Botanical Survey Report for the Casa Diablo IV Power Plant Site

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Introduction

Botanical survey work was performed at the potential site of a proposed geothermal power generation facility in the Casa Diablo fumaroles area near Mammoth Lakes, in Mono County, California. The Casa Diablo IV geothermal power plant and its requisite pipelines, roads and injection well pads would be constructed on privately owned land adjacent to existing power plants and production wells (Figure 1). The purpose of the 2008 botanical survey was to describe the vegetation that would be affected and to determine whether rare plant species are present.

The new power plant would be located within a landscape that is moderately to highly disturbed by historical development and by naturally occurring geothermal activity. Botanical resources were documented within a 35.5 acre area in 2008, hereafter referred to as the "study area", amid an extensive field of fumaroles. Although the study area is mostly undeveloped, the vegetation reflects an unusually dynamic history of serial dieback and recovery responses to localized variations in soil heating associated with fumaroles.

The average elevation surveyed was 7300 ft (2230 m). The terrain is low, rolling hills and flats below steep slopes that rise to the north and east. The climate at this elevation on the eastern side of the central Sierra Nevada Range is montane, with more than 50% of annual precipitation falling as snow (Mono County Planning Department, 2001). The frost-free growing season for areas that are not influenced by fumaroles is about 120 days (NRCS, 1996). Summer months are characterized by low humidity and moderate daytime temperatures. However, the xeric summer is irregularly interrupted by heavy rains from thunderstorms. The average summer temperature is 70^{o} F, and average winter temperature is 30^{o} F. Constant heat is radiated near active fumaroles, providing a warmer microclimate in some areas during winter months. Hot soils also limit the distribution of plants in the areas nearest active fumaroles.

Literature Search

The rare plant species *Astragalus monoensis* (Mono milkvetch), *Botrychium crenulatum* (scalloped moonwort), *Epilobium howellii* (subalpine fireweed), *Fritillaria pinetorum* (pine fritillary), *Lupinus duranii* (Mono Lake lupine), and *Potamogeton robbinsii* (Robbins pondweed) appear to have some potential to occur within the study area, based upon a review of available regional data (Mono County Planning Department, 2001, Halford and Fatooh, 1994, CalFlora, 2008, California Department of Fish and Game, 2008a, 2008b), published regional floras (Hickman, 1993, Jepson Herbarium, 2008), and a review of botanical surveys that have been performed in the preparation of environmental documents for nearby projects (Taylor, 1987, Paulus 2001a, 2001b, 2002a, 2002b, 2002c, 2003, 2004a, 2004b). All six species are herbaceous perennials whose expected phenologies at the time of the survey would be blooming or setting fruit (Table 1).

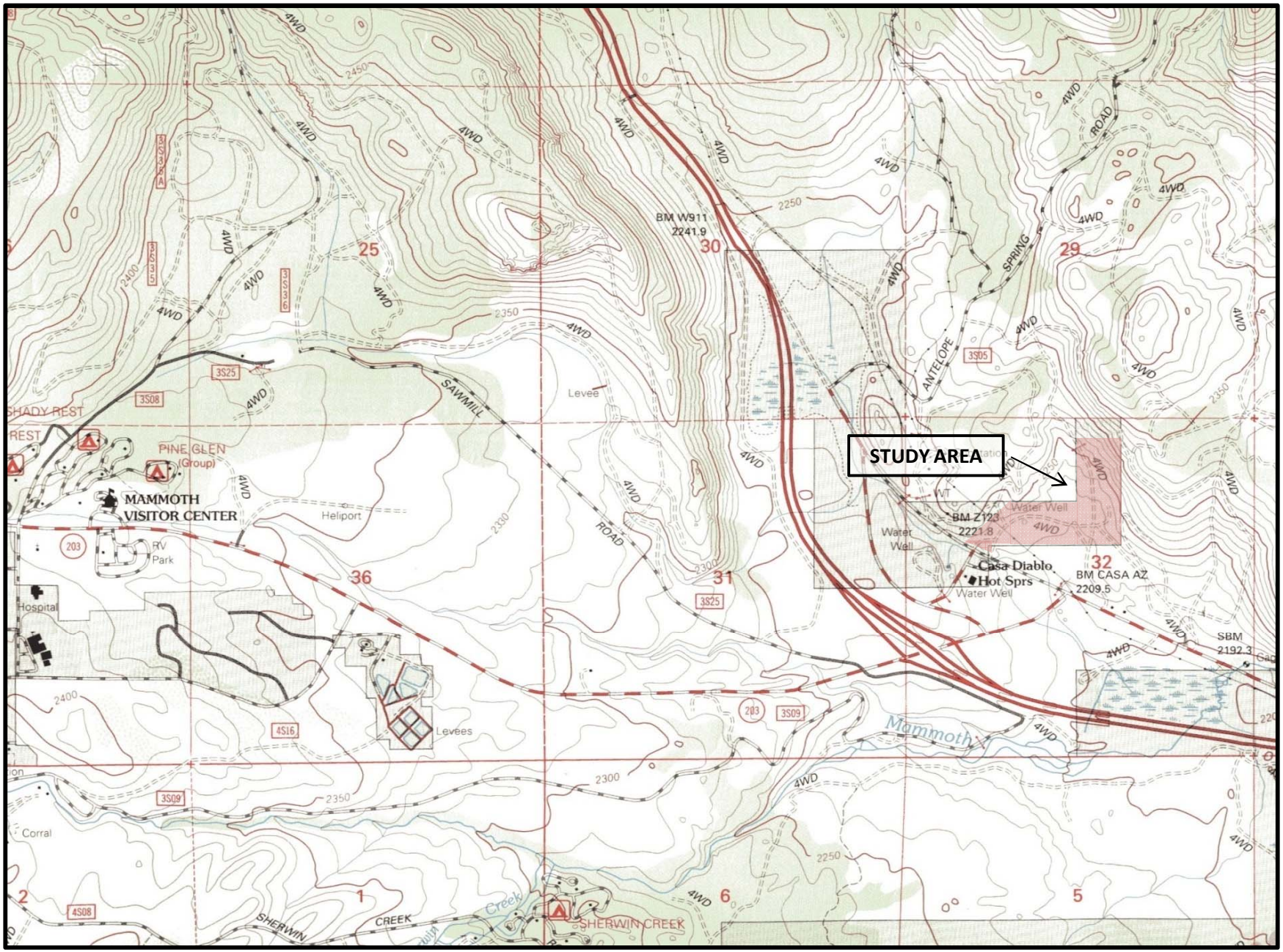

Figure 1. Location of the Casa Diablo IV Power Plant study area on privately owned land near Mammoth Lakes, California.

Table 1. Rare plant species that potentially could occur within privately owned lands where construction of the Casa Diablo IV power plant project has been proposed. Flowering period data is from CNPS (2001). A key to the rank or status symbols follows the table. NL = not listed.

Scientific Name Common Name Life Form	Rank or Status[1]					Habitat	Flowering Period
	USFWS	CDFG	USFS	CNPS	NDDB		
Astragalus monoensis[2] Mono milkvetch herbaceous perennial	NL	R	S	1B	S2.2	open pumice soils	June-August
Botrychium crenulatum scalloped moonwort herbaceous perennial	NL	NL	S	2.2	S2.2	open forest, meadow	Fertile June-July
Epilobium howellii subalpine fireweed herbaceous perennial	NL	NL	S	1B.3	S2.3	meadows and wet margins	July-August
Fritillaria pinetorum pine fritillary herbaceous perennial	NL	NL	NL	4.3	S3.3	scrub, forest slopes	May-July
Lupinus duranii Mono Lake lupine herbaceous perennial	NL	NL	S	1B.2	S2.2	open scrub, pumice	May-July
Potamogeton robbinsii Robbins pondweed herbaceous perennial	NL	NL	NL	2.3	S2.3?	deep water, lakes	July-August

1. Rank or status, by agency:
   USFWS = US Fish and Wildlife Service status under the Endangered Species Act (CDFG, 2008c)
   CDFG = California Department of Fish and Game listings under the Native Plant Protection Act and the California Endangered Species Act (CDFG, 2008c).
   R = Rare
   USFS = US Forest Service, Inyo National Forest, Bishop Office (2006a, 2006b)
   S = Sensitive List, October 2006
   CNPS = California Native Plant Society listings (CNPS, 2001, 2008)
   1B = rare and endangered in California and elsewhere
   2 = rare, threatened or endangered in California, but more common elsewhere
   4 = plants of limited distribution in California – watchlist species
   Threat Code extensions:
   .1 is Seriously endangered in California (over 80% of occurrences threatened / high degree and immediacy of threat)
   .2 is Fairly endangered in California (20-80% of occurrences threatened)
   .3 is Not very endangered in California (< 20% of occ's threatened or no current threats known.
   NDDB = California Natural Diversity Data Base rankings by the CDFG (CDFG, 2008b)
   S2 is 6-20 occurrences or 1000-3000 individuals or 2000-10000 acres
   S3 is 21-100 occurrences or 3000-10000 individuals or 10000-50000 acres
   "threat numbers" follow decimal:
   .1 = very threatened, .2 = threatened, .3 = no threat currently known,
   ? indicates CNDDB uncertainty in status.

2. Syn. *Astragalus monoensis* var. *monoensis*

A search of CNDDB occurrences within the USGS Old Mammoth, Whitmore Hot Springs, Convict Lake, Bloody Mountain, Crystal Crag, Mammoth Mountain, June Lake, Crestview, and Dexter Canyon quadrangles was performed in June 2008. Search results indicate that four rare plant species (eight populations of *Astragalus monoensis*, three populations of *Epilobium howellii*, nine populations of *Lupinus duranii*, and one population of *Potamogeton robbinsii*) and one sensitive plant community (Mono Pumice Flats) occur within ten miles and in mid-elevation forest or scrub habitats that may bear some resemblance to habitats available within the study area. No previously documented occurrences of rare plant species within the study area were found in CNDDB records (CDFG, 2008d). This information, however, must be interpreted in the general context that the absence of CNDDB records concerning the study area does not signify that rare plants are absent, rather that none have been reported.

The milkvetch *Astragalus monoensis* has been state listed as "Rare" since 1982, and is known from only 20 occurrences in the state of California. Both *A. monoensis* and *Lupinus duranii* occur in Mono County in relatively open habitat, either within the sensitive Mono Pumice Flat community (CDFG, 2008d) or in relatively open pumice soil amid vegetation classified as Great Basin Mixed Scrub (Bagley, 1995). Records of *L. duranii* occurrences on forested slopes near Mammoth (well outside the more typical Mono Pumice Flat habitat) are likely mis-identifications of the more common Gray's lupine (*L. grayii*) that occurs widely in the Mammoth Basin (personal observation). The nearest occurrence of Mono Lake lupine that has been confirmed by Inyo National Forest personnel is at Smokey Bear Flat (K. Nelson, personal communication), which is 2.5 miles to the north of the study area. The Smokey Bear Flat occurrence of the Mono Pumice Flats community supports populations of *L. duranii* and *A. monoensis* in an internally drained, treeless area of level terrain and coarse pumice soils, amid very sparse shrubs.

Pine fritillary (*Fritillaria pinetorum*) is not documented by CDFG (2008d) as occurring within the Mammoth Basin, despite historical and recent reports. Voucher specimens have been collected in scrub and forest vegetation "one mile north of Old Mammoth" by C.W. Sharsmith in 1965 (CalFlora, 2008) and at Valentine Reserve (Orr, 1981). It has been found within one half mile of the project area in the shade of Jeffrey pine canopies in relatively undisturbed forest (Paulus, 2002c). Its distribution in the Sierra Nevada is fairly broad, but it typically occurs only in sparse populations. While this species is uncommon both locally and state-wide, it is not thought to be seriously threatened, and thus likely does not meet the definitions of Sec. 1901, Chapter 10 of the Native Plant Protection Act, or the definitions of Secs. 2062 and 2067 of the California Endangered Species Act.

The remaining potentially occurring rare species require habitats with significantly increased soil moisture, at least seasonally, such as found near lakes and streams, or in wetland meadows. The diminutive plant *Botrychium crenulatum* typically occurs in forest habitat at shaded seepzone margins. It is distinctive among forest vegetation due to its frond-like leaves and sporangia. *B. crenulatum* is widely distributed in California, but always occurs in low abundance. Although not documented to occur within ten miles of the project area by CDFG (2008d), it was included in the rare plant search list due to the general paucity of information available for this species' distribution, and with regard to populations that have been found recently in the nearby Convict Basin (D. Taylor, pers. comm.). The nearest known population of the perennial herb *Epilobium howellii* is in the Mammoth Basin at Twin Lakes, 7 miles west at an elevation of 8600 ft (2620 m). It occurs there in mossy, lakeside meadow habitat. Pondweeds

(*Potamogeton* spp.) require still water pond, stable lakeshore, or lake outflow habitat for rooting. The nearest known population of *P. robbinsii* occurs at Satcher Lake, west of Mammoth Pass and about 10 miles distant.

Two other "rare" species, *Plagiobothrys glomerata* and *Sedum pinetorum*, were once believed to have occurred in the local environment in relatively dry forest or scrub habitats, as cited by Paulus (2003) and others. However, both species were deleted from consideration during this review due to their being removed from the flora of California in the most recent consensus (Jepson Herbarium, 2008).

During field surveys, occurring plant species were considered to be "rare" if they have current state or federal status as rare, threatened or endangered (CDFG, 2008c), are listed in the California Natural Diversity Database list of special plants (CDFG, 2008a, 2008b), are listed by the California Native Plant Society (CNPS) in their inventory of sensitive California plants (CNPS, 2001, 2008), or are included in the most recent sensitive plant or watch lists prepared by Inyo National Forest (U.S. Forest Service, 2006a, 2006b).

Field Surveys

Field surveys were performed during the month of June 2008. June is within the normal anthesis periods (Table 1) for those potentially occurring rare plants that are adapted to an upland setting. Community descriptions were developed during site visits on June 6-8 by recording plant species frequencies for each stratum, community cover for each stratum, and overall community height. The site's plant communities were mapped, and were classified (Table 2) using the CDFG (2003) naming system, with classification numbers cross-referenced to 1) the system proposed by Holland (1986), and 2) the Sawyer and Keeler-Wolf (1995) system that is currently being adopted by CDFG (2007). Attention was given to identifying vegetation assemblages that include a significant presence by species adapted to wetland habitats, using wetland status data provided by Reed (1988), because mesic habitat types are required by several of the potentially occurring rare plant species. Thorough searches for rare plants were conducted on June 11-16, 2008. Parallel transects across the 35.5 acre study area were searched by walking slowly and wandering side-to-side to view areas around and under shrub canopies. Transects were centered every 50 feet. All plant species encountered were identified. Any species that were not at once recognized were keyed by the consulting botanist using The Jepson Manual (Hickman, 1993) or the Intermountain Flora (Cronquist, *et al.*, 1984). Plants were identified to the level of taxa sufficient to determine rare species presence or absence. J. Paulus of Oakhurst, California, performed survey work totaling 15 person hours.

Nearby known populations of Mono milkvetch and Mono Lake lupine at Smokey Bear Flat were visited on June 11 in order to form a clear search pattern for recognizing these species if they should occur in the study area, and to verify that important flower and fruit characters would be available at the time of survey work. Populations of Mono milkvetch and Mono Lake lupine at Smokey Bear Flat were flowering when they were visited on June 11, and both species exhibited leaves and immature fruit.

Plant communities and species

Human activities and naturally occurring changes in geothermal venting have disturbed, altered, and in small areas removed the plant communities of the study area. Vegetation shaped by and adapted to disturbance constitutes nearly all of the area surveyed in 2008. Seral recovery in these areas ranges widely, from early colonization with pioneer herbs, to recovery to relatively stable native shrublands. Forest and scrub plants that were removed by mechanical disturbances in past years such as roadbuilding have been replaced mainly by introduced grasses and herbs. Areas mapped as mechanically disturbed (Figure 2) include patches of vegetation that may be classified as Introduced Perennial Grassland, embedded clearings that are totally devegetated, and existing pads and roadways. Plant cover in areas that have recently become unsuitable for scrub or forest species due to naturally occurring changes in fumarole activity was designated as "thermally disturbed". It now consists of mainly introduced annual species, or as mainly native Wright Buckwheat Dwarf Scrub. In either vegetation type, shallow-rooted species dominate, and dead trees and shrub crowns often remain to mark areas where elevated soil temperatures have caused dieback most recently. Relatively undisturbed upland forest and scrub stands classified as Jeffrey Pine Forest, Singleleaf Pinyon Woodland, and Big Sagebrush Scrub (Table 2) were found only on the steepest slopes and in one central zone of reduced thermal disturbance (Figure 2).

Table 2. Plant communities that occur in 2008 within privately owned lands where construction of the Casa Diablo IV power plant project has been proposed.

Plant Community Name	Community Number[1]	Alliance[2]	Acreage in Study Area
Jeffrey Pine Forest	87.020.26	*Pinus Jeffreyi-Pinus monophylla*	7.6
Singleleaf Pinyon Woodland	87.040.02	*Pinus monophylla-Artemisia tridentata*	4.0
Big Sagebrush Scrub	35.110.07	*Artemisia tridentata-Purshia tridentata*	5.6
Wright Buckwheat Dwarf Scrub	32.041.00	*Eriogonum wrightii* var. *subscaposum*	7.7
thermally disturbed	42.050.00	-	3.3
mechanically disturbed	-	Semi-Natural Non-Native Grassland[1]	7.3

1. Taken from CDFG (2003)
2. Taken from classification proposed by CDFG (2007)

Figure 2. Plant communities within the Casa Diablo IV study area in June 2008. The base image is a georectified color-IR aerial photograph taken July 15, 1995 from 5800 ft height.

A total of 91 species belonging to 26 plant families were identified within the study area (Appendix A). Herbaceous species are most important within thermally disturbed areas, where non-native "winter annuals" can comprise up to 100% of the assemblage. Herb diversity in the relatively less disturbed areas dominated by Jeffrey Pine Forest, Singleleaf Pinyon Woodland, and Big Sagebrush Scrub includes a considerably greater proportion of native species, but one weedy non-native species, cheat grass (*Bromus tectorum*), has gained prominence within the herbaceous layer of all the study area's plant communities. No populations of rare plants were found, but the warmed habitats near fumaroles have encouraged colonization by several locally unusual species, and currently support the regionally rare plant community Wright Buckwheat Dwarf Scrub.

Plant community naming has been in flux in recent years as CDFG works to adopt the NatureServe system (Grossman, *et al*, 1998) to California by numbering distinctive community types in a hierarchical array (CDFG, 2003) that embraces California community relationships recognized by Holland (1986) and Sawyer and Keeler-Wolf (1995). The recent move toward using alliances as the primary identifier of plant communities (CDFG, 2007) will be subject to another major revision in early 2009. In any case, the plant community as defined by typical dominants in the tree, shrub and herbaceous strata remains the proper unit for describing the vegetation that may be unavoidably impacted or intentionally avoided by the proposed project. Clear differences in the average vegetation height, density, and dominant canopy species, as described below, serve to make the on-site plant communities visually distinct. Community transitions are usually abrupt. Locating community edges for the purposes of planning and avoidance during construction should therefore be relatively straightforward.

Jeffrey Pine Forest

Jeffrey pine (*Pinus jeffreyi*) accounts for about 80% of the tree canopy cover within the areas mapped as Jeffrey Pine Forest (CDFG 87.020.26, Holland code 85100). Jeffrey pine trees average about 40 ft height and 16 inches diameter at breast height. Trees up to 70 ft height were observed north of the existing MPLP II-III. Singleleaf pinyon (*Pinus monophylla*) and mountain juniper (*Juniperus grandis*) are minor canopy components that are present within the study area in clumped distributions. The average tree canopy closure is 20% but closure patchily exceeds 40% to sometimes provide dense shading. In the context of the surrounding landscape, this plant community is widespread. It generally occurs at or above the elevation of the study area. All recognized *Pinus jeffreyi* alliances in the Mammoth Lakes area, including the *Pinus jeffreyi - Pinus monophylla* alliance (CDFG 87.020.00) are assigned priority code G5S4, signifying a common and widespread vegetation type as defined by Natureserve (2008). *Pinus jeffreyi* alliances are common in California (CDFG, 2007), and are regionally widespread in Mono County (Mono County Planning Dept., 2001).

The shrubby understory is composed mainly of big sagebrush (*Artemisia tridentata*) and antelope bush (*Purshia tridentata*). Jeffrey Pine Forest in the study area exhibits a mixed shrub stratum that seldom exceeds 5% total cover, and can therefore be firmly distinguished from the sensitive *Pinus jeffreyi - Purshia tridentata* alliance (87.020.21), a vegetation type that is known to occur at significantly higher elevations in the Glass Mountains 10 miles to the east of the study area (Taylor, 1980). The density of cover contributed by shrubs decreases as tree cover increases. The understory is also sparsely grassy, with grasses attaining greatest prominence as

nearly pure carpets of cheat grass along the northern edge of the community. Understory vegetation was absent only where Jeffrey Pine Forest canopy cover exceeds 40%. The forest floor characteristically exhibits a dense accumulation of pine litter.

The boundaries of Jeffrey Pine Forest mapped within the study area (Figure 2) were based upon a perceived continuity of tree dominance and shading, and a related shift in the relative cover of understory shrubs. The edge between Jeffrey Pine Forest and Big Sagebrush Scrub was perhaps the most difficult to definitively locate in the field of any mapped in 2008. Jeffrey Pine Forest includes patchy stands of sagebrush, while Big Sagebrush Scrub includes scattered pine and singleleaf pinyon. One consistent contrast between the two communities is found in the forest floor. The soil profile in Jeffrey Pine Forest includes a continuous, 1-6 inch organic horizon, composed mainly of accumulated pine needles and cones, which is absent from Big Sagebrush Scrub. This community characteristic is considered notable, as areas of Jeffrey Pine Forest with intact, deep forest duff accumulation are the only communities that have been observed to be free of cheat grass infestation within the study area and nearby (Paulus, 2001a, 2002b, 2002c).

Singleleaf Pinyon Woodland

Singleleaf Pinyon Woodland within the study area is confined to one steep southwest-facing slope at the northern edge. Jeffrey pine is absent, with the exception of a few seedlings and long-dead snags. Singleleaf pinyon has established dominance with a clumped distribution that averages 20% canopy closure. Mountain juniper is a minor canopy component. Singleleaf Pinyon Woodland (CDFG 87.040.02, Holland code 72122) is widespread in Mono County at about the elevation of the project area (Mono County Planning Dept., 2001). Recognized *Pinus monophylla* alliances in the Mammoth Lakes area, including the *Pinus monophylla - Artemisia tridentata* alliance present within the study area (CDFG 87.040.00, priority code G5S4) are considered common in California (CDFG, 2007).

Big sagebrush and antelope bush are overall dominants in the shrub layer, while native perennial grasses and cheat grass dominate in the herb layer. The understory observed in 2008 is much more diverse than found in any other community surveyed. Roughly twice as many species are present in Singleleaf Pinyon Woodland at subdominant frequencies. This community occurs between active fumaroles areas, and upslope of other study area communities, in a landscape position that may encourage diversity of shallow-rooted species by providing rooting zone soils that are *moderately* warmed all year (but apparently warmed enough to kill large Jeffrey pine). Revegetation efforts conducted within the study area would be facilitated if palette development is informed by the Singleleaf Pinyon Woodland example (Appendix A), and may be facilitated if propagule collection is carried out within locally adapted (thermal soil-tolerant) populations such as those present within Singleleaf Pinyon Woodland.

Big Sagebrush Scrub

Big sagebrush and antelope bush comprise the shrub stratum of Big Sagebrush Scrub (CDFG 35.110.07, Holland code 35210). These native shrubs dominate in 1-2 ft tall stands in the relatively undisturbed, open areas between and around Jeffrey Pine Forest. Big sagebrush usually outnumber antelope bush. Regionally, *Artemisia tridentata* alliances including the *Artemisia tridentata - Purshia tridentata* alliance present within the study area (35.110.00, priority code

G5S4) are widespread throughout the Great Basin Floristic Province on the eastern slopes of the Sierra Nevada (CDFG, 2007). The community is classified as Basin Sagebrush in the Mono County Master Environmental Assessment (Mono County Planning Dept., 2001).

The amount of existing perennial cover varies across the study area. Average cover by native shrubs is 30%. Perennial grasses, mainly native squirreltail grass (*Elymus elymoides*) or non-native intermediate wheatgrass (*Elytrigia intermedia*), have on average established less than 10% cover amid the shrubs. Needle-and-thread grass (*Hesperostipa comata*) and needlegrasses (*Achnatherum nevadensis* and *A. occidentale*) occur patchily at lesser frequency. Native species diversity is generally higher where non-native grasses are absent or sparse. Intermediate wheatgrass has established up to 20% cover at the community's ecotone with mechanically disturbed areas. Average height is 2 ft where shrubs predominate and is 1 ft where grasses dominate. Cheat grass is the only non-native species whose abundance in 2008 was on average greater than the abundances of co-occurring native species where soil disturbance is not evident.

Wright Buckwheat Dwarf Scrub

Wright Buckwheat Dwarf Scrub (CDFG 32.041.00, no Holland equivalent) is restricted to perennially warmed soils near fumaroles. Wright buckwheat (*Eriogonum wrightii* var. *subscaposum*) is not the only shrub present, but it is overall the most conspicuous because its mats make up more than 90% of the total cover. Co-occurring big sagebrush and antelope bush are sparse and stunted. The average vegetation cover is 10-20% and average height is less than 1 ft, but areas that have been invaded by "winter annuals" (see below) can produce dense cover averaging 3 ft tall for at least part of each year. This community's ecotones are characteristically sharp. Its boundaries are readily visible where the small, open patches of Wright buckwheat grade abruptly into surrounding, more densely vegetated forest and scrub communities. Like other plant communities in the study area, Wright Buckwheat Dwarf Scrub has been fragmented by past development.

The occurrence of nearly pure stands of the small shrub Wright buckwheat, classified here as *Eriogonum wrightii* var. *subscaposum* alliance, may represent a rare combination of native plants that is confined to fumarole field margins. Taylor (1987) labeled the original, larger stand that pre-dated construction of the existing power generating facilities as "botanically sensitive habitat" because it is not found elsewhere. Paulus (2001c) called the small fragments remaining on slopes adjoining MPLP II-III (Figure 2) "regionally rare", noting that other fumarole habitats in the Basalt Canyon, Upper Basalt, and Rhyolite Plateau Geothermal Exploration Areas do not harbor vegetation of this type. Wright buckwheat, which can also be found at lower frequencies in Big Sagebrush Scrub throughout the study area, is not itself a rare plant in California. The community, however, is currently classified by CDFG as G4S3?, signifying that it is "vulnerable and at moderate risk" (the question mark signifies CDFG uncertainty due to a lack of comprehensive distribution data), and thus would likely be considered sensitive by the State of California. The overwhelming threat to this community's continued existence within the study area is the proximity to active fumaroles and soils heated beyond the tolerance of plants. Fumarole activity and Wright Buckwheat Dwarf Scrub extent both appear to have changed noticeably (a personal observation) since this area was previously surveyed in 2001 (Paulus, 2001c).

Heated soils that support Wright Buckwheat Dwarf Scrub are also vulnerable to dense growths of non-native annuals that are typically found in disturbed habitats at lower elevations. Collectively termed "winter annuals" in recognition of their adaptation to early-season growth and subsequent stand dominance over native annuals that germinate later in spring, non-native species such as black mustard (*Brassica nigra*), redstem filaree (*Erodium cicutarium*) tumble mustard (*Sisymbrium altissimum*), and clasping pepperweed (*Lepidium perfoliatum*) were very abundant in 2008 but appeared to be mostly restricted to the edges of this community. Cheat grass, in contrast, has attained up to 20% cover in a carpet-like stand across the entirety of this community's extent within the study area.

Thermally Disturbed

Non-native annuals such as cheat grass, redstem filaree, black mustard, Russian thistle (*Salsola tragus*), and silver hairgrass (*Aira caryophyllea*) attain weedpatch dominance and up to 90% cover where recent thermal activity has killed native shrubs and trees. The only native annual species found widely in thermally disturbed areas were skunky monkeyflower (*Mimulus nanus* var. *mephiticus*) and goosefoot (*Chenopodium* spp.). Scattered woollypod milkvetch (*Astragalus purshii*) and pussypaws (*Calyptridium monospermum*) were found at low frequencies among the non-native "winter annuals" (see Wright Buckwheat Dwarf Scrub, above), but perennial species in general occur only rarely. All surfaces within about 20 ft of active fumaroles are barren.

Non-native weedy species confined to heated soils near fumaroles, or in the thermally limited Wright Buckwheat Dwarf Scrub, likely do not present a significant threat of spreading into areas that are not associated with thermal disturbance, including Jeffrey Pine Forest, Big Sagebrush Scrub, and mechanized disturbed (a caveat would be that some of the areas that were mapped as mechanized disturbed in 2008 may be also thermally disturbed). These species have not spread in such a manner so far, despite high abundances and successful seed production. It is reasonable to conclude that these species will not widely invade outside areas mapped here as thermally disturbed, if they are in fact adapted only to the warmer microclimate that is available at perennially warmed soils.

Mechanically Disturbed

Areas that have been mechanically disturbed within the past decade are dominated by non-native perennial grasses. Intermediate wheatgrass and crested wheatgrass (*Agropyron cristatum*) were probably introduced in revegetation seed mixes. Dominants that are typical of nearby Big Sagebrush Scrub have failed to return, but native rabbitbrush (*Ericameria nauseosa* and *E. parryi*) shrubs occur patchily. Species observed to be restricted to the areas of greatest ongoing disturbance (*e.g.*, where topsoil has been scraped away for recent well pad or road construction) included cheat grass, Russian thistle, California willowherb (*Epilobium foliosum*), yellow salsify (*Tragopogon dubius*), and common knotweed (*Polygonum aviculare* ssp. *depressum*). Gravel-capped pads remain nearly barren. Meanwhile, several pipeline corridors that cross through the study area (pipelines are elevated on 1-2 ft stilts) have attained a high degree of native vegetative recovery. Pipeline corridors constructed in the early 1990's are now largely indistinguishable from the surrounding vegetation types.

Cheat grass is likely the most problematic of the non-native species present within the study area. Cheat grass is an annual grass that is an invasive noxious weed as defined by the California Exotic Pest Plant Council (1999, CalEPPC code A-1: "the most invasive pest plants, and are already widespread"). High density cheat grass stands are thought to increase the risk and frequency of wildfire (CalEPPC, 1999). It has become well-established in thermally and mechanically disturbed soils throughout Casa Diablo and adjoining geothermally active areas and, with Russian thistle ("considered but not listed" by CalEPPC), has invaded into nearby relatively undisturbed Jeffrey Pine forest and Big Sagebrush Scrub (Paulus, 2002a-c, 2004a). Yellow salsify is also considered an invasive noxious weed (CalEPPC code B: "invasive pest plants that spread less aggressively than A-1 or A-2 species"). Soil disturbance associated with the project could contribute to the ongoing local spread of invasive cheat grass, Russian thistle and yellow salsify in all habitats. In areas that are both mechanically and thermally disturbed, existing populations of non-natives adapted to thermal disturbance will be encouraged, but this will not likely cause spread of these species into adjacent non-thermal habitats.

Rare Plants and Plant Communities

Wright Buckwheat Dwarf Scrub occurs widely near fumaroles within the Casa Diablo area, including several tens of acres on adjacent lands administered by the Inyo National Forest and by the Bureau of Land Management. The expansive occurrence that intersects the northern portion of the study area (Figure 2) is confined mainly to slopes of > 10% that are not likely to be extensively developed. The gentle slope occupied by the southern occurrence of this community is more suitable to development. Wright Buckwheat Dwarf Scrub there has already become fragmented by facility construction at MPLP II-III, and native vegetation has generally not returned. It is believed this assemblage would be very difficult to replace on the short term usually specified for post-project revegetation. On the longer time scale, the boundaries of this community likely are somewhat transient in response to natural variations in soil warming near geothermal vents. Changes in soil warming, and increased wildfire vulnerability associated with already well-established weedy swards, are considered the most significant threats to Wright Buckwheat Dwarf Scrub at this site.

Vegetation that is typically associated with wetland habitats was found in one patch-sized location within the study area. A low 10 ft x 30 ft patch of nearly pure *Carex nebrascensis* (OBL, per Reed's 1988 wetland adaption classification for Region 0, meaning the species has a 99+% likelihood of occurrence in wetlands) is located in a swale-like drainage near fumaroles in the central study area (Figure 2). This area exhibited completely dry surface soils during the time of the rare plant search in June 2008. It does not support dense or lush growth of sufficient area to map as a separate plant community, nor does it harbor any rare species. This isolated area may meet jurisdictional criteria established by the U.S. Army Corps of Engineers and Regional Water Quality Control Board pursuant to their Clean Water Act regulatory activities. Development scheduled to occur in this area should be preceded by an investigation into the presence/absence of any nexus to state or federal protections for wetland habitats. Vegetation and evidences of hydrologic regimes that could signal the presence of a riparian corridor subject to Riparian Conservation Area policy as defined by USFS (2004) were not found anywhere within the study area.

The general absence of seasonally to perennially moist habitats greatly reduces the likelihood that populations of *Botrychium crenulatum*, *Epilobium howellii*, or *Potamogeton robbinsii* occur within the study area. No pond habitats were found, thus excluding *P. robbinsii* due to lack of suitable habitat. No rhizomatous herbs bearing frond-like leaves of less than 10 cm height with sporangia, as would be expected of *B. crenulatum*, and no prostrate and fragile appearing members of the genus *Epilobium*, as would be expected of *E. howellii*, were found within the small, relatively wet area described above, or elsewhere within the study area.

The perennial herbs Mono milkvetch (*Astragalus monoensis*) and Mono Lake lupine (*Lupinus duranii*), typically occur in montane "flats" habitats with pumice soil. The nearest known location of this habitat type, 2.5 miles to the north at Smokey Bear Flat, is separated from the study area by a forested, east-west trending ridge. Pumice soil is widespread within the study area, but relatively level terrain that exhibits signs of internal drainage or soil infertility such as stunting or absence or normal shrub or herbaceous dominants was found in Big Sagebrush Scrub north of MPLP II-III only. Careful searching of this potential habitat and others for *A. monoensis* and *L. duranii* found no occurrences of these species and identified no occurrences of the Mono Pumice Flat community.

It is unlikely that *A. monoensis* or *L. duranii* would be confused with other commonly occurring species. *A. monoensis* vegetative and fruit characteristics are considered distinctive in Mono County (Halford and Fatooh, 1994). *A. monoensis* produces glabrous lower stems, and would not produce cushion-like growth or hairy fruits. The small *A. purshii* mounds that were found in Big Sagebrush Scrub and Wright Buckwheat Dwarf Scrub in the study area were overall pubescent and bore densely long-hairy fruits, and so were readily differentiated from the potentially occurring rare species. Mounded growth form and densely long-hairy fruit characters also firmly distinguish the common species *A. purshii* from *A. johannis-howellii* (state listed "Rare"), a plant of lower elevations of Long Valley that has a prostrate but never matted growth form and papery, glabrous fruits. No members of the genus *Lupinus* were found within the study area in 2008. All *Arabis* populations observed during the survey exhibited purple or violet, relatively large (>5 mm) petals. These petal characteristics firmly differentiated the common species occurring in the study area from *A. cobrensis*, which occurs in dissimilar scrub habitat three miles to the east (Paulus, 2003).

Pine fritillary, a robust lily, is the only bulbiferous plant on the rare plant search list. The habitat occupied by a population of widely scattered individuals mapped immediately north of the study area by Paulus (2002c) appears to extend into the study area only in the northern patch of Jeffrey Pine Forest. However, no *F. pinetorum* were found during careful searching within Jeffrey Pine Forest or elsewhere within the study area, and no similar lilies that could be confused with *F. pinetorum* were found in 2008. Fritillaries at the known population are usually shaded under trees with 10-40% canopy closure (plants can be found even where needle accumulation is dense), although a few individuals were found in shrubby forest gaps. After the completion of anthesis, which can be brief, the single-stemmed plant afterwards is somewhat non-descript and can be difficult to spot if the forest floor is shrubby. A check of individuals in the known population confirmed that the 2008 search was conducted during local *F. pinetorum* anthesis.

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Appendix A. List of plant species observed in June 2008 within privately owned lands where construction of the Casa Diablo IV power plant project has been proposed.

Plant Families and Species		Habit	Occurrence in Study Area: Jeffrey Pine Forest	Singleleaf Pinyon Woodland	Big Sagebrush Scrub	Wright Buckwheat Scrub	Mechanically Disturbed Soils	Thermally Disturbed Soils
Cupressaceae								
Juniperus grandis [1]	mountain juniper	NT	x	x	x			
Pinaceae								
Pinus jeffreyi	Jeffrey pine	NT	x		x			x
Pinus monophylla	single leaf pinyon	NT	x	x				x
Amaranthaceae								
Chenopodium atrovirens [2]	pinyon goosefoot	NAH						x
Chenopodium desiccatum [2]	aridland goosefoot	NAH	x				x	x
Salsola tragus [2]	Russian thistle	IAH					x	
Asteraceae								
Agoseris glauca var. *monitcola*	mountain agoseris	NPH			x			
Anisocoma acaulis	scale bud	NAH				x		
Artemisia tridentata ssp. *vaseyana*	mountain big sagebrush	NS	x	x	x	x	x	
Artemisia tridentata ssp. *wyomingensis*	Wyoming big sagebrush	NS	x					
Chaenactis stevioides	dusty maiden	NAH			x	x	x	x
Chrysothamnus viscidiflorus ssp. *viscidiflorus*	curl leaf rabbitbrush	NS	x	x	x		x	
Dieteria canescens var. *canescens* [3]	hoary aster	NPH	x	x	x	x	x	x
Ericameria bloomeri	rabbit goldenbush	NS			x			
Ericameria nauseosa var. *speciosa* [4]	rubber rabbitbrush	NS		x	x		x	x
Ericameria parryi [5]	Parry rabbitbrush	NS			x	x	x	
Erigeron divergens	spreading fleabane	NAH	x					
Gaillardia aristata	blanket flower	IPH					x	
Gnaphalium palustre	marsh cudweed	NAH						x
Layia glandulosa	white tidy tips	NAH				x		
Stephanomeria exigua ssp. *exigua*	slender wirelettuce	NAH		x	x			
Tetradymia canescens	cotton thorn	NS		x	x			
Tragopogon dubius	yellow salsify	IPH					x	

Plant Families and Species		Habit	Occurrence in Study Area: Jeffrey Pine Forest	Singleleaf Pinyon Woodland	Big Sagebrush Scrub	Wright Buckwheat Scrub	Mechanically Disturbed Soils	Thermally Disturbed Soils
Boraginaceae								
Cryptantha echinella	prickly cryptantha	NAH	x	x	x			
Cryptantha micrantha	purpleroot forget-me-not	NAH		x		x	x	
Plagiobothrys kingii var. *harknessii*	Harkness popcornflower	NAH		x		x	x	
Brassicaceae								
Arabis inyoensis	Inyo rock cress	NPH	x	x	x			
Arabis holboellii var. *retrofracta*	Holboell rock cress	NPH	x	x				
Arabis perennans	perennial rock cress	NPH		x		x		x
Brassica nigra	black mustard	IAH		x			x	x
Descurainia incisa ssp. *filipes*	mountain tansy mustard	NAH	x	x		x	x	x
Descurainia pinnata ssp. *intermedia*	western tansy mustard	NAH		x		x		x
Lepidium densiflorum var. *macrocarpum*	bigseed pepperweed	NAH					x	
Lepidium perfoliatum	clasping pepperweed	IAH					x	x
Sisymbrium altissimum	tumble mustard	IAH					x	
Caprifoliaceae								
Symphoricarpos rotundifolius var. *rotundifolius*	roundleaf snowberry	NS	x					
Fabaceae								
Astragalus purshii	woollypod milkvetch	NPH	x	x	x	x	x	x
Medicago sativa	alfalfa	IPH					x	x
Geraniaceae								
Erodium cicutarium	redstem filaree	IAH		x			x	x
Grossulariaceae								
Ribes cereum var. *cereum*	wax currant	NS	x					
Loasaceae								
Mentzelia congesta	clustered blazing star	NAH	x	x	x	x		x
Mentzelia veatchiana	Veatch's blazing star	NAH				x		

Plant Families and Species		Habit	Occurrence in Study Area: Jeffrey Pine Forest	Singleleaf Pinyon Woodland	Big Sagebrush Scrub	Wright Buckwheat Scrub	Mechanically Disturbed Soils	Thermally Disturbed Soils
Onagraceae								
Epilobium foliosum	California willowherb	NAH					x	x
Gayophytum diffusum ssp. *parviflorum*	summer snowflakes	NAH	x	x	x	x	x	x
Oenothera caespitosa ssp. *marginata*	desert evening primrose	NPH		x				
Orobanchaceae								
Orobanche californica ssp. *feudgei*	California broomrape	NPH$		x				
Papaveraceae								
Argemone munita	prickly poppy	NPH					x	
Phrymaceae								
Mimulus nanus var. *mephiticus* [6, 7]	skunky monkeyflower	NAH						x
Mimulus torreyi [6]	Torrey monkeyflower	NAH			x			
Polemoniaceae								
Aliciella leptomeria [8]	Great Basin gilia	NAH						x
Gilia brecciarum ssp. *brecciarum*	Nevada gilia	NAH	x	x		x		x
Eriastrum sparsiflorum	Great Basin woollystar	NAH	x	x	x	x	x	x
Eriastrum wilcoxii	Wilcox woollystar	NAH						x
Linanthus pungens [9]	granite prickly phlox	NPH			x			
Phlox stansburyi	Stansbury phlox	NPH			x	x		x
Polygonaceae								
Eriogonum palmerianum	Palmer buckwheat	NAH	x	x		x		
Eriogonum spergulinum var. *reddingianum*	spurry buckwheat	NAH	x		x			
Eriogonum umbellatum var. *nevadense*	sulphur flower	NS		x	x	x		x
Eriogonum wrightii var. *subscaposum*	Wright buckwheat	NS			x	x		x
Polygonum aviculare ssp. *depressum* [10]	knotweed	IAH					x	x
Portulacaceae								
Calyptridium monospermum	oneseeded pussypaws	NPH		x	x	x	x	x

Plant Families and Species		Habit	Occurrence in Study Area: Jeffrey Pine Forest	Singleleaf Pinyon Woodland	Big Sagebrush Scrub	Wright Buckwheat Scrub	Mechanically Disturbed Soils	Thermally Disturbed Soils
Rhamnaceae								
Ceanothus velutinus	tobacco brush	NS	x					
Rosaceae								
Holodiscus microphyllus var. *microphyllus*	rock spiraea	NS		x				
Prunus andersonii	desert peach	NS			x	x		x
Purshia tridentata var. *tridentata*	antelope bush	NS	x	x	x	x	x	
Scrophulariaceae								
Verbascum thapsus	woolly mullein	IBH		x			x	
Violaceae								
Viola purpurea ssp. *venosa*	goosefoot violet	NPH	x		x			
Cyperaceae								
Carex douglasii	Douglas sedge	NPGL	x					x
Carex nebrascensis	Nebraska sedge	NPGL						x
Cares praegracilis	clustered field sedge	NPGL						x
Carex rossii	Ross sedge	NPGL	x	x	x			
Juncaceae								
Juncus mexicanus	Mexican rush	NPGL	x					x
Liliaceae								
Calochortus leichtlinii	smokey mariposa lily	NPGL	x	x	x	x		x
Poaceae								
Achnatherum hymenoides	ricegrass	NPG	x		x	x		x
Achnatherum nevadense	Nevada needlegrass	NPG	x		x	x		
Achnatherum occidentale ssp. *pubescens*	western needlegrass	NPG	x		x	x	x	
Achnatherum pinetorum	pine needlegrass	NPG		x				

Plant Families and Species		Habit	Occurrence in Study Area: Jeffrey Pine Forest	Singleleaf Pinyon Woodland	Big Sagebrush Scrub	Wright Buckwheat Scrub	Mechanically Disturbed Soils	Thermally Disturbed Soils
Poaceae (cont.)								
Achnatherum thurberianum	Thurber needlegrass	NPG	x					
Aira caryophyllea	silver hairgrass	IAG						x
Agropyron cristatum	crested wheatgrass	IPG	x			x	x	x
Agrostis pallens	leafy bentgrass	NPG						x
Bromus tectorum	cheat grass	IAG	x	x	x	x	x	x
Dactylis glomerata	orchard grass	IPG					x	
Elymus elymoides ssp. *elymoides*	squirreltail grass	NPG	x	x	x	x	x	
Elymus trachycaulus ssp. *trachycaulus*	slender wheatgrass	NPG	x			x	x	x
Elytrigia intermedia ssp. *intermedia*	intermediate wheatgrass	IPG			x	x	x	x
Hesperostipa comata ssp. *comata*	needle and thread grass	NPG	x		x	x		x
Hordeum jubatum	foxtail barley	NPG	x					
Leymus cinereus	ashy wildrye	NPG	x	x	x			
Melica stricta	rock melic	NPG			x			
Poa compressa	Canada bluegrass	IPG						x
Poa palustris	fowl bluegrass	IPG				x		

key to growth habit codes:

A	annual
B	biennial
G	grass
GL	grass-like
H	herb
I	introduced
N	native
P	perennial
S	shrub
T	tree
$	parasitic

synonymy:

1 syn. *Juniperus occidentalis* var. *australis*
2 genus formerly included in family Chenopodiaceae
3 syn. *Machaeranthera canescens* var. *canescens*
4 syn. *Chrysothamnus nauseosus* ssp. *albicaulis*
5 syn. *Chrysothamnus parryi*
6 genus formerly included in family Scrophulariaceae
7 syn. *Mimulus mephiticus*
8 syn. *Gilia leptomeria (currently treated by Jepson Herbarium as an "undescribed species")*
9 syn. *Leptodactylon pungens*