

**Solano Grass**  
(*Orcuttia mucronata* = *Tuctoria mucronata*)

**5-Year Review:  
Summary and Evaluation**

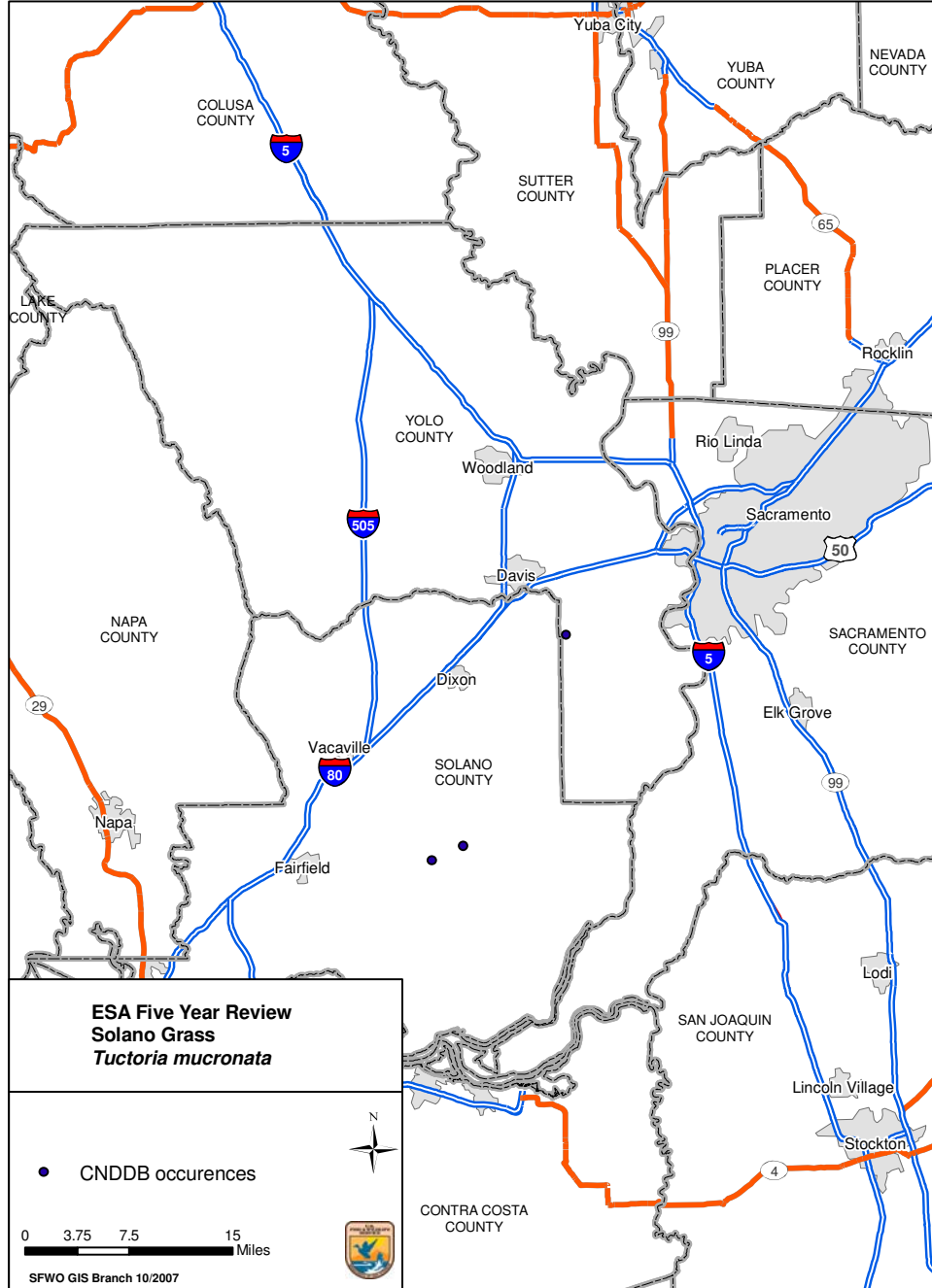


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**U.S. Fish and Wildlife Service  
Sacramento Fish and Wildlife Office  
Sacramento, California**

**March 2009**

# MAP



**5-YEAR REVIEW**  
**Solano grass (*Orcuttia mucronata* = *Tuctoria mucronata*)**

**I. GENERAL INFORMATION**

**I.A. Methodology used to complete the review:**

This review was developed by Sacramento Fish and Wildlife Office staff using information from the following sources: the December 2005 *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (Recovery Plan) (U.S. Fish and Wildlife Service [Service] 2005); species survey and monitoring reports; peer-reviewed journal articles; management plans; documents generated as part of Endangered Species Act section 7 consultations; and species experts. The Recovery Plan and personal communications with preserve managers and species experts were our primary sources of information used to update the species status and threats sections of this review.

**I.B. Contacts**

**Lead Regional or Headquarters Office** – Diane Elam, Deputy Division Chief for Listing, Recovery, and Habitat Conservation Planning, and Jenness McBride, Fish and Wildlife Biologist, Pacific Southwest Region, 916-414-6464

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**I.C. Background**

**I.C.1. FR Notice citations announcing initiation of this review:** 72 FR 7064, February 14, 2007. We received no information from the public in response to this notice.

**I.C.2. Listing history**

Original Listing

FR notice: 43 FR 44810

Date listed: September 28, 1978

Entity listed: Species, Solano grass (*Tuctoria mucronata* [formerly named and originally listed as *Orcuttia mucronata*])

Classification: Endangered

**I.C.3. Associated rulemakings:**

Critical Habitat: Critical habitat for the Solano grass was originally designated in a final rule published in 68 FR 46683 on August 6, 2003. A revised final rule for critical habitat, with a re-evaluation of non-economic exclusions, was published in 70 FR 11140 on March 8, 2005. Economic exclusions from the 2003 final rule were evaluated in 70 FR 46923 on August 11,

2005. Administrative revisions with species-by-unit designations were published in 71 FR 7117 on February 10, 2006, providing one critical habitat unit for the Solano grass totaling 440 acres. On May 31, 2007, the Service published a clarification of the economic and non-economic exclusions for the 2005 final rule designating critical habitat for four vernal pool crustaceans and eleven vernal pool plants in California and southern Oregon (72 FR 30269).

#### **I.C.4. Review History**

90-Day finding: A 90-day finding on a petition to delist the Solano grass was published in 68 FR 13943 on March 21, 2003. The finding determined that the petition and additional information did not present substantial scientific or commercial information indicating that delisting the Solano grass was warranted.

#### **I.C.5. Species' Recovery Priority Number at start of review:**

The Solano grass has a recovery priority number of 2 (based on a 1 to 18 ranking system where 1 indicates the highest recovery priority and 18 the lowest priority), which signifies that the species is subject to a high degree of threat, but also has a high potential for recovery.

#### **I.C.6. Recovery Plan or Outline**

Name of plan: *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon*  
Date issued: December 15, 2005

The *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* is the recovery plan that provides recovery criteria for the Solano grass. The grass was covered previously under the Delta Ground Beetle and Solano Grass Recovery Plan, which was issued on September 11, 1985.

## **II. REVIEW ANALYSIS**

### **Species Overview**

Solano grass (*Tuctoria mucronata*), also known as Crampton's tuctoria, is a member of a small tribe (three genera and nine species) of semi-aquatic annual grasses that are unique among grasses in exhibiting single-cell C<sub>4</sub> photosynthesis, which occurs in only 0.003 percent of known species of C<sub>4</sub> flowering plants (Boykin *et al.* 2008). Plants with C<sub>4</sub> photosynthesis utilize a more complex biochemical process than most plants (with C<sub>3</sub> photosynthesis) in converting CO<sub>2</sub> to energy, which increases photosynthetic efficiency at low CO<sub>2</sub> concentrations (Boykin *et al.* 2008). The species germinates under water and produces a whorl of submerged leaves that are considered to be juvenile leaves, and are replaced by foliage that allows the plants to persist in the terrestrial environment when the pools dry (Keeley 1991). Solano grass is a small (1 to 8-inch tall) grass. It produces stems and leaves covered with small droplets of a sticky, acrid secretion. This is characteristic of the genus *Tuctoria*, which includes the endangered Greene's tuctoria (*Tuctoria greenei*) and the genus *Neostapfia*, which contains only the threatened Colusa grass (*Neostapfia colusana*). Solano grass is grayish-green, pilose (hairy), and viscid; several

solid stems (up to 4.7 inches long) do not branch and grow somewhat decumbently (lying on the ground), turning up only at the tips. The leaves lack ligules, which are the small, scalelike leaf outgrowths found on some grasses. Solano grass blooms from June to July. Seven to 19 spikelets overlap one another along the full length of the spike-like inflorescence. Unlike other closely related species, the inflorescence of Solano grass remains partially enclosed by the upper leaf sheath and is never fully exerted from the uppermost leaf. The lemma (bract) ends in a single tooth with a short, narrow point (Service 2005).

Many life history characteristics are common to all members of the Orcuttieae. In particular, they are all annuals and are all endemic to vernal pools (Griggs 1981). All are wind-pollinated, but pollen probably is not carried long distances between populations (Griggs 1980; Griggs and Jain 1983) and pollination may be limiting for small populations (Stephens *et al.* 1999; Davis *et al.* 2004; Taylor *et al.* 2004). Local seed dispersal is by water, which breaks up the inflorescences (Reeder 1965; Crampton 1976; Griggs 1980, 1981). Long-distance dispersal is unlikely (Service 1985), but seed may be carried occasionally by waterfowl (family Anatidae), or by tule elk (*Cervus elaphus nannoides*), or pronghorn (*Antilocapra americana*) in historical times (Griggs 1980). The seeds can remain dormant for an undetermined length of time (but at least 3 to 4 years) and germinate underwater after they have been immersed for prolonged periods (Crampton 1976; Griggs 1980; Keeley 1998). Unlike typical terrestrial grasses that grow in the uplands surrounding vernal pools, members of the Orcuttieae flower during the summer months (Keeley 1998).

Solano grass was considered to be a member of the genus *Orcuttia* at the time of listing, and was known as *Orcuttia mucronata*. Subsequent genetic analysis provided its location in a new genus, as described below in section II.C.1.d.

## **II.A. Application of the 1996 Distinct Population Segment (DPS) policy**

### **II.A.1. Is the species under review listed as a DPS?**

Yes.  
 No.

The Endangered Species Act of 1973, as amended (Act), defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listings as distinct population segments only to vertebrate species of fish and wildlife. Because the Solano grass is a plant and the DPS policy is not applicable, the application of the DPS policy to the species listing is not addressed further in this review.

## **II.B. Recovery Criteria**

### **II.B.1. Does the species have a final, approved recovery plan containing objective, measurable criteria?**

*Yes.*  
 *No.*

### **II.B.2. Adequacy of recovery criteria.**

#### **II.B.2.a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?**

*Yes.*  
 *No.*

#### **II.B.2.b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?**

*Yes.*  
 *No.*

All relevant listing factors were addressed in the Recovery Plan; however, there is new information regarding threats available since the Recovery Plan was published.

### **II.B.3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.**

General recovery criteria for the Solano grass and 19 other listed plants and animals are described in the Recovery Plan (Service 2005). This Recovery Plan utilizes an ecosystem-level approach because many of the listed species and species of concern co-occur or overlap in distribution within natural vernal pool habitats, and are, therefore, generally threatened by the same human activities. The overarching recovery strategy for vernal pool species, including Solano grass, is habitat protection and management. The five key elements that comprise this ecosystem-level recovery and conservation strategy are: (1) habitat protection; (2) adaptive management, restoration, and monitoring; (3) status surveys; (4) research; and (5) public participation and outreach.

The Recovery Plan provides recovery criteria that either directly or implicitly address the two listing factors noted in the final rule to list the species: destruction, modification, or curtailment of habitat or range (Factor A); and inadequacy of existing regulatory mechanisms (Factor D). Factor C, disease or predation, was not included as a threat in the listing rule and is not addressed in the Recovery Plan; it currently is not considered a relevant threat. Factor B, overutilization for commercial recreational, scientific, or education purposes, and Factor E, other man-made or natural factors affecting its continued existence, were not included as threats in the listing rule, but are addressed in the Recovery Plan due to information gained after the species was listed.

**Downlisting/delisting criteria for the Solano grass include:**

**1. Habitat Protection: Accomplish habitat protection that promotes vernal pool ecosystem function sufficient to contribute to population viability of the covered species.**

This criterion addresses listing Factor A<sup>1</sup>.

**1A. Suitable vernal pool habitat within each prioritized core area for the species is protected.**

In California, vernal pool regions have been delineated, based largely on the presence of endemic species, with soils and geomorphology as secondary elements. Each region contains one or more of the vernal pool species that are covered in the Recovery Plan. The Recovery Plan recommends protection of suitable habitat within core areas. Core areas are the specific areas, or contain the specific sites, that are necessary to recover the endangered or threatened species (or the species of concern) that are addressed in the Recovery Plan. Core areas are not species-specific and may contain multiple listed species and species of concern. For most of the species covered in the Recovery Plan, core areas are ranked as Zone 1, 2, or 3 in order of their overall priority for recovery. The Recovery Plan allows the Service to modify core areas in the future based upon the results of status surveys and research.

Solano grass is found only in the Solano-Colusa Vernal Pool Region. The plant has been located in two Zone 1 core recovery areas within the region: the Davis Communications Annex and the Jepson Prairie core areas. This downlisting criterion requires that (as of the time the Recovery Plan was published in 2005) 95 percent of the suitable habitat for the grass be protected both rangewide and within the two core areas. Protection will occur in such manner as to provide diverse vernal pool habitats in large habitat blocks that encompass local watersheds. Habitat blocks should also include unoccupied pools within vernal pool complexes, and appropriate upland buffers around and between vernal pool complexes. Habitat blocks should be effectively managed to maintain hydrologic function and prevent domination by invasive species.

By focusing on the protection of large habitat blocks within core recovery areas, this criterion should be adequate to ensure that suitable habitat for the grass is conserved. However, the Solano grass was known from only one occurrence at the time of its listing and only two additional occurrences have been identified since listing. It may have been extirpated at its type locality at Jepson Prairie since it was listed. This criterion has not yet been met.

**1B. 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.**

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<sup>1</sup>A) Present or threatened destruction, modification or curtailment of its habitat or range;  
B) Overutilization for commercial, recreational, scientific, or educational purposes;  
C) Disease or predation;  
D) Inadequacy of existing regulatory mechanisms;  
E) Other natural or manmade factors affecting its continued existence.

The criterion for downlisting specifies that 100 percent of known Solano grass occurrences be protected. The criterion for delisting specifies that 100 percent of newly discovered and re-introduced populations be protected. Two of the three known occurrences for this species are protected from development, although the plant is thought to be extirpated at one of the two protected sites. The third occurrence is located on private land. The criterion has not yet been met.

The downlisting criterion may not be adequate for recovery of the species, even if 100 percent of known occurrences within core recovery areas are protected as described. The numbers of individual plants observed at each site varies substantially by site and by year, with an overall downward trend (C. Witham, private consultant, pers. comm. 2007; CNDDDB 2009). Because the Solano grass is known only from three occurrences, and because one occurrence on protected lands is thought to be extirpated, it is possible that recovery of this species will rely on establishment of additional occurrences beyond the vernal pools from which the species is currently known.

Delisting requires that 100 percent of all newly discovered and reintroduced populations are protected. The extent to which the criterion for delisting is sufficient would depend on the number of new populations or reintroduced populations protected. The likelihood of discovering new populations is apparently very small (C. Witham, pers. comm. 2007). The number of additional populations protected would need to be sufficient to protect against stochastic (random or unpredictable) causes of extinction.

#### **1C. Reintroduction and introductions must be carried out and meet success criteria.**

This criterion has not been met. The recovery criterion for downlisting does not provide any direction that Solano grass should be reintroduced to additional locations; however, the criterion for delisting specifies that the species must be re-introduced to Olcott Lake and that additional populations must be discovered in order to delist the plant. No success criteria for re-introductions have been established. There are species experts who are interested in re-introducing the species to Olcott Lake at the Jepson Prairie Preserve (the plant's type locality) and potentially to nearby suitable habitat (C. Witham, pers. comm. 2007).

#### **1D. Additional occurrences identified through future site assessments, GIS and other analyses, and status surveys that are determined essential to recovery are protected. Any newly found occurrences may count towards recovery goals if the occurrences are permanently protected as described in the Recovery Plan.**

This criterion is adequate, but it has not been met. The Service is aware of two Solano grass occurrences that have been discovered since the species was listed in 1978, but were known before completion of the Recovery Plan. Both occurrences are essential to recovery of the species. Although additional properties in Solano County have been protected and may provide suitable habitat for the species, the species has not been located at any additional locations during surveys of playa pools in the 1980s or during more recent reconnaissance of all the playa pools within the general area of Jepson Prairie Preserve (C. Witham, pers. comm. 2007).



**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 as defined above, a multi-year drought, and a minimum of 5 years of post-drought monitoring.**

Hydrological studies will be needed for sites with known occurrences of the Solano grass to determine the extent to which vernal pool ecosystem function has been protected. Either surface or subsurface changes to water flow could have deleterious effects on vernal pool ecosystem function (see discussion in Williamson *et al.* 2005). To our knowledge, on protected habitat, assessment and monitoring of hydrology has not occurred over a multi-year period as described in this criterion, and as needed to determine whether the hydrology has been protected sufficiently to allow vernal pool function. Moreover, the Service has not identified parameters that need to be monitored to determine whether this criterion has been met.

## **2. Adaptive Habitat Management and Monitoring**

This criterion implicitly addresses listing Factors A, D, and E.

**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 in Sections 1 A-E, above.**

The criterion has been partially met. Two of three known occurrence sites are located on protected habitat. The first protected known occurrence, the type locality for the species, is located at Olcott Lake on the Jepson Prairie Preserve, although the species is currently thought to be extirpated at this site. The Jepson Prairie Preserve is protected and is managed under the Greater Jepson Prairie Ecosystem Regional Management Plan. The plan provides for resource monitoring at Jepson Prairie to the extent that resources allow. The plan states that annual monitoring for Solano grass is conducted by volunteers from conservation organizations such as the Nature Conservancy, the Solano Land Trust, and the California Native Plant Society, resource agencies, and the University of California, Davis (UC Davis). Additional monitoring for native and invasive plants is conducted, although no monitoring plans are included as part of the management plan document itself (Witham 2006).

The second protected occurrence consists of two pools on a 340-acre block of land that is managed by the Yolo County Parks and Resources Department (S. Lines and C. Alford, Yolo County Parks and Resources Department, pers. comm. 2007). The landholding is actually 2 parcels; the western half has been owned by Yolo County and is the “Grasslands Regional Park”, while the eastern portion of the block, the Davis Communications Annex, was owned by the Air Force (ESA 2008; S. Lines and C. Alford, pers. comm. 2007) until December of 2008 when Yolo County obtained the land under fee title (S. Lines, Yolo County Parks and Recreation, pers. comm. 2009). One pool harboring Solano grass was located on Air Force property, while the second pool straddled the border between the two properties. Now that both parcels are under county ownership, the county is working on filing a conservation easement to protect approximately 163 acres of the land; however, the easement has not yet been finalized (S. Lines

pers. comm. 2009). A management plan is being developed for the site (C. Witham, pers. comm. 2007; S. Lines and C. Alford, pers. comm. 2007).

**2B. Mechanisms are in place to provide for management in perpetuity and long-term monitoring of habitat protected in Sections 1 A-E, as previously discussed (e.g. funding, personnel, etc).**

This criterion has been partially met.

The conservation easement for the Jepson Prairie Preserve is retained by the Nature Conservancy. The Nature Conservancy thereby retains the rights to enforce and/or accomplish the purposes of the conservation easement, and all management plans are subject to approval by The Nature Conservancy. The Solano Land Trust is the landowner for Jepson Prairie Preserve. The preserve endowment is barely sufficient for management, providing only approximately \$6,000.00 per year for preserve management (B. Wallace, Solano Land Trust, pers. comm. 2007). Additional funding is provided through the grazing lease for the site, and through other Solano Land Trust funds. The Jepson Prairie Preserve functions as part of the UC Davis Natural Reserve System, so it benefits from research and volunteer activities that are conducted on site by University staff and students. However, the Solano Land Trust and the Nature Conservancy are interested in building the endowment for the preserve (B. Wallace, pers. comm. 2007).

Management and monitoring at the Grasslands Regional Park/Davis Communications Annex site has been accomplished to date through funding by a variety of grants. Between 2000 and 2004, a CALFED grant funded Environmental Science Associates (ESA) to work on monitoring and restoration plans that address invasive plants and hydrology of the vernal pools on the site. Since that time, the Service provided a bridge grant that continued the hydrology study. Yolo County has a grant through the Bureau of Reclamation to further fund restoration and work on invasive plants through at least 2010. The California State Wildlife Conservation Board has also provided a grant to address invasive plants that will continue through 2009. Yolo County has relied on the grants for management and monitoring of the area to date. The County would like to tie funding for the area to completion of the county's habitat conservation plan (HCP), but future funding may also come from Yolo County general funds (S. Lines and C. Alford, pers. comm. 2007).

**2C. Monitoring indicates that ecosystem function has been maintained in the areas protected under Sections 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.**

To our knowledge, monitoring of ecosystem function has not occurred at either protected location. This criterion has not been met.

**2D. Seed banking actions have been completed for species that would require it as insurance against risk of stochastic extirpations or that will require reintroductions or introductions to contribute to meeting recovery criteria.**

This criterion has not been met. The Recovery Plan recommends collection of seeds from each population of the species. In connection with a germination study, approximately 5,000 seeds from the Davis Communications Annex site were collected and accessioned at the Rancho Santa Ana Botanic Gardens herbarium in 2002 (C. Witham, private consultant, *in litt.* 2007). The UC Davis herbarium holds old specimen material from Olcott Lake that includes seeds, although the potential of the UC Davis holdings for germination is unknown (J. Shepard, UC Davis, *in litt.* 2007; E. Dean, UC Davis, *in litt.* 2007). Dr. Heather Davis at Sonoma State University has successfully germinated Colusa grass (*Neostapfia colusana*), and may potentially obtain Solano grass seeds from the extant populations, if populations germinate in sufficiently robust numbers (C. Witham, pers. comm. 2007; H. Davis, Sonoma State University, *in litt.* 2007).

### **3. Status Surveys:**

This criterion implicitly addresses listing Factors A, D, and E.

**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 a minimum of 5 years of post-drought monitoring.**

Status surveys that have been conducted for Solano grass indicate that known occurrences may not be viable and either are declining or perhaps near local extirpation (C. Witham, pers. comm. 2007). This criterion has not been met.

**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.**

This criterion has not been met. The primary threats identified in the listing rule were loss of habitat due to urban development, water supply/flood control activities, and conversion to agricultural use. Although two occurrences are on lands that receive protection from development, recent surveys indicate that threats due to factors such as encroachment by invasive plant species, and habitat changes due to management actions and climate change still exist (C. Witham, pers. comm. 2007; B. Wallace, pers. comm. 2007; CNDDDB 2009).

### **4. Research:**

Research implicitly addresses all listing factors.

**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.**

The Recovery Plan discusses a variety of research needs that would help to refine recovery actions and criteria, and guide overall recovery and long-term conservation efforts. The Recovery Plan recommends research on genetics, taxonomy, biology of vernal pool species, the effects of habitat management practices on vernal pool species and their habitat, and threats to vernal pool species and ecosystems (Service 2005).

Although progress has been made, the criterion has not been met. The majority of information needs discussed in the 2005 Recovery Plan are still outstanding for this species. Research addressing vernal pool ecosystem function has been conducted that informs management of the Solano grass. Research on invasive non-native plant removal has been ongoing since 2003 at the Davis Communications Annex site (ESA 2005). Recent research by Dr. Jaymee Marty on the effects of grazing on vernal pool species and inundation periods (Marty 2005; Pyke and Marty 2005) has been used to address grazing recommendations for preserves and private vernal pool habitat, although it has not been formally incorporated into management plans for this species. A study of vernal pool classification and hydrology has recently been completed (Williamson *et al.* 2005; Rains *et al.* 2006) that describes hydrologic connectivity between perched aquifers, surface water, and vernal pools, and provides information on how various vernal pool types function. A statewide floristic classification of vernal pools is underway, and includes a functional model of vernal pool hydrology and water quality (Williamson *et al.* 2005; see also Rains *et al.* 2006).

In 2008 the Service funded an initial replicated study to test the potential of mild disturbance to facilitate germination of Solano grass within portions of Olcott Lake where it was previously thought to occur. Lake bed disturbance was effected in treatment plots and experimental results will be quantified in late 2009 (C. Witham, *in litt.* 2008).

**4B. Research on genetic structure has been completed (for species where necessary – for reintroduction and introduction, seed banking) and results incorporated into habitat protection plans to ensure that within and among population genetic variation is fully representative by populations protected in the Habitat Protection section of this document (the Recovery Plan), described previously in Sections 1 A-E.**

This criterion has not been met. There have been several recent research efforts that have addressed the genetics of the species in the Orcuttieae tribe, including the Solano grass. Boykin *et al.* (2004 in review) completed a phylogenetic analysis of the Orcuttieae. The research indicates that the *Tuctoria* genus is paraphyletic (the genus contains some, but not all of the descendants of the common ancestor), but does not resolve the relationship between species. Additional research has addressed seed germination success under different treatments in the lab (Columbus and Porter 2003). To our knowledge, research results have not been specifically incorporated into habitat protection plans to date.

**4C. Research necessary to determine appropriate parameters to measure population viability for each species have been completed.**

This criterion has not been met. Dr. Heather Davis, Department of Biology at Sonoma State University, began an investigation in 2007 on the genetic variability of populations of five listed vernal pool plants, including the Solano grass. The study will also use Colusa grass in field experiments to assess gene-flow patterns, pollen transfer and limitation, and the role of invasive grasses in limiting pollen transfer within the Orcuttieae (Davis *et al.* 2006). This study has been hampered by the poor germination of plants in the spring of 2007, so no Solano grass material has been collected to date (H. Davis, *in litt.* 2007), but study results for Colusa grass should assist in measuring population viability for the Solano grass.

## **5. Participation and Outreach:**

Public participation and outreach implicitly address all relevant listing factors.

### **5A. Recovery Implementation Team is established and functioning to oversee range-wide recovery efforts.**

The Recovery Plan discusses a variety of participation programs to achieve the goal of recovery of the listed species in the plan. An essential component of this collaborative approach is the formation of a single recovery implementation team overseeing the formation and function of multiple working groups formed at the vernal pool region level. The Service is currently in the preliminary stages of organizing both a recovery implementation team and multiple working groups. Service employees have met with various stakeholders to determine interest of stakeholders to be involved in working groups and/or the recovery implementation team. This criterion has not yet been met.

### **5B. Vernal pool regional working groups are established and functioning to oversee regional recovery efforts.**

See 5A, above.

### **5C. Participation plans for each vernal pool region have been completed and implemented.**

This action has not been initiated.

### **5D. Vernal pool region working groups have developed and implemented outreach and incentive programs that develop partnerships contributing to achieving recovery criteria 1-4.**

This action has not been initiated.

## II.C. Updated Information and Current Species Status

### II.C.1. Biology and Habitat

#### II.C.1.a. Abundance, population trends (e.g., increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

Population sizes for this species, as with other species in the Orcuttieae tribe, fluctuate highly between years, depending on annual precipitation (Holland 1987). However, population trends for the species are thought to be generally downward and the species may be near extinction (C. Witham, pers. comm. 2007). At the time of listing, the Solano grass was only known from Olcott Lake, a large (approximately one square mile) alkaline vernal lakebed 12 miles south of Dixon in Solano County (43 FR 44810). The species was not observed at Olcott Lake from 1976 to 1981, when it reappeared, suggesting that seeds may remain viable for at least 5 years *in situ* (Holland 1987). The occurrence was last seen at Olcott Lake in 1993, when four individual plants were documented. The site has been surveyed since then to census rare vernal pools plants, most recently in 2007, when no individuals of Solano grass were found (C. Witham, pers. comm. 2007). This species occurrence is considered to be extirpated (CNDDDB 2009).

The latest rare grass surveys at the Yolo Regional Grasslands/Davis Communications Site were conducted in 2008, when approximately 5600 individual plants were counted within six relatively discrete basins onsite (J. Gerlach, Environmental Science Associates, *in litt.* 2008). In 2007, a year with little precipitation, monitors documented only 45 individual Solano grass plants that germinated but were not expected to produce seed (J. Gerlach, Environmental Science Associates, *in litt.* 2007). Several thousand individual plants were seen at this site in 2000, and transect counts in 2003 provided a population count of at least 1,400 plants. The distribution of the plants within pools has been found to change annually (ESA 2008; J. Gerlach, *in litt.* 2007). Because the number of germinated plants varies substantially each year depending on inter-annual climatic conditions, to date monitors have not been able to determine a trend for the occurrence (J. Gerlach *in litt.* 2008)..

In 2005, a census of the occurrence on private property near Jepson Prairie provided a count of five plants. The number of plants documented at the site has been up to 200, but is generally around 25 plants (C. Witham, pers. comm. 2007).

Among all members of the Orcuttieae, the soil seed bank may be 50 times or more larger than the population in any given year (Griggs 1980; Griggs and Jain 1983), although the current size of Solano grass seedbanks is not known. Population sizes for Orcuttieae 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 (Griggs 1980; Griggs and Jain 1983; Holland 1987). Thus, many years of observation are necessary to determine whether a population is stable, declining, or extirpated. In general, Solano grass populations appear to be most numerous when annual precipitation is between 17.7 and 23.6 inches (Holland 1987). As discussed above, extensive surveys of the Solano grass population at Olcott Lake have resulted in the conclusion that the population is extirpated from the site (CNDDDB 2009).

Although the various species have been found in pools ranging widely in size, the vast majority occur in pools of 0.025 acre to 24.7 acres (Stone *et al.* 1988). Large pools such as these retain water until May or June, creating optimal conditions for Orcuttieae (Crampton 1959, 1976; Griggs 1981; Griggs and Jain 1983). Within such pools, Orcuttieae occurs in patches that are essentially devoid of other plant species (Crampton 1959, 1976). Typically, plants near the center of a pool grow larger and produce more spikelets than those near the margins, but patterns vary, depending on individual pool characteristics and seasonal weather conditions (Griggs 1980).

**II.C.1.b. Spatial distribution, trends in spatial distribution (e.g., increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g., corrections to the historical range, change in distribution of the species' within its historic range, etc.):**

Populations: At the time of listing in 1978, the Solano grass was known from only one location, its type locality at Olcott Lake within the Solano Land Trust's Jepson Prairie Preserve. The population may be extirpated, and is listed as such in the CNDDDB (C. Witham, pers. comm. 2007; CNDDDB 2009). A second population was discovered on private lands in 1985, and another was discovered in 1993 on a former U.S. Air Force Base communication facility that is being transferred to the Yolo County Parks Department.

Range: Since the listing of Solano grass, surveys of vernal pools and other temporary waters in California have documented the grass in only the two additional locations discussed above, representing an increase in the known range of less than 20 miles. Within the range of the Solano grass, required surveys for federally listed vernal pool plants have likely increased the number of known sites where the plant is not found; however, the failure to detect a species at a location is not recorded in any database. A CNDDDB "occurrence" represents any documented collection, observation, or museum specimen of a species that is submitted to the CDFG by the public. Therefore, CNDDDB only records presence of a species (D. McGriff, CDFG, *in litt.* 2007). To our knowledge the locations where required surveys have failed to detect the grass have not been accumulated; however, species experts suggest that the potential of finding additional sites where the plant is extant are unlikely, based on their knowledge of previous surveys of playa pools in the Central Valley over the last 20 years (C. Witham, pers. comm. 2007).

Vernal Pool Regions: The Recovery Plan delineates a total of 85 core recovery areas that are based on mapped areas of extant vernal pool habitat and that are deemed necessary to recover one or more listed vernal pool species. The Solano grass is currently known to be extant in a total of three vernal pools in two core recovery areas within the Solano-Colusa Vernal Pool Region (Service 2005; CNDDDB 2009).

**II.C.1.c. Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):**

Solano grass is known only from the Northern Claypan type of vernal pool (Sawyer and Keeler-Wolf 1995) within annual grassland habitat within Solano and Yolo Counties (CNDDDB 2009). The pools where the species occurs are characterized by turbid water quality caused by

suspended clay sediments from the “lake” bed (Holland 1987). In Solano County the pools are essentially alkaline playa pools or intermittent lakes (Crampton 1959), while the pools at the Yolo County site are smaller, although they have the characteristic saline-alkali soil chemistry that is diagnostic of alkali vernal pools (ESA 2008). However, location of the species at the Davis Communications Annex may suggest that the species is not restricted solely to large playa-type pools, as the features there include a disturbed swale on pescadero clay loam (J. Gerlach, *in litt.* 2007). Preliminary work is being conducted at this site to restore clay-bottom alkali vernal pools that were filled during farming operations during the early to mid 1900s.

Yolo County lacks substantial areas of hardpan soils and has little flat land that is not in agriculture, so has little potential vernal pool habitat (Holland 1998). Additional suitable habitat for the Solano grass may occur on the California Department of Fish and Game’s Tule Ranch Vernal Pools section of the Yolo Bypass Wildlife Area, although the species was not located during baseline plant surveys in 2003 (Witham 2003). However, the pool soil type may have been mapped incorrectly, and may not be the correct soil type for Solano grass (C. Witham, pers. comm. 2007).

#### **II.C.1.d. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):**

Solano grass was first described as *Orcuttia mucronata*, based on specimens collected “12 miles due south of Dixon, Solano County” (Crampton 1959:108). Reeder (1982) used anatomical and morphological characteristics to transfer the species to a newly described genus, *Tuctoria*, which provided the currently accepted classification, *Tuctoria mucronata*.

Several recent research efforts have addressed the genetics of the species in the Orcuttieae tribe, including the Solano grass. Boykin *et al.* (2004 in review) completed a phylogenetic analysis of the Orcuttieae tribe. The research indicates that the *Tuctoria* genus is paraphyletic, but does not resolve the relationship between species. Research on other species within the Orcuttieae indicates that genetic variation within a “family” of seedlings from a single parent accounts for about half of the total genetic variation within each species, which represents a high level of out-crossing for a wind-pollinated group. (Out-crossing is a measure of the proportion of genetic variation that is contributed by plants other than the parent plant.) Within the Orcuttieae, the rates of gene flow are low between populations, regardless of distance (Boykin *et al.* 2004 in review). A germination study for Solano grass under different treatments in the lab has documented a low germination rate of 2.6 percent that did not differ by treatment or source population (Columbus and Porter 2003). Although recent research is providing information of the genetic variability of Orcuttieae members, the Service is not aware of any new information on trends in genetic variation.



## II.C.2. Five-Factor Analysis

### II.C.2.a. Present or threatened destruction, modification or curtailment of its habitat or range:

The original listing rule in 1978 noted that the plant was found in only one location, within a site surrounded by land used for agricultural purposes. Although the listing document noted that the alkaline vernal lakebed was unlikely to be used for agriculture in the near future, it proposed that such use could occur in the “eventual future”. The document also noted that housing developments within the region had destroyed many vernal pools (43 FR 44810). Solano grass has been known only from the Northern Claypan type of vernal pool (Sawyer and Keeler-Wolf 1995) within annual grassland habitat within Solano and Yolo Counties (CNDDDB 2009). The known occurrences of the Solano grass are currently threatened by destruction or modification of habitat due primarily to invasion of vernal pools by non-native plants and to altered hydrology. Development in the region may reduce the options for re-introducing the species to suitable habitat.

Non-native plant invasions: Perennial pepperweed (*Lepidium latifolium*), a non-native invasive plant, grows within vernal pools at the Yolo Grasslands Regional Park/Davis Communications Annex, and is considered by park managers and species experts to be a threat to persistence of the Solano grass at the site. The perennial pepperweed changes the water chemistry of vernal pools and shades out Solano grass (S. Lines and C. Alford, pers. comm. 2007). In 2005, one pool had a 90 percent cover of perennial pepperweed; however, over the past year management has used direct application of Aquamaster, a glyphosate herbicide, to reduce pepperweed plant numbers. Initial results indicate a 90 to 95 percent mortality of the perennial pepperweed; however, some plants are regenerating with onset of the wet season and will need re-treatment (J. Gerlach, Biological Resources Technology Associates, pers. comm. 2007). Additional treatments of the perennial pepperweed that occurs in the two pools are planned over the next two years. Other pools on the property that may serve as source populations of the plant are also to be treated under existing management (C. Alford, Yolo County Parks and Resources, *in litt.* 2007).

Other non-native plants also may pose threats to the Solano grass. Swamp grass, or swamp timothy (*Crepsis sp.*), has been noted as a potential threat to the Solano grass. The species is planted by waterfowl managers at State and Federal refuges, and at other sites as a waterfowl food (C. Witham, pers. comm. 2007; J. Gerlach, pers. comm. 2007). It has growth habits that are similar to those of the Solano grass and it is also a C<sub>4</sub> plant, so it is adapted to the same general conditions and it appears in the same pools as Solano grass (C. Alford, *in litt.* 2007; J. Gerlach, pers. comm. 2007). Studies conducted at the Yolo County site have not conclusively shown that the plant harms Solano grass populations, although the Solano grass may be able to establish denser stands when the swamp grass is not present (C. Alford, *in litt.* 2007), as the grass appears to overwhelm Solano grass when it becomes dense. Increased density of swamp grass may increase the threat of fire to persistence of Solano grass in the future if densities increase, but movement of fire into Solano grass occurrences is not thought to be a threat at this time (J. Gerlach, pers. comm. 2007). Swamp grass also occurs at Olcott Lake in the Jepson Prairie

Preserve, where Solano grass has been extirpated, and at the Solano grass occurrence on private land in Solano County (CNDDDB 2009).

Altered hydrology: The hydrology at Olcott Lake has likely been altered by bisection of the lake by an elevated gravel road, and by construction of a small drainage ditch. Altered hydrology has been suggested as one potential factor in the extirpation of Solano grass from the site (CNDDDB 2009). Vernal pool hydrology can also be altered by the non-native grasses that occur commonly in vernal pool complexes. Non-native grasses maintain dominance at pool edges, sequestering light and soil moisture, promoting thatch build-up, and shortening inundation periods. Although the mechanism responsible for the change in inundation is not documented, reduction in inundation period is thought to be due to increased evapo-transpiration at the vernal pools (Marty 2005). Italian ryegrass (*Lolium multiflorum*), an upland grass, has not been considered a problem in the past, but at the Yolo County site, it is starting to infringe on the edges of the vernal pools and is starting to invade. Additional research on this issue is planned at the site (C. Alford, *in litt.* 2007). Thatch accumulation may also present a threat to the Solano grass over time. Management of this site is addressing these issues through the weed whipping and flaming techniques for controlling Italian rye grass. Weed whipping refers to the use of a string or metal-edged handtool to trim growing plant material. Flaming is a technique that wilts green vegetation to kill it and does not actually burn vegetation or start a fire. Flaming, using a hand-held flaming torch and propane cylinder, can be conducted to control targeted non-native invasive species such as Italian ryegrass (*Lolium multiflorum*) when vegetation is green (Yolo County Planning and Public Works Department and ESA 2005). Management techniques also include selective use of mowing and grazing to limit thatch build-up, and selective glyphosate herbicide treatment for invasions of other upland plants (C. Alford, *in litt.* 2007; S. Lines and C. Alford, pers. comm. 2007).

Management activities at protected sites have the potential to modify habitat for this species. Volunteers began planting oak trees (*Quercus* spp.) at the Yolo County site about 15 years ago. Some trees were planted close to vernal pools; however, the plantings have been stopped. Managers do not consider the trees to be an issue for the Solano grass because the soils where the grass occurs are not conducive to growing oaks, so oaks seldom survived in that habitat. In addition, a prescribed burn and subsequent wildfires at the property have killed some of the oaks so that the oaks are not proximate to Solano grass occurrences (S. Lines and C. Alford, pers. comm. 2007).

Past farming activities at this site have apparently resulted in filling of potential habitat for the species, and have altered habitat where the species currently occurs, but the net effect is not known. Restoration of the altered habitat is currently being conducted at the site (ESA 2008; S. Lines and C. Alford, pers. comm. 2007). The Service has funded preliminary work at this site to restore clay-bottom alkali vernal pools that were filled during farming operations during the early to mid 1900s. Excavation of the pools has been initiated and eventual re-introduction of Solano grass populations is planned for the restored pools when study of their hydrology has been completed (ESA 2008; S. Lines and C. Alford, pers. comm. 2007). The current draft management plan for the site prohibits alteration of the topography within a buffer of 250 feet from edge of vernal pools; however, the final plan has not been completed at this time. Alteration of topography outside the 250-foot buffer but within the larger watershed could pose a

threat to pool hydrology (Williamson *et al.* 2005; Rains *et al.* 2006), but current activities are not expected to threaten the Solano grass (J. Gerlach, pers. comm. 2007).

Cessation of cattle grazing has been found to exacerbate the negative effects of invasive non-native plants on vernal pool inundation period, presumably due to the positive effects of grazing on evapo-transpiration rates. The change in vernal pool inundation due to loss of grazing is an emerging threat for vernal pool species. Vernal pool inundation has been reduced by 50-80 percent in the southeastern Sacramento Valley when grazing is discontinued (Marty 2005). In annual grasslands that are not mowed or grazed, wetland characteristics may change over relatively short periods of time. Currently Olcott Lake at Jepson Prairie and the occurrence at the Yolo County site are not grazed; however, management and monitoring are tracking non-native grasses, as noted above. Anecdotal observations may suggest that the species germinates better when provided with some surface disturbance; and in 2008 a small study was initiated to test this potential (C. Witham, *in litt.* 2007, 2008).

### **Summary of Habitat Threats**

In summary, the loss and modification of vernal pool habitat continues to be the primary threat to the Solano grass, although the threat for known occurrences is primarily due to invasion of vernal pools by non-native species and altered hydrology due to past (and potentially current) land use. Loss of potentially suitable habitat for this species is expected to continue due to urban expansion into areas of remaining vernal pool habitat. Studies have not been conducted to determine the minimum area (upland and wetland) needed to sustain vernal pool species in the long term.

#### **II.C.2.b. Overutilization for commercial, recreational, scientific, or educational purposes:**

This factor was not considered to be applicable to this species at the time of listing (43 FR 44810). However, since that time information has suggested that between the 1950s and the 1970s the plant was over-collected at Olcott Lake in Jepson Prairie Preserve. The over-collection was a potential factor in the decline of the species at that location that led to its listing as endangered (C. Witham, pers. comm. 2007, 2008; CNDDDB 2009). The Service permits take of listed plants on Federal lands. Section 10(a)(1)(A) of the Endangered Species Act allows the Service to issue recovery permits for prohibited activities if it is for scientific purposes or to enhance the propagation or survival of the affected species. Removing plants or plant parts from private or State lands does not require a Federal permit, but must comply with State laws and regulations (Service 1995). The Service is not currently aware of collection on Federal land beyond that which has been permitted through the Service's recovery permit process (Service 2005; C. Witham, *in litt.* 2007).

#### **II.C.2.c. Disease or predation:**

The 1978 final rule to list the Solano grass stated that this factor was not applicable to the species. The Service is not aware of any information to indicate that this factor has become a threat since listing.

#### **II.C.2.d. Inadequacy of existing regulatory mechanisms:**

The final rule listing the Solano grass noted that the State of California had recently passed legislation to protect “native endangered plants”, but that the law primarily provided for salvage of rare or endangered plants threatened by a proposed change in land use. At the time that Solano grass was listed under the Endangered Species Act, the species was not listed as rare or endangered pursuant to state law (43 FR 44810). In July 1979, the California Department of Fish and Game listed the species (under the common name Crampton’s tuctoria) as endangered under the California Endangered Species Act (CESA) (Fish & Game Code §§2050 *et seq.*).

Federal Endangered Species Act: The Endangered Species Act of 1973, as amended (Act), is the primary Federal law that provides protection for the Solano grass since its listing as a federally endangered species in 1978. Section 7(a)(2) requires Federal agencies to consult with the Service to ensure any project they fund, authorize, or carry out does not jeopardize a listed species. Since 1994, the Service’s Sacramento Fish and Wildlife Office has completed section 7 consultations on impacts to almost 50,000 acres of vernal pool habitat (containing both pools and the supporting upland habitat), including direct impacts to over 1,314.5 acres of wetted vernal pool habitat and indirect impacts to 194.0 acres of wetted vernal pool habitat (Service 2007). The Service works with Federal, State, and local agencies, and with private project proponents, to minimize effects to listed vernal pool species, and to compensate for the loss of habitat through preservation of vernal pool habitat elsewhere and through creation (or restoration) of an equal acreage of vernal pool habitat. Service files contain nine section 7 consultations in which effects to the Solano grass were considered, including several for proposed activities at the Davis Communications site. However, none of the projects were expected to adversely affect the species (Service 2000a, b; Service 2003; Service 2007).

Federal Clean Water Act: Section 404 of the Clean Water Act (CWA) may afford some protection to the Solano grass. The Corps issues permits for the discharge of dredged or fill material into navigable waters of the United States. The Corps has interpreted “the waters of the United States” expansively to include not only traditional navigable waters, but also other defined waters that are adjacent or hydrologically connected to traditional navigable waters. In the past, vernal pools have been classified as Corps jurisdictional waters under the CWA. The CWA requires project proponents to obtain a permit from the Corps before initiating many types of activities (such as grading or discharge of soil) that could harm vernal pool habitat. However, the CWA exempts plowing, cultivating, disking, grazing, minor drainage, and other normal farming and ranching practices, from section 404 permit requirements where they are part of established operations (USEPA 2009a, b), so damage to vernal pool habitat could potentially accrue from such activities.

Recent Supreme Court rulings have called into question the Corps’ definition of Waters of the United States. On June 19, 2006, the U.S. Supreme Court vacated two district court judgments that upheld the Corp’s interpretation as it applied to two cases involving “isolated” wetlands. Currently, the Corps regulatory oversight of vernal pools is in doubt because of the “isolated” nature of the vernal pools. In response to the Supreme Court decision, the Corps and the U.S. Environmental Protection Agency (USEPA) have recently released a memorandum providing guidelines for determining jurisdiction under the CWA. The guidelines provide for a case-by-

case determination of a “significant nexus” standard that may protect some, but not all, vernal pool habitat (USEPA and USACE 2007). The overall effect of the new permit guidelines on loss of vernal pool habitat is not known at this time. In addition to the above, an unquantified but potential source of loss of vernal pool habitat is the potentially illegal fill of vernal pool wetlands that results from actions that are completed without the benefit of a required CWA permit.

National Environmental Policy Act: The National Environmental Policy Act (NEPA) (42 U.S.C. 4321 *et seq.*) requires all Federal agencies to formally document, consider, and publicly disclose the environmental impacts of major Federal actions and management decisions that have significant effects on the human environment (including natural resources), but NEPA does not require that mitigation alternatives be implemented. Additionally, NEPA applies only to actions by Federal agencies, so private landowners are not required to comply with NEPA unless a Federal agency is involved through provision of Federal funding or a Federal permit, including CWA and Endangered Species Act incidental take permits. Although NEPA requires disclosure of the effects of proposed Federal actions and may promote implementation of conservation measures for fish and wildlife resources, it does not guarantee that impacts to the Solano grass will be avoided or mitigated.

#### California State Laws:

The State’s authority to conserve rare wildlife and plants is comprised of four major pieces of legislation: the California Endangered Species Act, the Native Plant Protection Act, the California Environmental Quality Act, and the Natural Community Conservation Planning Act.

California Endangered Species Act (CESA) and Native Plant Protection Act (NPPA): The Solano grass was State-listed as endangered in 1979. The CESA (California Fish and Game Code, section 2080 *et seq.*) and NPPA (Division 2, Chapter 10, section 1908) prohibit the unauthorized take of State-listed threatened or endangered plant species. Unlike the take prohibition in the Federal Endangered Species Act, the State prohibition includes plants, however, landowners are exempt from this prohibition for plants via habitat modification. Landowners are required to notify the California Department of Fish and Game 10 days in advance of changing land use in order to allow salvage of listed plants (NPPA Division 2, Chapter 10, section 1913). However, salvaging is unlikely to be beneficial for Solano grass, an annual species, as no evidence exists that the species would survive transplantation.

California Environmental Quality Act (CEQA): The CEQA requires review of any project that is undertaken, funded, or permitted by the State or a local governmental agency. If significant effects are identified, the lead agency has the option of requiring mitigation through changes in the project or to decide that overriding considerations make mitigation infeasible (CEQA section 21002). Protection of listed species through CEQA is, therefore, dependent upon the discretion of the lead agency involved.

Natural Community Conservation Planning Act: The Natural Community Conservation Program is a cooperative effort to protect regional habitats and species. The program helps identify and provide for area wide protection of plants, animals, and their habitats while allowing compatible and appropriate economic activity. Many Natural Community Conservation Plans (NCCPs) are

developed in conjunction with Habitat Conservation Plans (HCPs) prepared pursuant to the Federal Endangered Species Act.

Summary of Existing Regulatory Mechanisms: In summary, without protection under the Endangered Species Act, regulatory mechanisms to protect the Solano grass would be inadequate. State regulations also do not protect habitat for the species. Changes in implementation of the Clean Water Act may result in greater losses of vernal pool habitat on private lands as fewer permits are required under section 404. Other Federal regulatory mechanisms provide discretionary protections for the species based on current management direction, but do not guarantee protection for the species absent its status under the Act.

#### **II.C.2.e. Other natural or manmade factors affecting its continued existence:**

The final listing rule noted only that there were no other natural or manmade factors affecting the continued existence of the species (43 FR 44810). Currently, habitat fragmentation, inbreeding depression, stochastic extinction, and drought and climate change threaten the species. In some cases contaminants could pose a threat to the species, since they are used to control invasive plant species that can occur in close proximity to the Solano grass.

Fragmentation: The continuing fragmentation of Solano grass habitat range-wide may increase the isolation of the few known occurrences of this species. In contrast with some other vernal pool plant species, Solano grass seeds are not likely to be dispersed by waterfowl, as seeds of the Orcuttieae tribe do not become viable until mid to late summer when vernal pool areas are dry and waterfowl are unlikely to be present (J. Gerlach, *in litt.* 2007).

Inbreeding Depression, Genetic Drift, and Stochastic Extinction: The Service does not have any additional information on inbreeding depression or genetic drift within Solano grass populations. The few populations are considered to be isolated from each other, and continue to be threatened by the risk of stochastic extinction due to unforeseen natural and man-caused catastrophic events (e.g., droughts, fires, and accidental destruction of suitable habitat by grading, etc.), that may eliminate one or more occurrences (Goodman 1987; Gilpin and Soulé 1986). In addition, pollination success may be hampered by the small size of extant populations (Davis *et al.* 2006).

Contaminants: The introduction of pesticides and other contaminants into vernal pool waters may threaten occurrences of the Solano grass. Glyphosate herbicides are being used to control invasive plant species at sites where the Solano grass is present (C. Alford, *in litt.* 2007); however, the Service has determined that at these sites the herbicides are being applied in a manner that precludes threats to the plant's persistence. Under Service-approved measures, broadcast application of herbicides and pesticides is restricted to areas that are a minimum of 250 feet from the outside edge of any vernal pool or swale habitat that may support federally listed species. Within the habitats of federally protected species, including the Solano grass, application of herbicides and pesticides is limited to hand application (such as painting/wick methods) that is completed only during the dry season when there is no standing water in the application areas (Service 2007).

Drought and Climate Change: Drought is likely to decrease or terminate reproductive output as pools fail to flood, or dry up before reproduction is complete. In a Mediterranean climate such as that of California, the annual season of precipitation (November to March) is relatively predictable, although the amount of precipitation can vary substantially from year to year (Graham 2003). For population maintenance, vernal pools must last longer, on average, than the time needed for a species to reach maturity and produce viable seeds, and relatively small changes in the timing or amount of precipitation can affect population dynamics (Graham 2003).

Climate change has the potential to adversely affect the Solano grass through changes in vernal pool inundation patterns and temperature regimes. Vernal pools in California's Central Valley are particularly sensitive to slight increases in evaporation or reductions in rainfall due to their shallowness and seasonality (Field *et al.* 1999). Climate change is expected to lead to increased variability in precipitation (McLaughlin *et al.* 2002), and to increased loss of soil moisture due to evaporation and transpiration of water from plants (Field *et al.* 1999), which may exacerbate effects due to drought. Although the specific effects of climate change on the Solano grass are unknown, the effect of warming temperatures on winter storm events and pool conditions have the potential to adversely affect this species. Germination of the Solano grass is known to vary dramatically with inter-annual variation in climatic conditions (Holland 1987). Such inter-annual population fluctuations may be amplified by changes in precipitation and lead to rapid extinctions of individual populations (McLaughlin *et al.* 2002).

#### **II.D. Synthesis**

We have no information indicating that threats to the Solano grass have decreased since the time of listing in 1978 (43 FR 44810). Although one site has been protected for a number of years, the plant may now be extirpated at that site, suggesting that land protection in and of itself does not guarantee persistence of the species. The primary threats to the species continue to be the modification, destruction, and degradation of suitable habitat, and the resulting habitat fragmentation. Modification of habitat is currently caused by altered site hydrology, inappropriate grazing levels (cessation of grazing or overgrazing), nonnative invasive plants, and related issues such as thatch build-up. Contaminant runoff into vernal pools, and drought and climate change are also major threats. Even on protected sites, new and emerging threats have been identified in the form of hydrologic alteration resulting from invasive nonnative plants and land use activities. Although restoration activities may negate these threats in the future, that has not happened at this time.

In addition, Solano grass occurrences are threatened by their small size and isolation. Small population size may be a factor in pollination success for this species. Currently populations fluctuate greatly, are thought to be declining, and one protected population is thought to be extirpated. The Service is working with the State of California, Yolo County, conservation organizations, and private landowners to protect the remaining suitable habitat and to restore the species to unoccupied suitable habitat.

Therefore, based on the reasons summarized above, we conclude that the Solano grass continues to meet the Endangered Species Act's definition of endangered. We recommend no status change for this species at this time.

### III. RESULTS

#### III.A. Recommended Classification:

- Downlist to Threatened**
- Uplist to Endangered**
- Delist** (*Indicate reasons for delisting per 50 CFR 424.11*):
  - Extinction*
  - Recovery*
  - Original data for classification in error*
- No change is needed**

Threats to the Solano grass have not decreased since the time of its listing in 1978, and additional threats have been identified.

### IV. IV. RECOMMENDATIONS FOR FUTURE ACTIONS

The Recovery Plan recommends research on genetics, taxonomy, biology of vernal pool species, the effects of habitat management practices on vernal pool species and their habitat, and threats to vernal pool species and ecosystems. Recommendations have been identified based on communication with land managers and species experts, and through the process of reviewing the literature, the status of existing records, and determining population-level status of the species.

1. *Recovery*: Re-introduce Solano grass to Olcott Lake at the Jepson Prairie Preserve. Introduce the plant to other suitable vernal pools in a buffer around Jepson Prairie, potentially including East Wilcox Ranch and the Tule Ranch area in the Yolo Bypass Wildlife Area. Pursue placing the unprotected Solano Grass occurrence on private land under a conservation easement. Work with the Rancho Santa Ana herbarium to preserve the accessioned Solano grass seeds for potential use in restoration efforts.
2. *Research*: Fund continuing research for the Solano grass that assesses the pollination ecology for the species, barriers to pollination, determines long-term trends in population growth, and experimentally measures probabilities of local extinction and recolonization.
3. *Monitoring*: Develop and implement a standardized formal monitoring program that collects data in sufficient detail to evaluate species status and examine changes in population dynamics and community composition.
4. *Habitat Management*. Develop management indicators for identifying potential problems and assessing ecosystem health as it pertains to the Solano grass. Establish requirements for appropriate management of vernal pool landscapes. Establish improved guidelines, monitoring protocols, and success criteria for appropriate management of this species.



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**U.S. FISH AND WILDLIFE SERVICE**

5-YEAR REVIEW of Solano grass (*Tuctoria mucronata*)

Current Classification Threatened

Recommendation resulting from the 5-Year Review

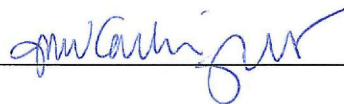
- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change is needed

Appropriate Listing/Reclassification Priority Number, if applicable NA

Review Conducted By Sacramento Fish and Wildlife Office staff

**FIELD OFFICE APPROVAL:**

Lead Field Supervisor, Fish and Wildlife Service

Approve  Date 2-20-07

**REGIONAL OFFICE APPROVAL:**

Lead Regional Director, Fish and Wildlife Service

Approve  Date 4/1/09