for Colusa grass is poorly understood. Grasses within the Orcuttieae tribe are thought to be primarily wind pollinated; however, some insect pollination may occur, including by native bees (*Halictidae* sp.), which have been observed gathering pollen from other species in the Orcuttieae tribe including Sacramento Orcutt grass and hairy Orcutt grass (*Orcuttia pilosa*; Griggs 1974, as cited in Stone *et al.* 1988, p. 16). The Agency’s final biological evaluations determined that all three pesticides are highly toxic to invertebrate pollinators including bees, have the potential to result in bee brood and colony reductions, and if affected bee colony declines are near Colusa grass, there is a potential for the three pesticides to indirectly adversely affect the species (Agency 2022a, p. 4; Agency 2022b, p. 2; Agency 2022c, p. 3). The Agency anticipates releasing amended proposed interim decisions and a national Section 7 consultation with the Agency is currently pending.

Recovery criteria:

General recovery criteria for Colusa grass and 19 other listed plants and animals are described in the Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon (Service 2005, Section III). The Recovery Plan uses an ecosystem-level approach because many of the listed species and species of concern addressed in the plan co-occur in the same natural ecosystem and share the same threats. The five key elements that comprise this ecosystem-level recovery and conservation strategy are habitat protection (recovery criteria 1A–E), adaptive habitat management and monitoring (recovery criteria 2A–D), status surveys (recovery criteria 3A–B), research (recovery criteria 4A–C), and participation and outreach (recovery criteria 5A–D). The recovery criteria for the Colusa grass have been partially met. The current status of each recovery criterion, and its status at the time of the 2008 5-year review, is detailed in Table 3 below.

Table 3. Summary of recovery criteria for Colusa grass described in the Recovery Plan (Service 2005, p. III-97). The current status of each criterion is compared with its status as described in the previous 5-year review (Service 2008, pp. 3–5).

Downlisting criteria	2008 Status	2023 Status
<p>1A. Percent suitable vernal pool habitat within each prioritized core area for the species is protected: 95% in Grasslands Ecological Area, 95% in Davis Communications Annex, 95% in Jepson Prairie, 95% in Madera, 95% in Merced, 85% in Farmington, 85% in Turlock, and 85% in Waterford.</p>	<p>Not met</p>	<p>Partially met. As of 2018, estimated total protected vernal pool grassland habitat in the core areas is as follows: 100 acres (99.7%) in Davis Communication Annex core area; 11,204 acres (35.5%) in Jepson Prairie core area; 23,221 acres (75.3%) in Grassland Ecological Area core area; 137 acres (3.1%) in Farmington core area; 17,564 acres (19.2%) in Madera core area; 3,161 acres (15.4%) in Merced core area; and 0 (0%) acres in Turlock and Waterford core areas (Vollmar <i>et al.</i> 2017, geodatabase; Witham 2021, entire). The Service is aware of seven protected areas with known populations of Colusa grass. Details of all protected areas and associated presumed extant occurrences are summarized in Appendix B.</p>
<p>1B. 90% of the species occurrences distributed across the species geographic range and genetic range are protected. Protection of extreme edges of populations protects the genetic differences that occur there.</p>	<p>Partially met. 12% of the 43 occurrences were partly or fully protected in 2008 (Service 2008, p. 10).</p>	<p>Partially met. Currently, 46% (21 out of 45) of the presumed extant occurrences are either partially or fully protected from land conversion by conservation easements or other land conservation mechanisms in Yolo, Solano, and Merced Counties. However, none of the presumed extant occurrences in Stanislaus County are protected. Details of all protected areas are summarized in Appendix B.</p>
<p>1C. Reintroductions must be carried out and meet success criteria established in the recovery plan.</p>	<p>Not met</p>	<p>Partially met. Seeding of Colusa grass (occurrence #74) to artificially created pools in Yolo County was completed in 2009 (Witham <i>et al.</i> 2013, Appendix A-2, pp. 11, D-13). However, no plants were detected in these pools in 2020; conditions within the created pools may only be suitable during heavy rainfall years for Colusa grass germination, growth, and seed production (Stone 2021, p. 4). Further, reintroduction efforts should target suitable habitat within the Turlock and Farmington core areas from which the known Diversity Database occurrences are described as extirpated, but vernal pool habitat remains. Details of all presumed extant occurrences are summarized in Appendix A.</p>
<p>1D. Additional localities that are detected (and determined essential to recovery goals) are permanently protected.</p>	<p>Not met. No additional localities detected.</p>	<p>Partially met. At this time, the Service is aware of seven additional occurrences (occurrence # 72–78) that have been identified since the 2008 5-year review (Figure 1). However, only four (occurrence #73, #74, #77, and #78) of the seven occurrences are currently protected (Vollmar <i>et al.</i> 2017, geodatabase). Details of all protected areas and associated presumed extant occurrences are summarized in Appendix B.</p>

Downlisting criteria	2008 Status	2023 Status
<p>1E. Habitat protection results in protection of hydrology essential to vernal pool ecosystem function, and monitoring indicates that hydrology that contributes to population viability has been maintained through at least one multi-year period that includes above average, average, and below average local rainfall, a multi-year drought, and a minimum of 5 years of post-drought monitoring.</p>	<p>Not met</p>	<p>Partially met. Hydrological monitoring has occurred on the Merced National Wildlife Refuge over multiple years spanning periods of drought and above average precipitation events (Service 2019, entire; Service 2020, entire; Service 2021, entire; Service 2022, entire). During years characterized as above average rainfall, vernal pools on the property contained water through spring, which allowed for germination of Colusa grass (Service 2019, p. 2). Thus, hydrology contributing to the population viability of Colusa grass has been maintained on the refuge. The Service is not aware of hydrological monitoring at any of the other known extant occurrences; therefore, we are unable to determine whether hydrology at those extant sites has been maintained to sufficiently support Colusa grass viability. However, managers of the Merced Vernal Pools and Grassland Reserve are currently seeking funding and approval to move forward with a stock pond hydrological restoration and habitat enhancement project (LAS 2020, entire; A. Malisch, Merced Vernal Pools and Grassland Reserve, <i>in litt.</i> 2024). Stock ponds may provide the hydrological features needed to hold water for longer durations that would support Colusa grass during periods of prolonged drought, similar to the Lame Cow Pond discussed in the Abundance section.</p>
<p>2A. Habitat management and monitoring plans that facilitate maintenance of vernal pool ecosystem function and population viability have been developed and implemented for all habitat protected as previously discussed in Criteria 1A–E.</p>	<p>Not met</p>	<p>Partially met. Sixteen of the 21 partially or fully protected, extant occurrences have active management plans (Annual Grazing Plan East Bear Greek, Snowbird and Arena Plains Units; UC Merced Management Plan; Conceptual Landscape Restoration Plan) that call for the use of prescribed herbivory to control annual plant biomass and invasive annual grasses to maintain vernal pool ecosystem function and promote growth and germination of special status vernal pool plants. The Greater Jepson Prairie Ecosystem Regional Management Plan also guides habitat restoration efforts and controls for invasive plants. Details of all protected areas with associated management plans are summarized in Appendix B.</p>

Downlisting criteria	2008 Status	2023 Status
2B. Mechanisms are in place to provide for management in perpetuity and long-term monitoring of all protected habitat as previously discussed in Criteria 1A–E (funding, personnel, etc.).	Not met	Partially met. Sixteen of the 21 partially or fully presumed extant occurrences that are currently protected also have mechanisms in place to provide for long-term management and monitoring. Monitoring of Colusa grass populations on the Merced Vernal Pool and Grassland Reserve is funded through an existing endowment provided by the University of Merced. Resource managers at the reserve also apply for additional funding from grazing funds and other state, federal, and local grants to supplement the funding provided by the endowment for survey efforts (Malisch <i>in litt.</i> 2024). Additionally, land managers of the Merced National Wildlife Refuge allocate refuge staff and resources to continue annual monitoring of vernal pools (F. Takahashi <i>in litt.</i> 2024).
2C. Monitoring indicates that ecosystem function has been maintained in the areas protected (as previously discussed in Criteria 1A–D) for at least one multi-year period that includes above average, average, and below average local rainfall, a multi-year drought, and a minimum of 5 years of post-drought monitoring.	Not met	Partially met. As described above for criterion 1E, monitoring at the Merced Vernal Pools and Grassland Reserve and the Merced National Wildlife Refuge indicates that ecosystem functioning has been maintained at the refuge for the time period described in the Recovery Plan to sustain viable populations across variable hydrologic regimes.
2D. Seed banking actions have been completed.	Not met	Not met. The Service is not aware of any collected seeds from this species that are held within seed storage facilities (A. Colwell, University of California Davis Center for Plant Diversity, <i>in litt.</i> 2024a; L. Ferneyhough, University of Santa Cruz Arboretum and Botanic Garden, <i>in litt.</i> 2024; H. Forbes, University of California Botanical Garden, <i>in litt.</i> 2024; K. Nelson, California Native Plant Society, <i>in litt.</i> 2024). However, seed collection for genetic research of Colusa grass has occurred at three known occurrences (occurrence #48, #58, #74) (Stone 2020, pp. 2–4). Any ungerminated seeds not used in this study were to be processed for long-term storage in the California Botanical Garden’s Seed Conservation Program; however, this has not yet occurred (D. Stone, California Botanical Garden, <i>in litt.</i> 2024). Additionally, the University of California Santa Cruz and University of California Davis are proposing to collect Colusa grass seeds as part of the California Plant Rescue Project in 2024 (Colwell <i>in litt.</i> 2024b).

Downlisting criteria	2008 Status	2023 Status
<p>3A. Status surveys, 5-year status reviews, and population monitoring show populations within each vernal pool region where the species occur are viable (e.g., evidence of reproduction and recruitment) and have been maintained (stable or increasing) for at least one multi-year period that includes above average, average, and below average local rainfall, a multi-year drought, and minimum of 5 years of post-drought monitoring.</p>	<p>Not met</p>	<p>Partially met. Annual monitoring of vernal pools over the time period specified in the Recovery Plan for 14 occurrences has occurred on the Merced Vernal Pools and Grassland Reserve and Merced National Wildlife Refuge in Merced County, and the Jepson Prairie Reserve in Solano County (see Abundance and Appendix B). Further, since development of the Recovery Plan (Service 2005) informal site visits have been conducted at some of the other known occurrences (Appendix A), but standardized survey protocols are still lacking for the species throughout its range and surveys at these localities have not been conducted over the required time periods and hydrologic regimes that are specified in the Recovery Plan.</p>
<p>3B: Status surveys, status reviews, and habitat monitoring show that threats identified during and since the listing process have been ameliorated or eliminated. Site-specific threats identified through standardized site assessments and habitat management planning also must be ameliorated or eliminated.</p>	<p>Not met</p>	<p>Not met. Systematic surveys and habitat monitoring has not occurred at all of the known Colusa grass occurrences since listing (see 3A, above). In addition, all Diversity Database occurrences of Colusa grass in three of the eight historical core areas are considered extirpated due to habitat loss, which suggests threats have not been ameliorated or eliminated throughout the range of the species.</p>

Downlisting criteria	2008 Status	2023 Status
<p>4A. Research actions necessary for recovery and conservation of the covered species have been identified (these are research actions that have not been specifically identified in the recovery actions but for which a process to develop them has been identified). Research actions (both specifically identified in the recovery actions and determined through the process) on species biology and ecology, habitat management and restoration, and methods to eliminate or ameliorate threats have been completed and incorporated into habitat protection, habitat management and monitoring, and species monitoring plans, and refinement of recovery criteria and actions.</p>	<p>Not met</p>	<p>Not met. The research needs have not been identified in the Recovery Plan.</p>
<p>4B. Research on genetic structure has been completed and results incorporated into habitat protection plans to ensure that within and among population genetic variation is fully representative by populations protected (as previously discussed in Criteria 1A–E).</p>	<p>Not met</p>	<p>Partially met. Research on range-wide genetic diversity and structure has been completed for Colusa grass (Gordon <i>et al.</i> 2012, entire; see also Genetics). Further, a comprehensive phylogenomic and population genomic study of vernal pool grass is currently ongoing. This research aims to clarify the relationship of vernal pool grasses in the tribe Cynodonteae, including Colusa grass, refine the classification, and evaluate landscape-scale diversity (Stone 2020, p. 1).</p> <p>Although genetic analysis for Colusa grass was completed in 2012, the Service is not aware of any habitat protection plan that has incorporated these results into specific management actions. Specifically, in Stanislaus County where there are no protection plans in place to preserve any of the natural gene pools in the county. However, 71% and 42% of the extant occurrences in the northern and southern regions, respectively, are on protected lands (see Genetics). As a result, genetic varieties within each of the two biogeographical regions are represented under existing conservation easements or other protected land designation. Details of all protected areas and associated presumed extant occurrences are summarized in Appendix B.</p>

Downlisting criteria	2008 Status	2023 Status
4C. Research necessary to determine appropriate parameters to measure population viability for each species has been completed.	Not met	Not met. The Service is not aware of any research effort to determine appropriate parameters to measure population viability for Colusa grass.
5A. Recovery Implementation Team is established and functioning to oversee rangewide recovery efforts.	Not met	Partially met. The Vernal Pool Implementation Team was established in 2009 to oversee the formation and functioning of multiple working groups focused at the scale of the vernal pool region. However, the Implementation Team is no longer active. The Service has established an internal vernal pool working group in the Sacramento Fish and Wildlife Office. This team will not function as the official recovery implementation team as it will only consist of Service employees, but the hope is that this internal working group will eventually provide the basis for creating a true Recovery Implementation Team as well as regional working groups.
5B. Vernal pool regional working groups are established and functioning to oversee regional recovery efforts.	Not met	Not met. There are currently no active working groups involving Colusa grass.
5C. Participation plans for each vernal pool region have been completed and implemented.	Not met	Not met. Participation plans have not been completed.
5D. Vernal pool regional working groups have developed and implemented outreach and incentive programs that develop partnerships contributing to achieving recovery criteria 1–4.	Not met	Not met. See 5B, above.

Conclusion:

After reviewing the best available scientific information, we conclude that Colusa grass remains a threatened species. Although significant progress towards achieving downlisting criteria has occurred since our previous review (see Table 3), most criteria have not yet been met. The evaluation of threats affecting the species under the factors in 4(a)(1) of the Endangered Species Act and analysis of the status of the species in our 2008 5-year review (Service 2008) remains an accurate reflection of the species' current status.

RECOMMENDATIONS FOR FUTURE ACTIONS:

In this section we propose recommendations which will aid in the recovery and conservation of Colusa grass. The recommendations put forth in the Recovery Plan (Service 2005, pp. ix–xii) and the previous 5-year review (Service 2008, pp. 21–22) are still relevant and are expanded upon in this section. Additional recommendations have been identified based on communication with species experts, a literature search, and a review of existing records.

- 1. Preserve additional, known extant occurrences to reach recovery goals outlined in the 2005 Recovery Plan.** Preservation of large blocks of vernal pool habitat that contain complete or large portions of vernal pool complexes is needed to ensure the genotypic variation exhibited by this species is protected. The Service should work with private landowners to secure protection of Colusa grass populations through conservation easements or other methods, particularly in Stanislaus County where Diversity Database occurrences of Colusa grass have recently been considered extirpated from two additional core areas as a result of land conversion to agriculture, and the remaining extant occurrences in the county are unprotected. Identifying and protecting additional populations of Colusa grass will be critical for the long-term viability of the species (Service 2005, p. 30; Service 2008, p. 18).
- 2. Initiate a collaborative seed banking program with botanical gardens to collect and preserve Colusa grass seeds from across its range.** Seed banking actions should ensure adequate collection from each population within the two biogeographical regions to preserve the genetic varieties as detected by Gordon *et al.* (2012, entire).
- 3. Develop regional and/or state-level working groups for vernal pool species.** Initiating regional working groups will develop the partnerships needed to oversee regional recovery efforts for vernal pool species, including Colusa grass.
- 4. Develop and implement standardized population trend survey protocols to complete population status surveys and surveys for Colusa grass in potentially suitable habitat. Specific actions and research items to achieve this recommendation include:**
 - a. Digitize and assess the annual monitoring data for Colusa grass on the Jepson Prairie Reserve.
 - b. Conduct surveys in habitats that have been identified as suitable within the historical range of the species. Surveying locations identified in the most recent vernal pool habitat mapping report (Witham 2021, entire) as potentially suitable

habitat (i.e., large playa pools in the species range) could result in the discovery of additional occurrences of Colusa grass and/or identify suitable locations for future translocations or introductions of the species.

- c. Annual population monitoring of all known extant locations. Incomplete and infrequent monitoring of this species makes population status and trends difficult to assess. An effort should be made to conduct regular status surveys for Colusa grass (and other listed vernal pool plants, like Witham's 2013 survey) to make assessment of population trends possible. Without better understanding of the population dynamics of the species, we do not know the extent to which protected lands provide self-sustaining populations of this species within each vernal pool region. Furthermore, monitoring of annual trends and stability needs to assess short- and long-term fluctuations of individual localities which would assist in anticipating demographic changes in response to climate change over time.
- 5. Design and implement reintroduction experiments.** Reintroductions should occur in the vernal pool regions and soil types from which the species is assumed extirpated and should be in accordance with preserving the unique genetic diversity detected by Gordon *et al.* (2012, entire; See Genetics section above). The Recovery Plan recommends prioritizing sites in Colusa County, the Arenas Plains parcel of the Merced National Wildlife Refuge, and the Farmington core area.
- 6. Conduct coordinated research on the impact certain threats and their management have on the Colusa grass:**
- a. Assess the long-term effects from urbanization and agricultural-related alterations to vernal pool sub-watersheds on the hydrology of vernal pools. Efforts should lead to determinations of appropriate hydrology (or upland) buffers. Stone *et al.* (1988, pp. 4–5) also recommended research focused on assessing the range of inundation conditions necessary to maintain Colusa grass.
 - b. Identify and understand the anticipated risks from climate change, specifically the effects of drought on the long-term viability of Colusa grass.
 - c. Determine if and how pesticides may threaten Colusa grass population viability. Evaluate if fungicides inhibit germination of Colusa grass, as is the case for other species in the Orcuttieae tribe (Keeley 1988, p. 1088). Additional research is warranted on how pesticides impact sensitive vernal pool plants in conjunction with other stressors. Specifically, identify the potential need for agricultural buffer zones and evaluate the overall tolerances of vernal pools to pesticides (Johnson 2006, p. 5).

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Approve _____ Date _____

LITERATURE CITED:

- [Airola] Airola Environmental Consulting. 2008. Management Plan for Conservation Lands and the Adjacent Campus Buildout Lands for the University of California, Merced. Prepared for University of California Merced, Merced, California by Airola Environmental Consulting, Sacramento, California with assistance from ICF/Jones and Stokes Associates and LSA Associates. September 2008.
- Battaglin W.A., K.C. Rice, M.J. Focazio, S. Salmons, and R.X. Barry. 2009. The occurrence of glyphosate, atrazine, and other pesticides in vernal pools and adjacent streams in. *Environmental Monitoring and Assessment*. 155:280–307.
- Bauder E.T. 2005. The effects of an unpredictable precipitation regime on vernal pool hydrology. *Freshwater Biology*. 50:2129–2135.
- Cahill T.M., C.M. Thomas, S.E. Schwarzbach, and J.N. Seiber. 2001. Accumulation of trifluoroacetate in seasonal wetlands in California, USA. *Environmental Science and Technology* 35(5):820–825.
- California Forever. 2024. East Solano Homes, Jobs, and Clean Energy Initiative. Submitted to the Solano County Registrar of Voters. Available at: https://downloads.ctfassets.net/ivxuf0dn6dhw/6p3T8ccrYuqrvj7BBO7khw/fba3cf4d7ca54dfdc4054e3717d7bf70/2024-02-14_Initiative.pdf Accessed on June 16, 2024.
- DiTomaso J.M., and G.B. Kyser. 2013. Weed control in natural areas in the western United States. *Weed Research and Information Center, University of California*. 544 pp.
- [Diversity Database] California Natural Diversity Database. 2023. RareFind 5 [Internet]. Occurrence Reports for *Neostapfia colusana* (Accessed August 15, 2023). California Department of Fish and Wildlife, California.
- Fernandez-Bou A.S., J.P. Ortiz-Partida, C. Pells, L.M. Classen-Rodriguez, V. Espinoza, J.M. Rodríguez Flores, L. Booth, J. Burmistrova, A. Cai, A. Cairo, et al. 2021. Regional report for the San Joaquin Valley region on impacts of climate change. California Natural Resources Agency. Publication number: SUM-CCCA4-2021-003
- Gordon S.P., C.M. Sloop, H.G. Davis, and J.H. Cushman. 2012. Population genetic diversity and structure of two rare vernal pool grasses in central California. *Conservation Genetics*. 13(1): 117–130.
- Helm Biological Consulting. 2010. Delineation of waters of the United States, including wetlands at the Yolo Grasslands Regional Park. Prepared for Yolo County Parks & Resources Department, Woodland, California. June 2010.
- Holland RF. 2009. California’s Great Valley vernal pool habitat status and loss. Prepared for Placer Land Trust, Auburn, California. Available at: https://www.placerlandtrust.org/uploads/documents/Vernal%20Pool%20Studies%20Report/Great%20Valley%20Vernal%20Pool%20Distribution_Final.pdf. Accessed on March

2024.

- Houlton B., and J. Lund. 2018. Sacramento Summary Report. California's Fourth Climate Change Assessment. University of California, Davis, California. Publication number: SUM-CCCA4-2018-002.
- ICF International, Inc. 2018. Yolo habitat conservation plan/natural community conservation plan: Volume 1. Prepared for Yolo Habitat Conservancy, Woodland, California. April 2018.
- Javornik C.J., and S.K. Collinge. 2016. Influences of annual weather variability on vernal pool plant abundance and community composition. *Aquatic Botany* 134:61–67.
- Johnson C.S. 2006. Evaluation of pesticides in vernal pools of the Central Valley. Sacramento, California: U.S. Fish & Wildlife Service.
- Keeley J.E. 1988. Anaerobiosis as a stimulus to germination in two vernal pool grasses. *American Journal of Botany*. 75(7):1086–1089.
- [LSA] LSA Associates Inc. 2020. Conceptual Landscape Restoration Plan. Prepared for University of California Merced, California by LSA, Roseville. Project Number: UCM1901. July 2020.
- [LSA] LSA Associates Inc. 2023. University of California Merced Tier 1(a) Conservation Lands Special-Status Plant Species Survey Report. Prepared for University of California Merced, Merced, California by LSA, Roseville. January 2024.
- Merced National Wildlife Refuge. 2023. Special Conditions - Annual grazing Plan East Bear Creek, Snowbird and Arena Plains Units. Cooperative Agreement with Cattle Ranchers. August 2022 – June 2023.
- Montrone A., L. Saito, P.J. Weisberg, M. Gosejohan, K. Merriam, and J.F. Mejia. 2019. Climate change impacts on vernal pool hydrology and vegetation in northern California.
- Mount J., A. Escrivá-Bou, and G. Sencan. 2021. Droughts in California. Public Policy Institute of California. Available at: <https://www.ppic.org/publication/droughts-in-california/> accessed on October 2023.
- Pyke C.R. 2004. Habitat loss confounds climate change impacts. *Frontiers in Ecology and the Environment*. 2: 178–182.
- [Service] U.S. Fish and Wildlife Service. 1997. Endangered and threatened wildlife and plants; determination of endangered status for three plants and threatened status for five plants from vernal pools in the Central Valley of California. *Federal Register*. 50:14338–14352.
- [Service] U.S. Fish and Wildlife Service. 2005. Recovery plan for vernal pools ecosystems of California and Southern Oregon. Portland, Oregon xxvi + 606 pages.

- [Service] U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; initiation of 5-year reviews of 58 species in California, Nevada, Arizona, and Utah; Availability of completed 5-year reviews in California and Nevada. Federal Register 7:12878–12883.
- [Service] U.S. Fish and Wildlife Service. 2015. San Luis National Wildlife Refuge Complex: Draft Comprehensive Conservation Plan and Environmental Assessment. U.S. Fish and Wildlife Service, San Luis National Wildlife Refuge Complex, Los Banos, California. January 2015.
- [Service] U.S. Fish and Wildlife Service. 2019. 2019 Colusa Grass Population Survey – Arena Plains. Memo. U.S. Fish and Wildlife Service, San Luis National Wildlife Refuge Complex, Los Banos, California. August 2019.
- [Service] U.S. Fish and Wildlife Service. 2020. 2020 Colusa Grass Population Survey – Arena Plains. Memo. U.S. Fish and Wildlife Service, San Luis National Wildlife Refuge Complex, Los Banos, California. July 2021.
- [Service] U.S. Fish and Wildlife Service. 2021. 2021 Colusa Grass Population Survey – Arena Plains. Memo. U.S. Fish and Wildlife Service, San Luis National Wildlife Refuge Complex, Los Banos, California. July 2021.
- [Service] U.S. Fish and Wildlife Service. 2022. 2022 Colusa Grass Population Survey – Arena Plains. Memo. U.S. Fish and Wildlife Service, San Luis National Wildlife Refuge Complex, Los Banos, California. September 2022.
- Sinnathamby S., J.M. Minucci, D.L. Denton, S.M. Raimondo, L. Oliver, Y. Yuan, D.F. Young, J. Hook, A.M. Pitchford, E. Waits, and S.T. Purucker. 2020. A sensitivity analysis of pesticide concentrations in California Central Valley vernal pools. *Environmental Pollution* 257(113486).
- Stone R.D., W.B. Davilla, D.W. Taylor, G.L. Clifton, and J.C. Stebbins. 1988. Status survey of the grass tribe Orcuttieae and *Chamaesyce hooveri* (Euphorbiaceae) in the Central Valley of California. For the Office of Endangered Species, US Fish and Wildlife Service.
- Stone, R.D. 2020. Phylogenomics and population genomics of endemic vernal pool grasses (Poaceae subtribe Orcuttiinae) in California and Baja California. California Botanic Gardens, Claremont, CA. USFWS Permit No. TE009018-5. Unpublished report submitted to the U.S Fish and Wildlife Service, Region 8, Sacramento, California.
- Thorne J.H., J. Wraithwall, and G. Franco. 2018. California’s Changing Climate 2018. California’s Fourth Climate Change Assessment. California Natural Resources Agency. Available at: https://www.energy.ca.gov/sites/default/files/2019-11/20180827_Summary_Brochure_ADA.pdf accessed in March 2024.
- Vollmar, J., E. Smith, and L. Neuhaus. 2017. Multi-scale assessment of past achievements and future directions for vernal pool habitat conservation and management: Great Valley,

California. Unpublished report submitted to the U.S. Environmental Protection Agency, Wetland Program Development Grant Program, San Francisco, California.

[Water Resource] California Department of Water Resources. 2020. California's most significant droughts: Comparing historical and recent conditions. Available at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/What-We-Do/Drought-Mitigation/Files/Publications-And-Reports/CalSigDroughts19_v9_ay11.pdf. Accessed on October 2023.

Winter T.C. 2000. The vulnerability of wetlands to climate change: a hydrologic landscape perspective. *Journal of the American Water Resources Association*. 36:305–311.

Witham C.W. 2013. Status Surveys for seven federally listed vernal pool grasses and *Chamaesyce hooveri* in the Sacramento and San Joaquin Valleys (Great Valley), California, USA. Sacramento, California: Carol W. Witham Consulting.

Witham C.W. 2021. Changes in the distribution of Great Valley vernal pool habitats from 2005 to 2018. Sacramento, California.

In Litteris References:

Colwell, A. 2024a. Curator. University of Davis Center for Plant Diversity. Electronic mail to Kristine Harman, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, dated January 16, 2024.

Colwell, A. 2024b. Curator. University of Davis Center for Plant Diversity. Electronic mail to Kristine Harman, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, dated February 17, 2024. Subject: coordination to collect Colusa grass seeds in 2024.

Ferneyhough, L. 2024. Native Plant Program Project Manager. University of Santa Cruz Arboretum and Botanic Garden. Electronic mail to Kristine Harman, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, dated January 16, 2024.

Forbes, H. 2024. Curator. University of California Botanical Garden. Electronic mail to Kristine Harman, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, dated January 16, 2024.

Malisch, A. 2024. Conservation Easement and Natural resource Land Manager, Merced Vernal Pool and Grassland Reserve. Electronic mail to Kristin Harman, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, dated March 27, 2024.

Nelson, K. 2024. Rare Plant Program Manager. California Native Plant Society. Electronic mail to Kristine Harman, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, dated January 16, 2024.

Stone, D.R. 2024. Research Associate. California Botanical Garden. Electronic mail to Kristine Harman, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, dated January 25, 2024.

Takahashi, F. 2024. Wildlife Biologist. San Luis National Wildlife Refuge Complex. Electronic mail to Kristine Harman, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, dated March 11, 2024.

Witham, C. 2023. Electronic mail to Kristine Harman, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, dated December 19, 2023.

Personal communication:

Westbrook-Barsukov, J. 2024. Solano Land Trust. Conversation between Jasmine Westbrook Barsukov, Project Manager, and Amanda Croteau, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, provided information about *Tuctoria mucronate* and *Neostapfia colusana*, dated January 3, 2024.

Witham, C. 2022. Conversation between Carol Witham, biological consultant, and Emilie Graves, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, provided information about *O. inaequalis* germination, dated February 23, 2022.

APPENDIX A:

Known Colusa Grass occurrence records showing county, recovery core area (Service 2005), ownership, status, the first and most recent survey conducted, and most recent plant counts for each Colusa grass population (Diversity Database 2023; LSA 2023; Stone *in litt.* 2020; Stone *in litt.* 2024; Witham *in litt.* 2023; and Witham *pers. comm.* 2023). We did not report occurrences that were listed as presumed extirpated in 2008 (Service 2008) and remained extirpated in 2023.

Occurrence No.	County	Core Area	Landownership	Status	Year of Recent Survey	No. Observed during Recent Survey	Notes
49	Yolo	Davis Communications Annex	Yolo County is awaiting transfer of ownership	Presumed Extant	2020	2	As reported by Stone (2020). Diversity Database reports more than 200 plants observed in 2017. This site is formally McClellan AirForce Base. Yolo County currently manages this occurrence as part of the Grasslands Regional Park (Helm Biological Consulting 2010, p. 4).
58	Yolo	Davis Communications Annex	Yolo County is awaiting transfer of ownership	Presumed Extant	2020	0	As reported by Stone (2020). Survey notes suggest the number of plants over the last decade appear much reduced. This site is formally McClellan AirForce Base. Yolo County currently manages this occurrence as part of the Grasslands Regional Park (Helm Biological Consulting 2010, p. 4).
74	Yolo	Davis Communications Annex	Yolo County	Presumed Extant	2020	0	The artificial pools were seeded with Colusa grass in 2009. Thousands of plants were detected in 2019 (Stone <i>pers. comm.</i> 2024). As reported by Stone (2020), no plants were detected in 2020.
19	Solano	Jepson Prairie	Solano Land Trust	Presumed Extant	2014	1,000s	This occurrence has been routinely surveyed for the previous thirty years; however, the data has not been organized for review and therefore is not currently available (Witham <i>pers. comm.</i> 2023).

Occurrence No.	County	Core Area	Landownership	Status	Year of Recent Survey	No. Observed during Recent Survey	Notes
48	Solano	Jepson Prairie	Private	Presumed Extant	2010	0	No plants were detected during surveys in 1989, 1991, 1992, 2000, 2004, 2005, or 2010. Property is within the boundaries of the proposed development, California Forever (Witham <i>in litt.</i> 2023).
72	Solano	Jepson Prairie	Solano Land Trust and Private	Presumed Extant	2017	> 100	This occurrence contains three vernal pools. One pool is on the Jepson Prairie Reserve and two pools are on adjacent private land.
73	Solano	Jepson Prairie	Private	Presumed Extant	2010	133	
40	Merced	Grasslands Ecological Area	Private	Presumed Extant	2011	600	
50	Merced	Grasslands Ecological Area	Private	Presumed Extant	2011	0	This site is part of the Service's Grassland Wildlife Management Area. No plants were detected during extensive surveys in 2010 and 2011. However, surveys were conducted during years of prolonged drought and until surveys are conducted during an average or above average precipitation year, the status remains presumed extant.
51	Merced	Grasslands Ecological Area	Service (USFWS)	Presumed Extant	2017	88	
01	Merced	Madera	Private	Presumed Extant	2010	0	The site is located on the Flying M Ranch with a conservation easement held by The Nature Conservancy. The most recent survey was conducted during a drought year and until surveys are conducted during an above average precipitation year, the status remains presumed extant.

Occurrence No.	County	Core Area	Landownership	Status	Year of Recent Survey	No. Observed during Recent Survey	Notes
14	Merced	Madera	University of California Merced	Presumed Extant	201X	present but uncounted	The site is located on the Virginia Smith Trust Preserve with a conservation easement held by The Nature Conservancy. The Diversity Database only reports "recent survey since 2013" but the exact year is unknown.
15	Merced	Madera	University of California Merced	Presumed Extant	201X	present but uncounted	The site is located on the Virginia Smith Trust Preserve with a conservation easement held by The Nature Conservancy. The Diversity Database only reports "recent survey since 2013" but the exact year is unknown.
17	Merced	Madera	Private	Presumed Extant	2017	0	No plants were detected during follow-up surveys in 2010 and 2017. However, these surveys were conducted during periods of prolonged drought and until surveys are conducted during an above average precipitation year, the status remains presumed extant.
18	Merced	Madera	Private	Presumed Extant	1992	present but uncounted	
26	Merced	Madera	Private	Presumed Extant	1986	1,000s	
27	Merced	Madera	Private	Presumed Extant	1986	unknown	Biologist were unable to relocate the site during a follow up visit in 1986; however, record is considered presumed extant.
29	Merced	Madera	Private	Presumed Extant	1986	2,000	
32	Merced	Madera	Private	Presumed Extant	2010	0	This site contains three vernal pools, of which one of these pools are located within a conservation easement held by The Nature Conservancy on the Flying M Ranch. The most recent survey was conducted during a drought year and until surveys are conducted during an above average precipitation year, the status remains presumed extant.

Occurrence No.	County	Core Area	Landownership	Status	Year of Recent Survey	No. Observed during Recent Survey	Notes
34	Merced	Madera	Private	Presumed Extant	2010	0	The most recent survey was conducted during a drought year and until surveys are conducted during an above average precipitation year, the status remains presumed extant.
36	Merced	Madera	Private	Presumed Extant	2001	25	
37	Merced	Madera	Private	Presumed Extant	1986	0	The most recent survey was conducted during a drought year and until surveys are conducted during an above average precipitation year, the status remains presumed extant.
38	Merced	Madera	Private	Presumed Extant	1986	0	The site is located on the Flying M Ranch and held in a conservation easement by The Nature Conservancy. The most recent survey was conducted during a drought year and until surveys are conducted during an above average precipitation year, the status remains presumed extant.
43	Merced	Madera	Private	Presumed Extant	1986	10,000	The site is located on the Flying M Ranch and held in a conservation easement by The Nature Conservancy. The population was considered stable in 1986 under the grazing regime occurring at that time.
45	Merced	Madera	Private	Presumed Extant	1986	25	
46	Merced	Madera	Private	Presumed Extant	1986	1000	
60	Merced	Madera	University of California Merced	Presumed Extant	2008	100,000	
78	Merced	Madera	Private	Presumed Extant	201X	present but uncounted	The Diversity Database only reports “recent survey since 2013” but the exact year is unknown.
59	Merced	Madera	UC Merced	Presumed Extant	2023	17–100,000	This site is located on the Virginia Smith Trust Preserve with a

Occurrence No.	County	Core Area	Landownership	Status	Year of Recent Survey	No. Observed during Recent Survey	Notes
							conservation easement held by The Nature Conservancy. Colusa grass was observed in the north-west vernal pool and southern playa pool in 2023. The largest population of Colusa grass is found on the southern playa pool (50,000 –100,000 individuals detected). No disturbance was noted during the survey. The southern playa pool population was reported as stable, but declining (LSA 2023, p. 9, See also Appendix A, p. 12).
66	Merced	Madera	UC Merced	Presumed Extant	2023	3	This site is located on the Virginia Smith Trust Preserve with a conservation easement held by The Nature Conservancy.
67	Merced	Madera	UC Merced	Presumed Extant	2011	29	This site is located on the Virginia Smith Trust Preserve with a conservation easement held by The Nature Conservancy.
68	Merced	Madera	UC Merced	Presumed Extant	2019	10	This site is located on the Virginia Smith Trust Preserve with a conservation easement held by The Nature Conservancy.
69	Merced	Madera	UC Merced	Presumed Extant	2023	1,000 – 4,000	This site is located on the Virginia Smith Trust Preserve with a conservation easement held by The Nature Conservancy. Approximately 60 –70% of the population was blooming. Population was reported as stable (LSA 2023, p. 9). This is a stock pond that holds water for longer periods of time.
70	Merced	Madera	UC Merced	Presumed Extant	2023	3	This site is located on the Virginia Smith Trust Preserve with a conservation easement held by The Nature Conservancy.
77	Merced	Madera	UC Merced	Presumed Extant	2018	31	This site is located on the Virginia Smith Trust Preserve with a

Occurrence No.	County	Core Area	Landownership	Status	Year of Recent Survey	No. Observed during Recent Survey	Notes
							conservation easement held by The Nature Conservancy.
02	Stanislaus	Merced	Private	Presumed Extant	2010	100	The primary population may be extirpated.
04	Stanislaus	Merced	Private	Presumed Extant	2009	100	
05	Stanislaus	Merced	Private	Presumed Extant	2008	> 1 million	Considered stable in 2008 as a large number of plants were observed despite habitat damage due to grazing regime.
08	Stanislaus	Merced	Private	Presumed Extant	1986	1,000	Considered as likely declining due to grazing regime in 1986.
20	Stanislaus	Merced	Private	Extirpated	2010	0	Extirpated. Site was filled-in for agricultural production in 2010.
24	Stanislaus	Merced	Private	Presumed Extant	1981	1,000	
55	Stanislaus	Merced	Private	Presumed Extant	2017	1,000	The population appears to be persisting despite grazing activities.
57	Stanislaus	Merced	Private	Extirpated	2010	0	The population was assumed to be located in an area that was destroyed by deep ripping.
62	Stanislaus	Merced	Private	Presumed Extant	2008	500	The biologist noted moderate levels of grazing may be important for controlling Eleocharis.
71	Stanislaus	Merced	Private	Presumed Extant	2010	1,000	
75	Stanislaus	Merced	Private	Presumed Extant	2017	25	
76	Stanislaus	Merced	Private	Presumed Extant	2017	6	
47	Stanislaus	Farmington	Private	Extirpated	2011	0	Presumed extirpated. Aerial imagery shows area has been converted to crop fields between 2011 and 2013.

Occurrence No.	County	Core Area	Landownership	Status	Year of Recent Survey	No. Observed during Recent Survey	Notes
56	Stanislaus	Waterford	Private	Extirpated	2001	0	Extirpated. 2016 aerial imagery shows area has been converted to an orchard.
64	Stanislaus	Waterford	Private	Extirpated	2001	0	Extirpated. 2016 aerial imagery shows area has been converted to an orchard.
65	Stanislaus	Waterford	Private	Extirpated	2010	0	Extirpated. 2016 aerial imagery shows area has been converted to an orchard.
11	Stanislaus	Not within a core area	Private	Extirpated	2010	0	Extirpated. 2011 aerial imagery shows area has been converted to an orchard.

APPENDIX B:

List of known ownership, conservation easement holder, protection status, total acreage protected, and associated management plan for each extant occurrence of Colusa grass (Diversity Database 2023, Vollmar *et al.* 2017)

Landownership	Easement Holder	Protection Area	Acreage	Protected Occurrence Number(s)	Management Plan
Yolo County ¹	Not applicable	Grasslands Regional Park	313.5	74	Colusa grass is not covered under the current habitat conservation plan because the species is not expected to be adversely impacted by the covered activities (ICF 2018, p. C-37).
Yolo County is awaiting transfer of ownership ¹	Not applicable	Managed as part of the Grasslands Regional Park	320.0	49, 58	Colusa grass is not covered under the current habitat conservation plan because the species is not expected to be adversely impacted by the covered activities (ICF 2018, p. C-37).
Solano Land Trust	The Nature Conservancy	Jepson Prairie Reserve Easement	1,558.6	19, 72 (partial)	Greater Jepson Prairie Ecosystem Regional Management Plan (Service 2005, p. 11).
Service (USFWS)	Not applicable	Merced National Wildlife Refuge	2,475.2	51	San Luis National Wildlife Refuge Complex Conservation Plan (Service 2015, entire); and the Annual Grazing Plan East Bear Greek, Snowbird and Arena Plains Units (Merced NWR 2023, entire).
Private	Service (USFWS)	Grasslands Wildlife Management Area	2,565.1	50	San Luis National Wildlife Refuge Complex Conservation Plan (Service 2015, entire); and the Annual Grazing Plan East Bear Greek, Snowbird and Arena Plains Units (Merced NWR 2023, entire).
University of California Merced	The Nature Conservancy	Vernal Pools and Grassland Reserve (Virginia Smith Trust Preserve)	6,375.5	14, 15, 59, 66, 67, 68, 69, 70, 77, 78	UC Merced Management Plan (Airola 2008, entire); Conceptual Landscape Restoration Plan (LAS 2020, entire)
Private	The Nature Conservancy	Flying M Ranch Easement	4,948.4	01, 32 (partial), 38, 43	UC Merced Management Plan (Airola 2008, entire)
Total	-	-	18,556.3 acres protected	19 occurrences are fully protected; 2 occurrences are partially protected	

¹ Protected area does not currently meet the requirements for protected habitat as outlined in the Recovery Plan's recovery criteria (Service 2005, p. III-93).