

1 **A.33 BUTTE COUNTY MEADOWFOAM**
 2 **(*LIMNANTHES FLOCCOSA* SSP.**
 3 ***CALIFORNICA*)**

4 **A.33.1 Legal and Other Status**

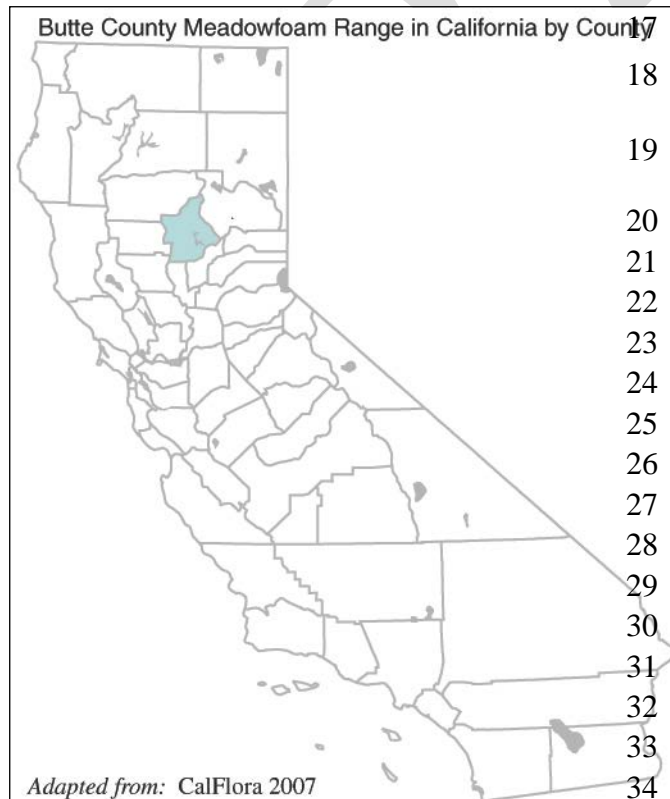
5 Butte County meadowfoam (*Limnanthes floccosa* ssp.
 6 *californica*) is listed as endangered under both the federal
 7 Endangered Species Act (ESA) and California ESA (DFG
 8 2011a).



photo courtesy Dr. Dean William Taylor

9 The California Native Plant Society (CNPS) includes Butte
 10 County meadowfoam on List 1B, rare and endangered in California and elsewhere, with a state
 11 rank of S.1.1 and a global rank of G4T1: seriously endangered in California; less than six
 12 occurrences or less than 2,000 acres (CNPS 2006).

13 Critical habitat has been designated for this species, all of which is located in the Butte Regional
 14 HCP/NCCP Plan Area. A total of 16,636 acres (6,732 hectares) has been designated critical
 15 habitat in four separate areas (Units 1, 2, 3, and 4), all of which are on private property in Butte
 16 County (71 FR 7118).



17 **A.33.2 Species Distribution**
 18 **and Status**

19 **A.33.2.1 Range and Status**

20 Butte County meadowfoam occurs
 21 primarily in areas of grassland and blue oak
 22 savanna in swales, vernal pools with flashy
 23 hydrology, along the upper margins of
 24 vernal pools with more persistent
 25 hydrology, and secondarily as ephemeral
 26 occurrences in seasonal streams from 150
 27 to 2,800 feet (50 to 930 meters) in
 28 elevation. It is restricted to a narrow 30-
 29 mile (50-kilometer) strip along the eastern
 30 margin of the Sacramento Valley from
 31 central Butte County to near the northern
 32 border of Butte County. The extent of its
 33 range has not changed substantially since it
 34 was identified as a distinct taxon, but the

1 number of occurrences, the area occupied, and the extent of available habitat within its range
2 have declined significantly over the last 30 years (57 FR 24192, USFWS 2008, DFG 2011b).

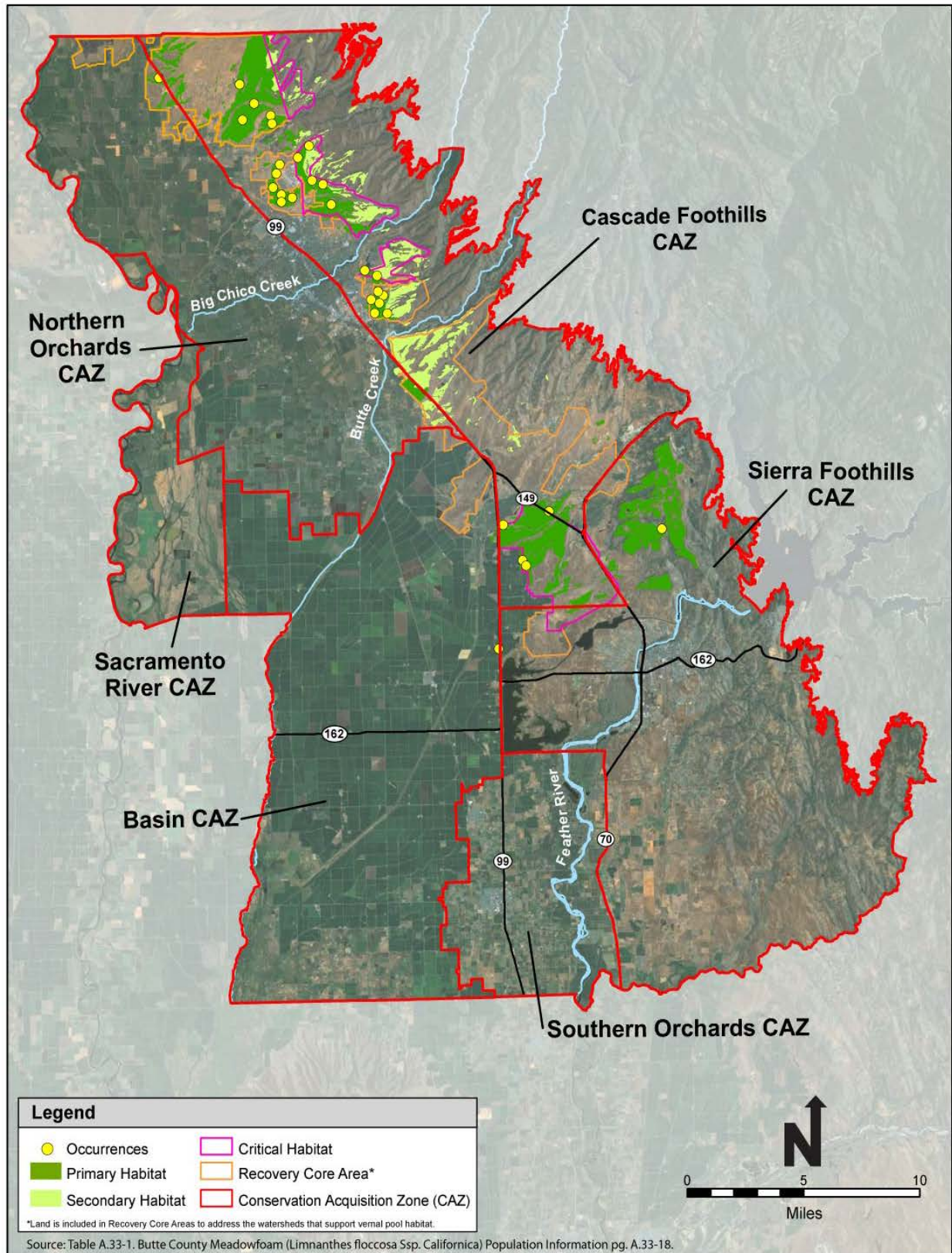
3 **A.33.2.2 Distribution and Status in the Plan Area**

4 Butte County meadowfoam distribution is fragmented, with the largest occurrences clustered in
5 central Butte County near the City of Chico. Although never extensive in range, Butte County
6 meadowfoam occurrences have been substantially reduced in number and fragmented by
7 development in the Chico area (USFWS 2006, Keeler-Wolf et al. 1998). The USFWS has
8 compiled Butte County meadowfoam known occurrence information from CNDDDB data,
9 available data from botanical surveys, and USFWS file data (Figure A-33.1).

10 Primary sources of survey data include academic papers (Dole and Sun 1992), draft conservation
11 plans (Jokerst 1989), Butte County meadowfoam Field Survey for City of Chico (Dole 1988),
12 Farm Credit Project (Kelly and Associates 1991), Greater Chico Urban Redevelopment Project
13 (Jones and Stokes 1993), Rock Creek-Keefe Slough Flood Control Project (USACE 1999),
14 Canyon View High School Butte County meadowfoam Biological Survey (Jones and Stokes
15 2000), Butte 70/149/99/191 Highway Improvement EIR (Caltrans 2003), Bidwell Ranch Butte
16 County meadowfoam Survey (Gallaway 2006a), Meriam Park Biological Assessment (Gallaway
17 2006b), Thomasson Ranch Survey (Restoration Resources 20010, genetic analysis report (Sloop
18 2009), and the California Natural Diversity Database (DFG 2011b). Additional data generated
19 by the USFWS through the Endangered Species Act section 7 consultations were obtained from
20 the USFWS during a series of technical meetings. Butte County meadowfoam population data
21 gathered from the available information is presented in Table A.33-1 and depicted in Figures
22 A.33-1, A.33-2, and A.33-3.

23 In addition to the naturally occurring populations, an experimental population of Butte County
24 meadowfoam was introduced on the Tuscan (Wurlitzer) Preserve near the northwestern limit of its
25 range (USFWS 2005) but no data are available regarding its persistence and seasonal fluctuations in
26 the number of individuals.

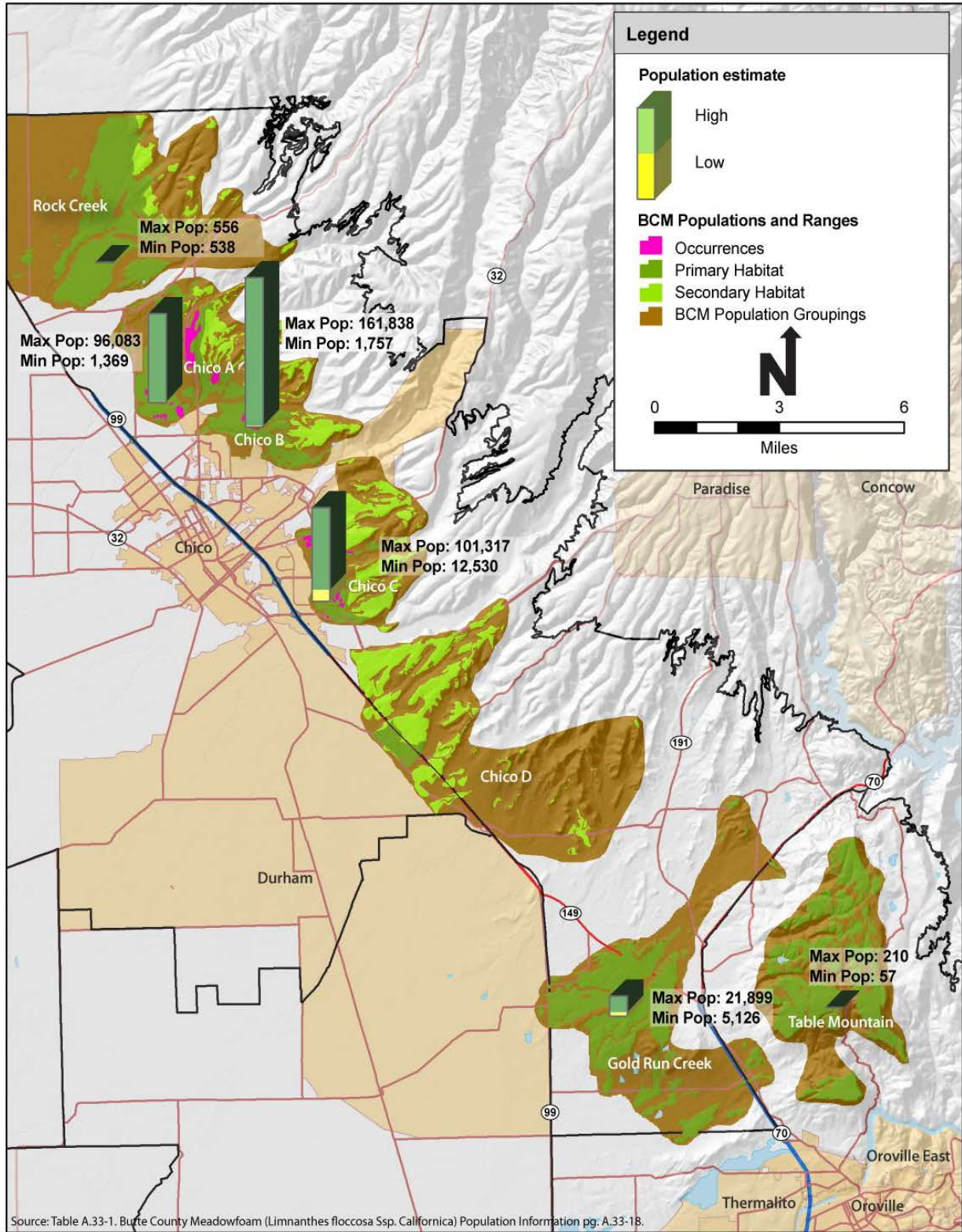
27 The compiled occurrence data described above indicates that Butte County meadowfoam occurs
28 almost exclusively on three geological formations (Divisions of Mines and Geology 1992: 1)
29 Red Bluff pediment (and inclusions of Tuscan formation); 2) strath terraces; and 3) Lovejoy
30 basalt. Based on landscape characteristics that would tend to isolate plants from breeding (see
31 Life History section of this account), Butte County meadowfoam was separated into seven
32 geographically characterized population groupings: four populations on Red Bluff pediment
33 (Rock Creek population and Chico populations A, C, and D), one population on an inclusion of
34 Tuscan formation along the border of the Redbluff pediment (Chico B), one population on the
35 strath terraces (Gold Run Creek population near SR 149), and one population on Lovejoy basalt
36 (Table Mountain) (Figure A.33-1). The term “population grouping” is defined here using the
37 evolutionary paradigm that a population is a “group of inter-breeding individuals that exist
38 together in time and space” (Waples and Gaggiotti 2006).



1

2

Figure A.33-1. Butte County Meadowfoam Modeled Habitat and Recorded Occurrences

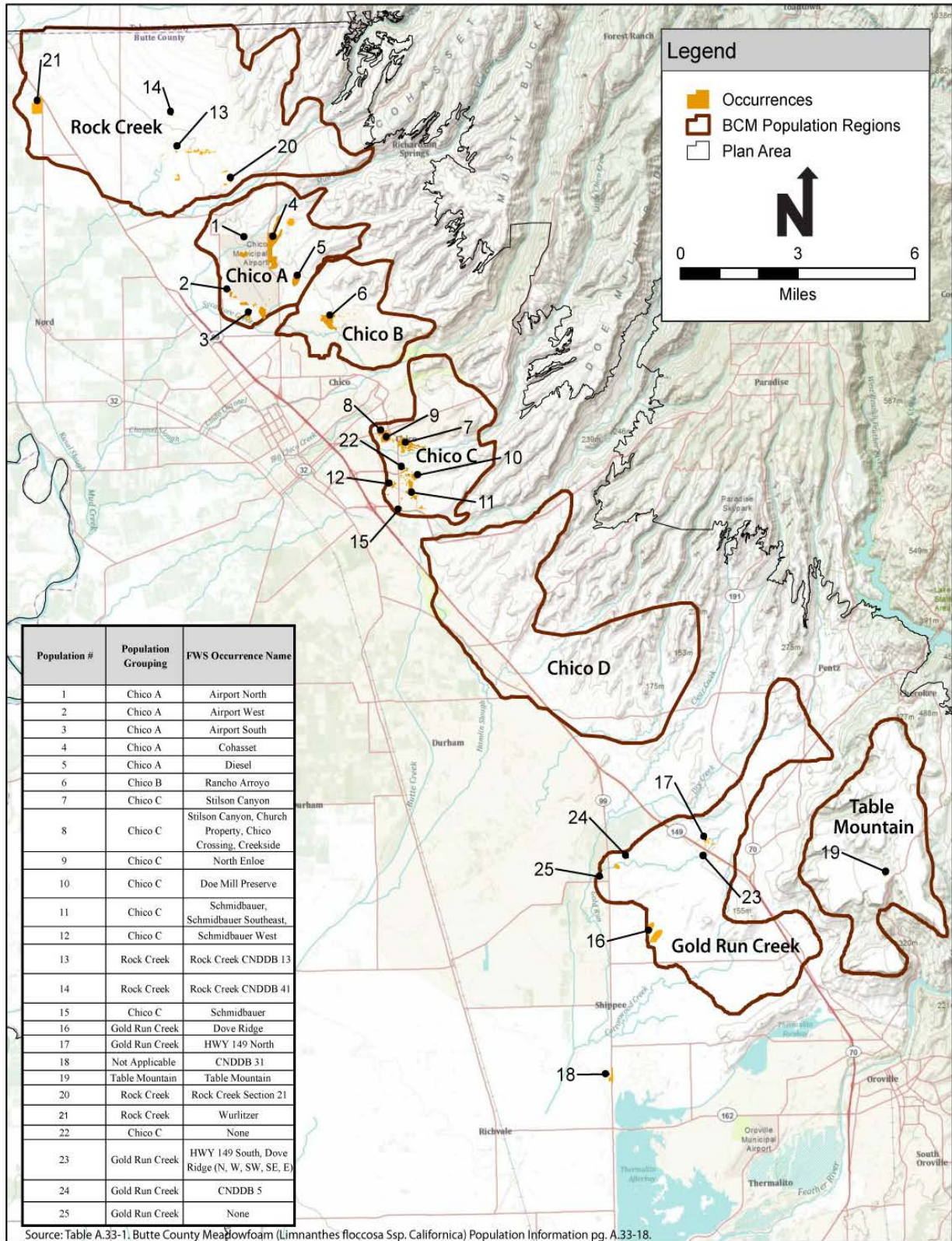


1

2

3

Figure A.33-2. Butte County Meadowfoam Population Groupings, Occurrences, Modeled Habitat, and Population Estimates



1

2

3

4

Figure A.33-3. Butte County Meadowfoam Recorded Occurrences Standard Names and Numbers

1 All of the population groupings from Chico D northward are separated from each other by
2 westward running streams that divide the Red Bluff pediment in Butte County into the discrete
3 lobes on which Butte County meadowfoam is found. All of the large populations of Butte
4 County meadowfoam, historical and current, are found on Redswale soil within two soil
5 complexes: 302-Redtough-Redswale complex 0 to 2 percent slopes; 305-Redtough-Redswale-
6 Anita, gravelly duripan, complex 0 to 5 percent slopes.

7 Redswale is a cobbly loam, underlain by a duripan generally at a depth of 7 inches, that is found
8 on the treads at the base of slopes, and has a swale microtopography. Where the soil complex
9 abuts the Tuscan formation, such as at the Doe Mill Preserve, the soil is underlain by volcanic
10 lahar and tuff bedrock (O’Geen et al. 2008). The Redswale soil, because of its shallow depth,
11 coarse texture, and large cobble content, has a very low water holding capacity of 0.7 inch of
12 water. The combined effect of the geomorphic surface, landscape position, duripan or bedrock
13 impermeable layer, cobble content, and coarse texture creates the unique hydrologic microhabitat
14 that tends to support Butte County meadowfoam, characterized as saturated but not ponded soils
15 during the wet season that dry rapidly during the dry season. The dynamics of the wetting and
16 drying periods are extremely variable in response to El Niño-southern oscillation and Pacific
17 decadal oscillation events (Minnich 2007).

18 **A.33.3 Habitat Requirements and Special Considerations**

19 Butte County meadowfoam generally occurs on level to gently sloping terrain on very shallow,
20 infertile, and poorly drained soils over a water impermeable substrate that consists of bedrock,
21 hard pan, or claypan depending on the soil. It is found primarily in vernal swales and the
22 margins of vernal pools on alluvial terraces in annual grasslands with small mounds topography.
23 Swales vary in width from narrow channels to broad, pool-like areas and may connect in
24 branching, tree-like patterns or in net-like patterns around the low mounds. It does not persist in
25 vernal pools or swales that are inundated for prolonged periods during the wet season or are wet
26 during the dry season, nor does it persist in drainages where water flows swiftly. In vernal pools,
27 the plants more often grow along the margins than on the bottom, but the pattern is reversed in
28 swales, with the plants more often growing along the bottom of the swale. It typically occurs in
29 long, narrow bands in connected swales or along pool margins but can also be found in irregular
30 clusters in isolated drainages. The species has also been found occasionally in disturbed areas,
31 such as drainage ditches, firebreaks, and graded sites (USFWS 2005).

32 Common associate species of Butte County meadowfoam vary depending on the general
33 location. In most of the sites near the City of Chico, it is found with Fremont’s tidy-tips (*Layia*
34 *fremontii*), whiteflower navarretia (*Navarretia leucocephala*), yellow carpet (*Blennosperma*
35 *nanum*), and California goldfields (*Lasthenia californica*). In the Shippee area, toad rush
36 (*Juncus bufonius*), long-beak heron’s bill (*Erodium botrys*), and coyote thistle (*Eryngium vaseyi*
37 ssp. *vallicola*) are common associates. In some locations, Butte County meadowfoam occurred
38 with other *Limnanthes* species including *L. alba* and *L. douglasii* ssp. *rosea*. The woolly
39 meadowfoam (*L. floccosa* ssp. *floccosa*) is a conspecific of Butte County meadowfoam and has

1 been observed growing with a population of Butte County meadowfoam in three locations, but
2 there is no evidence that the two subspecies were hybridizing (USFWS 2005, CNDDDB 2006).
3 Woolly meadowfoam is known from Lassen, Siskiyou, Lake, Napa, Trinity, Shasta, and Tehama
4 counties and extends into northern Butte County¹ where it may co-occur with Butte County
5 meadowfoam.

6 The largest and most extensive populations of Butte County meadowfoam are found on two
7 geological formations: 1) the Red Bluff pediment; and 2) the strath terraces composed of the A
8 and B units of the Tuscan formation in an ancient abandoned drainage of the Feather River that
9 parallels the north side of Table Mountain (see Helley and Harwood 1985; Division of Mines
10 1992). There are two sizable occurrences of Butte County meadowfoam not on those two
11 geological features that are on various units of the Tuscan formation where it grades into Butte
12 County meadowfoam occupied areas on the Red Bluff pediment (Chico B population grouping
13 and the eastern edge of the Chico C population grouping). There is also a very small isolated
14 population on Lovejoy basalt on top of Table Mountain.

15 Surface exposures of the Red Bluff pediment on which Butte County meadowfoam habitat
16 occurs are not continuous but are periodically broken into smaller areas through stream incision
17 or isolated by surficial alluvium carried by westward trending foothill streams such as Pine
18 Creek and Butte Creek in the south. Additionally, drainages originating on the Red Bluff
19 pediment or small drainages originating immediately upslope on the Tuscan formation have
20 established local areas of incision and recent alluvium on top of the Red Bluff pediment. The
21 combined effects of the foothill streams and the local streams results in a series of three-
22 dimensionally convex triangular lobes of Red Bluff pediment emanating and sloping downward
23 from the foothill Tuscan formation until the lobes are buried by the recent alluvium that has
24 accumulated further from the foothills. The Chico monocline affects the extent of surface
25 exposure of the Red Bluff pediment and it runs from its highest point in the north near Antelope
26 Creek in Tehama County southward like a sideways inclined stair-step along the toe of the
27 foothills until its surface expression is completely attenuated where the monocline terminates
28 south of Chico. The lobes of Red Bluff pediment tend to be smaller southward as the monocline
29 loses elevation and the lobes of Red Bluff pediment are increasingly buried by more recent
30 alluvial deposits that ultimately cover them completely and lap against the Tuscan formation
31 south of Chico.

32 Butte County meadowfoam habitat on the strath terraces is confined to alluvial deposits on the
33 lowest terrace immediately above the channels of the current drainages, which are actively
34 cutting into the A and B units of the Tuscan formation. The strath terraces were cut by the
35 Feather River which lowered the base level of the entire area and significantly increased drainage
36 head cutting and erosion rates into the Tuscan Formation to the north and the Lovejoy basalt and
37 underlying Ione Formation of Table Mountain to the south. The alluvial material deposited on

¹ Calflora. http://www.calflora.org/cgi-bin/species_query.cgi?where-calrecnum=4833.

1 the terraces originated both from the Tuscan formation as well as the Lovejoy and Ione
2 formations of Table Mountain.

3 The two substantial occurrences of Butte County meadowfoam that are found at the toe of the
4 Tuscan formation occur where the slope and relief of that formation are indistinguishable from
5 that of the adjacent Red Bluff pediment. The soils in the soils complexes of those two areas of
6 the Tuscan formation as well as that of the strath terraces are the same as those mapped on the
7 Red Bluff pediment parent material (Division of Mines and Geology 1992, NRCS 2006).

8 As noted above, all of the current and historical larger Butte County meadowfoam occurrences
9 except two are found on Red Bluff pediment or strath terraces on 302-Redtough-Redswale-(plus
10 305-Anita on strath terraces) 0-2 percent slope soil complexes (or soils closely associated with
11 those complexes) that are underlain by a cobbly cemented hard pan. Of the two soil types, Butte
12 County meadowfoam habitat occurs on Redswale, cobbly loam which comprises 35 percent of
13 the complex and its relatively impermeable layer is at a typical depth of 7 inches (NRCS 2006).
14 The two exceptions are the Chico B population area and the eastern edge of the Chico C
15 population area on Tuscan formation are found on 614-Doemill-Jokerst complex 0-3 percent and
16 615-Doemill-Jokerst complex 3-8 percent soils. The Jokerst, cobbly loam (40 percent of the
17 extent of the complex) soil component of the complex is more important in supporting Butte
18 County meadowfoam habitat characteristics, as it has the appropriate mound and swale
19 microtopography and a typical bedrock contact depth of 4 inches, which restricts the percolation
20 of water and ensures soil saturation. Vernal pools are only present on 1 percent of the Jokerst
21 soil component in the complex, which frequently floods and ponds, while the Doemill soil
22 component neither floods nor ponds, does not possess vernal pools, and is a deeper soil with a
23 typical lithic contact depth of 10 inches.

24 The soil closely associated with the Redtough-Redswale soil complex that supports occurrences
25 of Butte County meadowfoam on the Red Bluff pediment is the 301-Wafap-Hamslough
26 complex, 0 to 2 percent slopes, which occurs in the abandoned channels of local drainages
27 running over the Red Bluff pediment from Pine Creek in the north to Butte Creek in the south.
28 Butte County meadowfoam habitat is likely restricted to the Hamslough clay soil component of
29 the complex, and the deposited clay material is the water-restrictive layer closest to the surface
30 overlying a cemented cobbly and gravelly alluvium that predates the clay material. In the strath
31 terrace area the soil closely associated with the Redtough-Redswale-Anita soil complex is the
32 321-durixeralfs-typic petraquepts complex, 0 to 2 percent slopes. This complex consists of
33 loams deposited on clays which overlie duripans on strath terraces. The clay material is the
34 water restrictive layer that is closest to the surface.

35 Butte County meadowfoam is restricted to areas with saturated soils during winter and early
36 spring that may occasionally pond or flood for short periods of time and which dry rapidly in
37 mid-spring. Because almost all of the Butte County meadowfoam occupied area is on soils with
38 a duripan, it appears that the same environmental conditions that established and maintain the
39 duripan are highly correlated with the habitat requirements of Butte County meadowfoam. On a

1 fine scale, Butte County meadowfoam predominately occurs in appropriate microtopographic
2 locations, swales, on the Redswale, cobbly loam soil. Similar but apparently less ideal
3 environmental conditions can occur on other soils.

4 Local hydrology that supports the saturated soils is determined by many factors that include
5 slope steepness; slope shape (concave, etc.), slope position (toe, tread, etc.); soil water holding
6 capacity (soil texture and soil profile thickness); continuity of and depth to restrictive layer;
7 microtopography (swale, etc.); and watershed extent. Butte County meadowfoam occurrences
8 are only found in areas where the slope steepness is 2 percent or less and the slope is convex.
9 Because their steepness is already 2 percent or less, slope position appears to not be critical on
10 the Red Bluff pediment and strath terraces but the two large populations on the Tuscan formation
11 are both on the relatively flat transitional areas from the slope of Tuscan formation to the tread of
12 the Red Bluff pediment at the bottom of the slope. Soil water holding capacity varies on the
13 Redtough-Redswale-(Anita) complexes with the depth of the soil above the duripan – mounds
14 are deeper and hold more water than swales (2.4 inches for mounds versus 0.7 inch for swales).
15 The Doemill-Jokerst complexes are similar (2.1 inches for mounds versus 0.4 inch for swales).
16 Butte County meadowfoam occurrences are almost always found in swales.

17 Watershed extent is the most difficult to establish of all of the factors that support local
18 hydrology. On the Red Bluff formation, large occurrences of Butte County meadowfoam are
19 found both on the rounded summits and on the gradually sloping sides of the lobes of the
20 formation in swales on the soils of the Redtough-Redswale-(Anita) complexes. Direct
21 precipitation, surface flow, and subsurface flow above the duripan maintain the saturated soils in
22 the swales. Even on the summits of the Red Bluff formation where surface and subsurface flows
23 are away from the summit, the extent of the watershed at lower positions may prolong the period
24 of saturation at the summit, because the water holding capacity of the soil tends to retard
25 subsurface flow.

26 Complex surface and subsurface flow patterns exist due to variability in percolation through the
27 duripan and bedrock or the diversion of surface water in streams and artificial channels. Because
28 of the complex patterns, it is impossible to identify areas where the duripan is not continuous or
29 to precisely predict the effects of local drainages except where they are in an uphill position in
30 close proximity to the Butte County meadowfoam occurrences. A similar situation occurs on the
31 other adjoining duripan soils. For the Doemill-Jokerst complex soils that support the two large
32 Butte County meadowfoam occurrences, the watershed extent necessary to support local
33 hydrology is similar to and controlled by similarly complex factors as for the Redtough-
34 Redswale complex. The hydrology of any potential Butte County meadowfoam habitat on the
35 Doemill-Jokerst complex soils that occurs at a distance that is significantly upslope of the Red
36 Bluff pediment will also be controlled by the characteristically regular alternating side drainages
37 on the Tuscan formation slopes that occur at approximately 1,000 to 2,000-foot intervals along
38 alternating sides of the slopes and that are marked by woody vegetation.

1 A.33.4 Life History

2 Butte County meadowfoam is a small, winter annual in the false mermaid family
3 (*Limnanthaceae*). It produces fragrant flowers beginning in February through May.

4 There is no life history information specifically on the Butte County meadowfoam, but various
5 other species in the genus *Limnanthes* have been studied and the following information includes
6 life history traits from both observations of Butte County meadowfoam as well as other species
7 in this genus (USFWS 2005). Seeds of Butte County meadowfoam germinate in the late fall
8 after the rainy season begins, with the earliest reported observation of seedlings from November.
9 Seed that does not germinate in the first year following production may still be viable. In
10 laboratory tests on the more common closely related woolly meadowfoam (*Limnanthes floccosa*
11 ssp. *floccosa*), two-thirds of the seed remained dormant even after exposure to favorable
12 conditions, and some ungerminated seed remained in soil samples after 3 years. Seed dormancy
13 would explain population fluctuations of up to two orders of magnitude between years in which
14 Butte County meadowfoam has been observed at some of its reported locations (USFWS 2005).
15 Seedlings can apparently tolerate short periods of submergence and develop into rosettes, which
16 do not begin producing flowering stems immediately. Butte County meadowfoam typically
17 begins flowering in February, reaches peak flowering in March, and may continue into April or
18 May if conditions are suitable. Nutlets are produced in March and April, and the plants die back
19 by early May. Nutlets of Butte County meadowfoam are apparently dispersed by water and can
20 remain afloat for up to 3 days. Most meadowfoam nutlets are dispersed only short distances.
21 Birds and livestock are potential sources of long-distance seed dispersal, but specific instances of
22 such dispersal have not been documented (USFWS 2005).

23 The particular pollinators of Butte County meadowfoam have not been identified, but other
24 meadowfoam species are pollinated by native burrowing bees, honeybees, beetles, flies, true
25 bugs (order Hemiptera), butterflies, and moths. Butte County meadowfoam has floral adaptations
26 that allow for cross-pollination by insects, but self-pollination mechanisms ensure seed set if insect
27 pollinators are scarce (semi-autogamous breeding system). These adaptations include stamens that
28 begin shedding pollen one day before the stigma is receptive, and during this period, flowers could
29 not self-pollinate. If pollen remains in the anthers when the stigma matures, gravity can carry it to
30 the stigma, which is situated below the anthers. The rate of self-pollination may vary among years or
31 among sites, depending on the size of insect populations.

32 Butte County meadowfoam is a habitat specialist on the hydrologic microhabitat and has a very
33 short lifespan that is closely correlated with the mean characteristics of the hydrologic habitat
34 (Arroyo 1973, Dole and Sun 1992). To offset the variability or the wetting and drying periods,
35 Butte County meadowfoam possess a phenotypically plastic flowering time which, combined
36 with its semi-autogamous breeding system, allows Butte County meadowfoam plants to
37 reproduce even within very short growing seasons (Dole and Sun 1992). Dole and Sun found
38 that each Butte County meadowfoam flower generally produces 3 seeds under ideal conditions
39 but that plants subjected to water stress produce few or no seeds (Dole and Sun 1992). With the

1 combined evolutionary strategies of a semi-autogamous breeding system, phenotypic plasticity
2 in life history traits, and a persistent soil seed bank, Butte County meadowfoam populations are
3 able to persist across even greater seasonal variations (Ritland and Jain 1984). Dole and Sun
4 (1992) concluded that due to a high rate of inbreeding within Butte County meadowfoam
5 populations, very limited dispersal among populations (Chico A-C population groupings) of
6 approximately 1 seed every 200 years, and a persistent seed bank, that Butte County
7 meadowfoam populations have been purged of deleterious alleles thus resulting in reduced levels
8 of inbreeding depression in comparison to outcrossing species. Dole and Sun identified three
9 centers of genetic diversity, north, northeast, and southeast, which correspond to the Chico A, B,
10 and C populations identified for the BRCP, respectively.

11 Dole and Sun also concluded that, because they used allozyme markers which are neutral or
12 nearly neutral genetic markers, the genetic variation among the Butte County meadowfoam
13 populations in their study is more likely attributable to genetic drift and not the action of natural
14 selection on adaptive traits (1992; see also McKay and Latta 2002, McKay et al. 2005, Rice and
15 Espeland 2007, Leinonen et al. 2008). A recent study (Sloop 2009, Sloop et al. 2011) using
16 microsatellite genetic markers, which are also neutral markers that are not correlated with
17 adaptive genetic variation (McKay and Latta 2002, Avise 2010, Frankham 2010, He and Lamont
18 2010, and Oubourg et al. 2010), found inconsistent evidence of genetic drift among the Butte
19 County meadowfoam populations depending on whether the populations were analyzed using
20 Nei's genetic distance or Wright's F_{st} statistics (Sloop 2009) (See Table A.33-1). It is important
21 to keep in mind that the genetic results reported in Sloop (2009) and Sloop et al. (2011) using
22 microsatellite markers do not correspond to adaptive genetic variation (McKay and Latta 2002,
23 Avise 2010, Frankham 2010, He and Lamont 2010, Oubourg et al. 2010).

24 Because Butte County meadowfoam grows in a very specific microhabitat that is broadly
25 distributed across each of the seven population locations and faces similar climatic variability
26 across those sites, and because each population has been isolated from each other over periods of
27 at least 200 hundred years as indicated by Dole and Sun (1992), the genetic variability upon
28 which selection can act is therefore likely contained within each population.

29 **A.33.5 Threats**

30 All remaining known populations of Butte County meadowfoam are threatened by urban
31 development, airport maintenance activities, road widening or realignment, conversion of
32 agricultural lands to other uses, and changes in grazing practices (57 FR 24192, CNPS 2006;
33 USFWS 2006). Loss of habitat has been identified as the primary threat to Butte County
34 meadowfoam. Although not identified as a primary threat to this species, several occurrences
35 have been identified as being threatened by overgrazing and trampling and others could be
36 threatened if grazing were increased in areas occupied by Butte County meadowfoam.
37 Insufficient grazing may also be a threat in areas where nonnative grasses can out-compete
38 species such as the Butte County meadowfoam (USFWS 2005).

1 Threats to vernal pool habitat and species in general, including Butte County meadowfoam, are
2 described in the Recovery Plan for Vernal Pool Ecosystems for California and Southern Oregon
3 (Recovery Plan), approved by the USFWS in December 2005 (USFWS 2005) and include the
4 following:

- 5 • Habitat loss and fragmentation generally resulting from urbanization, agricultural
6 conversion, mining, and also occurring as a result of habitat alteration and degradation
7 due to changes to natural hydrology, invasive species, incompatible grazing regimes
8 (including insufficient grazing for prolonged periods), infrastructure projects (such as
9 roads and utility projects), recreational activities (such as off-highway vehicles and
10 hiking), erosion, climatic and environmental change, and contamination.
- 11 • Competition from invasive species and native species. Native competitors include coyote
12 thistle (*Eryngium* spp.), alkali mallow (*Malvella leprosa*), lippia (*Phylanodiflora* sp.),
13 hard-stemmed tule (*Scirpus acutus* var. *occidentalis*), alkali bulrush (*Scirpus maritimus*),
14 and cocklebur (*Xanthium strumarium*). Nonnative competitors include bindweed
15 (*Convolvulus arvensis*) and swamp grass (*Crypsis schoenoides*). Increasing dominance
16 by competitors may also contribute to changes in hydrology and livestock grazing
17 practices. Competition from grasses and weedy species, including the non-native filaree
18 (*Erodium botrys*), was identified as a threat at some of the locations that support Butte
19 County meadowfoam (CNDDDB 2006). At the Doe Mill Preserve, competition from the
20 nonnative, invasive medusa head (*Taeniatherum caput-medusae*) had reduced
21 populations and seed set in Butte County meadowfoam (USFWS 2005).
- 22 • Changes in hydrology that result in a change in the timing, frequency, and duration of
23 inundation in vernal pools, creating conditions that render existing vernal pools
24 unsuitable for vernal pool species (USFWS 2005). The USFWS identified protection of
25 the watersheds that contributes runoff to meadowfoam habitat as a requirement to ensure
26 the continuation of the moisture regime of vernal pools, discourage competition by
27 aggressive upland species, and maintain Butte County meadowfoam occurrences
28 (USFWS 2006). Several occurrences are in areas proposed for development or road
29 improvements, which may not only directly remove individuals or habitat of Butte
30 County meadowfoam, but could also indirectly affect the species by altering the
31 hydrology of vernal pools in the vicinity (CNDDDB 2011).
- 32 • The decline of pollinator species due to habitat fragmentation and the loss of upland
33 habitat that supports pollinators. Although specific pollinators for the species have not
34 been identified, it is likely that the loss of habitat in area where this species occurs also
35 represents a loss of habitat for its pollinators; however, the extent of this and its effect on
36 the species can't be evaluated at this time (USFWS 2005).
- 37 • Several other threats to vernal pools and their associate species in general were identified
38 in the Recovery Plan. Water contamination can occur from use of herbicides, fertilizers,
39 and other chemicals commonly used in urban and agricultural settings. Fertilizers may
40 also contribute to the growth of invasive plants (USFWS 2005). Increased human

1 presence may lead to overuse, trampling (by walking or off-road vehicles), vandalism,
2 and dumping (USFWS 1997). Habitat alteration may also occur due to large-scale
3 climate and environmental changes, such as global warming, which lead to local changes
4 in the precipitation pattern and atmospheric conditions (USFWS 2005).

5 **A.33.6 Relevant Conservation Efforts**

6 Several areas have been set aside for the conservation of Butte County meadowfoam. These
7 areas include the DFG Stone Ridge Ecological Reserve (131 acres, 53 hectares [ha]), the 15-acre
8 (6-ha) Doe Mill Preserve, a conservation easement of about 35 acres (14 ha) on Humboldt Road,
9 a conservation easement of 38.5 acres (15.6 ha) associated with the Merriam Park development,
10 and a 7-acre (2.8-ha) conservation easement on the publicly owned Gillick-Evans Firing Range.
11 The City of Chico also has a conservation easement on 292 acres (118 ha) of habitat that appears
12 to be suitable for Butte County meadowfoam, although very few plants are present. The Dove
13 Ridge Conservation Bank, which contains over 200 acres of vernal pool habitat, is operated as
14 conservation bank for this and other vernal pool species. The Center for Natural Lands
15 Management holds a conservation easement and conducts management and monitoring of the
16 site. Other conservation efforts for Butte County meadowfoam have been accomplished through
17 mitigation programs. The Bruce-Stilson population was enhanced by spreading nutlets to
18 unoccupied areas within a proposed preserve.

19 **A.33.7 Species Habitat Suitability Model**

20 The habitat suitability model is based on vegetative cover, soil type, and slope conditions
21 described in this section.

22 **A.33.7.1 Habitat**

23 Butte County meadowfoam habitat includes areas with suitable soil type in the following land
24 cover types:

- 25 • Vernal pool;
- 26 • Altered vernal pool
- 27 • Grassland with vernal swale complex; and
- 28 • Grassland
- 29 • Blue oak savanna (secondary habitat only).

30 Suitable soil types are identified in the descriptions of primary habitat and secondary habitat,
31 below.

1 **A.33.7.2 Assumptions**

2 Butte County meadowfoam generally occurs on level to gently sloping terrain in very shallow,
3 infertile, and poorly drained soils over a water impermeable substrate that consists of bedrock,
4 hard pan, or claypan depending on the soil. It is found primarily in vernal swales and the
5 margins of vernal pools on alluvial terraces in annual grasslands with small mounds. Butte
6 County meadowfoam does not persist in vernal pools or swales that are inundated for prolonged
7 periods during the wet season or are wet during the dry season, nor does it persist in drainages
8 where water flows swiftly. Butte County meadowfoam often grows along the margins of vernal
9 pools rather than on the bottom; however, this pattern is reversed in swales, with the plants more
10 often growing along the bottom of the swale.

11 Butte County meadowfoam occurs almost exclusively on three geological formations (Division
12 of Mines and Geology 1992): 1) Red Bluff pediment (and inclusions of Tuscan formation); 2)
13 strath terraces; and 3) Lovejoy basalt in areas of grassland and blue oak savanna in swales,
14 vernal pools with flashy hydrology, along the upper margins of vernal pools with more persistent
15 hydrology, and as ephemeral occurrences in seasonal streams. Elevation ranges from 150 to
16 2,800 feet (50 to 930 meters) in elevation.

17 The following soil survey map units support soil series that are considered to be suitable soil
18 types for Butte County meadowfoam: Redtough-Redswale complex (302) with 0 to 2 percent
19 slopes and Redtough-Redswale-Anita complex (305) with 0 to 5 percent slopes. Redswale, a
20 cobbly loam underlain by a duripan generally at a depth of 7 inches, is found on the treads at the
21 base of slopes and has a swale microtopography. Redswale soil has a very low water holding
22 capacity of 0.7 inch of water due to its shallow depth, coarse texture, and large cobble content.
23 These characteristics create a unique hydrologic microhabitat of saturated, but not ponded, soils
24 during the wet season that dry rapidly during the dry season.

25 Given these habitat preferences, suitable habitat for the Butte County meadowfoam was modeled
26 as primary habitat and secondary habitat within the Plan Area.

27 **Primary Habitat**

28 Primary habitat is defined as lands with large patches of soil types and hydrologic conditions that
29 are known to support occurrences of Butte County meadowfoam with large numbers of plants
30 often in dense stands and thus represent lands that have the greatest potential for supporting high
31 functioning Butte County meadowfoam habitat.

32 Primary habitat is defined as the extent of the following NRCS soil map units (SSURGO GIS
33 soil data) where they intersect with vernal pool, altered vernal pool, grassland with vernal swale
34 complexes, grassland, and blue oak savanna land cover types in the BRCP GIS vegetation layer:

- 35 • 302 and 305-Redtough-Redswale-(plus Anita on strath terraces) 0 to 2 percent slope
36 soils;

- 1 • 301-Wafap-Hamslough complex, 0 to 2 percent slopes;
- 2 • 321-durixeralfs-typic petraquepts complex, 0 to 2 percent slopes;
- 3 • 614-Doemill-Jokerst complex 0 to 3 percent slopes soil polygons adjoining 302-
4 Redtough-Redswale 0 to 2 percent slopes complex soils, including 1,000-foot buffers into
5 any adjoining 615-Doemill-Jokerst complex 3 to 8 percent slopes²;
- 6 • 341-Elsey-Beatsonhollow-Campbellhills-rock outcrop complex, 2 to 5 percent slopes
7 where those complexes occur flat areas on top of North Table Mountain and not on the
8 weathered and rounded tops of features elsewhere; and
- 9 • 340-rock outcrop-thermalrocks Campbellhills complex, 2 to 15 percent slopes where
10 those complexes occur on flat areas on top of North Table Mountain and not on the
11 weathered and rounded tops of features elsewhere.

12 Modeled primary habitat is shown in Figure A.33-2.

13 *Secondary Habitat*

14 Secondary habitat is defined as lands with soil types and hydrologic conditions that may support
15 localized inclusions of Butte County meadowfoam habitat, but that are unlikely to support
16 occurrences of Butte County meadowfoam with large numbers of plants. Secondary habitat was
17 defined as all 614-Doemill-Jokerst complex 0 to 3 percent slopes and 615-Doemill-Jokerst
18 complex 3 to 8 percent slopes soils that were not included in the modeled primary habitat with
19 land cover consisting of vernal pool, altered vernal pool, grassland with vernal swale complexes,
20 grassland, and blue oak savanna. Modeled secondary habitat is shown in Figure A.33-1.

21 Generally, secondary habitat extends from the edge of primary habitat in both continuous and
22 discontinuous patches upslope on the Tuscan formation. The hydrology of the secondary habitat
23 is much more complex and variable than that of primary habitat and it provides habitat for Butte
24 County meadowfoam only in very localized flats or depressions (estimated at less than 1 percent
25 of the area of the Doemill-Jokerst complexes) that become increasingly rare with distance from
26 primary habitat.

27 **A.33.8 Recovery Plan Goals**

28 Recovery Plan HCP goals for the Butte County meadowfoam include reducing threats to the
29 species to ensure the species continues to survive throughout its range in perpetuity.

² The 1,000-foot buffer distance was determined by using Google Earth imagery (2010) and the Google Earth distance measurement tool to determine the maximum distance of the slope change from 2 percent to 3 percent using the mapped soil polygons, digital elevation models, and topographic maps and was verified during a site visit. The digital elevation models and topographic maps were not at a fine enough resolution to map the extent of the transition area and the 1,000-foot buffer was used as an alternative to capture the slope break and the corresponding change in hydrological conditions.

1 USFWS (2005) recovery criteria for species, including Butte County meadowfoam, in areas with a
2 HCP are as follows:

- 3 • Permanent protection of vernal pool preserves within the area covered by the Habitat
4 Conservation Plan (HCP) in large contiguous blocks of suitable habitat;
- 5 • Protection of the entire genetic range of each listed species within the area covered by the
6 HCP;
- 7 • Protection of all populations of species with 25 or fewer total occurrences addressed in
8 this plan within the area covered by the HCP;
- 9 • Connectivity with other preserves within the area covered by the HCP;
- 10 • Adaptive management of the preserves within the area covered by the HCP; and
- 11 • Sufficient funding for management, maintenance, and monitoring of the preserves in
12 perpetuity.

1

Table A.33-1. Butte County Meadowfoam (*Limnanthes floccosa* Ssp. *Californica*) Population Information [pending further survey information from USFWS]

#	Population Grouping	FWS Occurrence Name	Others Name(s) Used	Site Potential (Maximum # Plants Recorded)(Year of Survey)	Site Low (Minimum # Plants Recorded)(Year of Survey)	# Plants Recorded (Sloop, 2008)	Occurrence Extent (acres) (11)	Genetic Unit (from Sloop 2009) (20)	Genetic Unit (from Dole and Sun 1992) (9)	Reproductive Output (from Dole and Sun 1992) (10)
Primary Population Information										
1	Chico A	Airport North	CNDDDB 37	7,819 (1) (1988)	7,819 (1) (1988)	105	3.2	1 or 1	B (north)	7.7
2	Chico A	Airport West	None	1,011(2) (1988)	1000 (1) (1988)	47	11.0	1 or 2	A (north)	4.1
3	Chico A	Airport South	CNDDDB 36	7,153(2) (1988)	1520 (1) (1988)	117	2.6	2 or 6 and 3 or 4	B (north)	6.9
4	Chico A	Cohasset	CNDDDB 3, Stone Ridge ER, Airport Northeast	80,000(2) (1988)	40,000 (2) (1988)	~1,000	130.7	3 or 4	Not applicable	7.8
5	Chico A	Diesel	CNDDDB 39	<100(2) (1988)	<100(2) (1988)		0.4	Not applicable	Not applicable	Not applicable
6	Chico B	Rancho Arroyo	West Rancho Arroyo, Bidwell Ranch	161,838(4) (2006)	1757 (1) (1988)	~5,000	37.5	1 or 2	A (northeast)	5.2
7	Chico C	Stilson Canyon	Bruce-Stilson Canyon, CNDDDB 7	22,980(1) (1988)	22,980(1) (1988)	~500	21.7	3 or 4	E (southeast)	11.2
8	Chico C	Stilson Canyon, Church Property, Chico Crossing, Creekside	Meriam Park BCM Preserve, Bruce and Hwy 32, Church, CNDDDB 7	9,000(3) (1991)	7,780 (1) (1988)	~1,660	18.4	3 or 4	D (southeast)	12.8
9	Chico C	North Enloe	Meriam Park Project and Meriam Park BCM Preserve, CNDDDB 7	45,689(1) (1988)	45,689(1) (1988)	~1,065	15.6(13)	3 or 4	E (southeast)	12.8
10	Chico C	Doe Mill Preserve	Doe Mill Preserve, Stonegate, CNDDDB 20	15,454(3) (1991)	8463 (2) (1988)	~8,177	15.3	1 or 2	E (southeast)	10.3
11	Chico C	Schmidbauer, Schmidbauer Southeast, CNDDDB 43	Schmidbauer East, Doe Mill, CNDDDB 43	295(3) (1991)	295(3) (1991)	~1,365	0.6	1 or 2	Not applicable	
12	Chico C	Schmidbauer West	Canyon View High School	6,916(3) (1991)	354(1, 2) (1988)	~452	2.2	1 or 2	Not applicable	11.5
13	Rock Creek	Rock Creek CNDDDB 13	Nord Population, Unnamed Rock Creek Population	109(5) (1999)	109(5) (1999)	Not applicable	1.0	Not applicable	Not applicable	Not applicable
14	Rock Creek	Rock Creek CNDDDB 41	Upper Rock Creek, Tomasson Ranch	391(5) (1999)	391(5) (1999)	Not applicable	1.0	Not applicable	Not applicable	Not applicable
15	Chico C	Schmidbauer	Bruce and Skyway	193(6) (2002)	193(6) (2002)	Not applicable	2.3	1 or 2	Not applicable	Not applicable
16	Gold Run Creek	Dove Ridge	CNDDDB 48	3000 ⁽¹⁸⁾ (2008)	3000 ⁽¹⁸⁾ (2009)	~3000	7.2	5 or 7	Not applicable	Not applicable
17	Gold Run Creek	HWY 149 North	CNDDDB 1, Hwy 99 and Western Canal	17,575(8) (1992)	17,575(9) (1992)	~802	5.7	9 or 5	Not applicable	Not applicable
18	Not Applicable	CNDDDB 31	Shippee Road, North of Thermalito; Southern-most known population	Not available	200(6) (1999)	Not applicable	13.9	Not applicable	Not applicable	Not applicable
19	Table Mountain	Table Mountain	CNDDDB 42, Table Mtn Population	Not available	57 (2005)	~210	5.0	4 or 3	Not applicable	Not applicable
20	Rock Creek	Rock Creek Section 21	Thomasson Ranch, Loafer Creek	Not available	56 (14) (2010)	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Total				379,780	159,744	~33,702	295.3			

1

2

Table A.33-1. Butte County Meadowfoam (*Limnanthes floccosa* Ssp. *Californica*) Population Information [pending further survey information from USFWS] (continued)

#	Population Grouping	FWS Occurrence Name	Others Name(s) Used	Site Potential (Maximum # Plants Recorded)(Year of Survey)	Site Low (Minimum # Plants Recorded)(Year of Survey)	# Plants Recorded (Sloop, 2008)	Occurrence Extent (acres) (11)	Genetic Unit (from Sloop 2009) (20)	Genetic Unit (from Dole and Sun 1992) (9)	Reproductive Output (from Dole and Sun 1992) (10)
Other Population Information										
21	Rock Creek	Wurlitzer	Wurlitzer	20,000	1500	6078	56	9 or 6	Not applicable	Not applicable
22(16)	Chico C	None	Farm Credit (east of Chico Diversion Channel) Bruce Road- Warfield Lane	Not available	150 (2002)	Not applicable	Not available	Not applicable	Not applicable	Not applicable
23(17)	Gold Run Creek	HWY 149 South, Dove Ridge (N, W, SW, SE, E)	CNDDDB 1, Dove Ridge (N, W, SW, SE) Mitigation Bank, HWY 149 South Population	"many small populations over the years" (7)	Not applicable	~4,124	977 (10)	4 or 6	Not applicable	Not applicable
24(18)	Gold Run Creek	CNDDDB 5	Shippee Road	Not applicable	159 (2008)	Not applicable	Not applicable	9 or 5	Not applicable	Not applicable
25(19)	Gold Run Creek	None	CNDDDB 6, Type Population, 229A	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

(1) Published in Dole and Sun (1992). Survey conducted on March 23 and April 3, 1988.

(2) Published in Jokerst (1989). Surveys conducted by Dole, Meyer, Stern, and Jokerst predominantly in 1988.

(3) Published in Kelley and Associates (1991). Survey conducted in March-May, 1991.

(4) Published in Gallaway (2006), Bidwell Ranch Butte County Meadowfoam Survey. Survey conducted on April 5- 6, 2006.

(5) 400 plants are known from Occurrence #13 and # 41 (CNDDDB 2008). The relative number of plants in each occurrence was assigned based on the relative areas of the occurrences according to the CNDDDB.

(6) Published in CNDDDB 2008.

(7) CNDDDB 2008. Number of plants is not specified.

(8) Published in Caltrans (October 27, 2004) "Habitat Mitigation and Monitoring Plan Butte 70/149/99/191 Highway Improvement Project". Survey conducted in 1992.

(9) Based on genetic distances amongst occurrences, three centers of genetic diversity (north, northeast, and southeast) and five smaller genetic units were found. See Dole and Sun 1992 for details.

(10) Acreage of CNDDDB Occurrence # 1 (Dove Ridge) was not included in the analysis because of its lack of specificity regarding acreage and population numbers.

(11) Extent of occurrence for each of these records is an approximate estimate based on best available data (i.e., often surveys conducted in different years and with different methodologies).

(12) From Jokerst (1989). Reproductive output is based on estimates of the average number of nutlets per 5 flowers. Data used as an indicator of site quality and population viability.

(14) Based on information provided by Restoration Resources and Gallaway, 2009.

(15) Created population for mitigation bank to offset loss resulting from the Farm Credit development.

(16) Extirpated by Farm Credit development project in 2006.

(17) Not used as a primary data source because information is not specific information.

(18) Published in CNDDDB 2011.

(19) Not used as a primary data source because the occurrence is presumed extirpated.

(20) First value or set of values is based on Nei's genetic distance at the third SAHN cluster level and the second value or set of values is based on Wright's Fst at the sixth SAHN cluster level. Cluster level was selected for equal population group numbers - nine.

3

4

1 A.33.9 References

2 Literature Cited

- 3 Arroyo, M. T. K. 1973. Chiasma frequency evidence on the evolution of autogamy in
4 *Limnanthes floccose* (Limnanthaceae). *Evolution* 27:679-688.
- 5 Avise, J. C. 2010. Perspective: conservation genetics enters the genomics era. *Conservation*
6 *Genetics* 11:665-669.
- 7 Calflora: Information on California plants for education, research and conservation. [web
8 application]. 2007. Berkeley, California: The Calflora Database (a non-profit
9 organization). Accessed May 1, 2007 from <http://www.calflora.org/>.
- 10 Caltrans (California State Department of Transportation). 2003. Butte 70/149/99/191 Highway
11 Improvement Project. California State Department of Transportation. Sacramento, CA.
- 12 CNPS (California Native Plant Society). 2006. Inventory of Rare and Endangered Plants (online
13 edition, v7-06d). Sacramento. Accessed December 4, 2006 from
14 <http://www.cnps.org/inventory>.
- 15 DFG (California Department of Fish and Game). 2011a. Special Vascular Plants, Bryophytes, and
16 Lichens List, Natural Diversity Database. Accessed May 22, 2011 from
17 <http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/SPPlants.pdf>.
- 18 DFG (California Department of Fish and Game). 2011b. RareFind California Department of Fish
19 and Game Natural Diversity Database ver. 3.1.0, April 30, 2011 data.
- 20 Division of Mines and Geology. 1992. Geologic Map of the Chico Quadrangle, California,
21 1:250,000. California State Division of Mines and Geology: Map number 7A, Sheet 1 of
22 5. Compiled by G.J. Saucedo and D.L. Wagner, 1992.
- 23 Dole, J. A. 1988. Results of a field survey for the Butte County Meadowfoam in the vicinity of
24 the City of Chico, California. Conservation. City of Chico, May 27, 1988.
- 25 Dole, J. A. and M. Sun. 1992. Field and genetic survey of the endangered Butte County
26 meadowfoam – *Limnanthes floccosa* subsp. *californica* (Limnanthaceae). *Conservation*
27 *Biology* 6:549-558.
- 28 Frankham, R. 2010. Where are we in conservation genetics and where do we need to go?
29 *Conservation Genetics* 11:661-663.
- 30 Gallaway Consulting. 2006a. Draft biological assessment for the proposed Merian Park
31 development. Prepared for Urban Builders. November 2006.

- 1 Gallaway Consulting. 2006b. Bidwell Ranch Butte County Meadowfoam survey. Letter report to
2 the City of Chico, Clif Sellers, from Shirley M. Innecken, Senior Botanist. May 16, 2006.
- 3 He, T. and B. B. Lamont. 2010. High microsatellite genetic diversity fails to predict greater
4 population resistance to extreme drought. *Conservation Genetics* 11:1445-1451.
- 5 Helley, E. J. and D. S. Harwood. 1985. Geologic map of the late Cenozoic deposits of the
6 Sacramento Valley and northern Sierran foothills. USGS MF-1790
- 7 Jokerst, J.D. 1989. Plan for the conservation of Butte County Meadowfoam in the City of Chico.
8 Unpublished report to the City of Chico, October, 17, 1989. 128 pages.
- 9 Jones and Stokes. 2001. Draft environmental impact report for Canyon View High School. Chico
10 Unified School District, Chico, California.
- 11 Keeler-Wolf, T., D. R. Elam, K. Lewis, and S. A. Flint. 1998. California vernal pool assessment
12 preliminary report. California Department of Fish and Game, Sacramento.
- 13 Kelly and Associates. 1991. Biological report on Butte County Meadowfoam (*Limnanthes*
14 *floccose* ssp. *Californica*). Farm Credit Project Bruce and Warfield Roads, Chico, Butte
15 County, California.
- 16 Leinonen, T., R. B. O'Hara, J. M. Cano, and J. Merila. 2008 Comparative studies of quantitative
17 trait and neutral marker divergence: a meta-analysis. *Journal of Evolutionary Biology*
18 doi:10.1111/j.1420.
- 19 McKay, J. K. and R. G. Latta. 2002. Adaptive population divergence: markers, QTL, and traits.
20 *Trends in Ecology and Evolution* 17:285-291.
- 21 McKay, J. K., C. E. Christian, S. Harrison, and K. J. Rice. 2005. How local is local? A review of
22 practical and conceptual issues in the genetics of restoration. *Restoration Ecology*
23 13:432-440.
- 24 Minnich, R. A. 2007. Climate, Paleoclimate, and Paleovegetation. In *Terrestrial Vegetation of*
25 *California*, 3rd ed., edited by M. G. Barbour, T. Keeler-Wolf, and A. A. Schoenherr.
26 Berkeley: University of California Press.
- 27 NRCS (Natural Resources Conservation Service). 2006. Soil survey of Butte Area, parts of Butte
28 and Plumas Counties.
29 http://soildatamart.nrcs.usda.gov/Manuscripts/CA612/0/Butte_CA.pdf.
- 30 O'Geen, A. T., W. A. Hobson, R. A. Dahlgren, and D. B. Kelley. 2008. Evaluation of soil
31 properties and hydric soil indicators for vernal pool catanas in California. *Soil Science*
32 *Society of America Journal* 72:727-740.

- 1 Oubourg, N. J., F. Angeloni, and P. Vergeer. 2010. An essay on the necessity and feasibility of
2 conservation genomics. *Conservation Genetics* 11:643-653.
- 3 Restoration Resources. 2010. Thomasson Ranch survey. Unpublished survey map.
- 4 Rice, K. J. and E. K. Espeland. 2007. Genes on the range. In *Ecology and Management of*
5 *California Grasslands*, edited by M. R. Stromberg, J. Corbin, and C. D'Antonio.
6 Berkeley: University of California Press.
- 7 Ritland, K. and S. Jain. 1984. The comparative live histories of two annual *Limnanthes* species in
8 a temporally variable environment. *American Naturalist* 124:656-679.
- 9 Sloop, C. 2009. Application of molecular techniques to examine the genetic structure of
10 populations of Butte County meadowfoam (*Limnanthes floccose* ssp. *californica*). Final
11 Report to U.S. Fish and Wildlife Service. Sacramento, CA. February 16, 2009.
- 12 Sloop, C., C. Pickens, and S. P. Gordon. 2011. Conservation genetics of Butte County
13 meadowfoam (*Limnanthes floccose* ssp. *californica* Arroyo), and endangered vernal pool
- 14 USACE (U.S. Army Corp of Engineers). 1999. Rock Creek – Keefer Slough Flood Control
15 Project: A field botanical survey of Rock Creek, Keefer Slough, and Sand Creek, along
16 with their tributaries, between Highway 32 and the northern boundary of the Thomassen
17 ranch, extending to one half mile above the confluence of the Anderson branch of Rock
18 Creek. California.
- 19
- 20 USFWS (U.S. Fish and Wildlife Service). 2005. Recovery Plan for Vernal Pool Ecosystems of
21 California and Southern Oregon. Portland, OR.
- 22 USFWS (U.S. Fish and Wildlife Service). 2006. Sacramento Fish and Wildlife Office. Species
23 Account: Butte County meadowfoam (*Limnanthes floccosa* ssp. *californica*).
24 http://www.fws.gov/sacramento/es/plant_spp_accts/butte_county_meadowfoam.htm.
- 25 USFWS (U.S. Fish and Wildlife Service). 2008. *Limnanthes floccose* ssp. *californica* (Butte
26 County Meadowfoam) 5-Year Review; Summary and Evaluation. Sacramento, CA
27 office. June.
- 28 Waples, R. S., and O. Gaggiotti. 2006. What is a population? An empirical evaluation of some
29 genetic methods for identifying the number of gene pools and their degree of
30 connectivity. *Molecular Ecology* 15:1419-1439.

31 Federal Register

- 32 57 FR 24192. 1992. Endangered and threatened wildlife and plants; Determination of
33 Endangered Status for the Plant *Limnanthes floccosa* ssp. *californica* (Butte County
34 meadowfoam). *Federal Register* 57:24192.

1 71 FR 7118. 2006. Endangered and Threatened Wildlife and Plants: Designation of Critical
2 Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants; Final Rule.
3 Federal Register 71:7118.

4

DRAFT