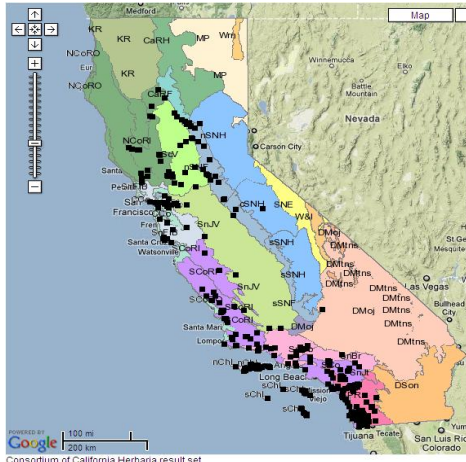


SPECIES	<i>Nassella pulchra</i> (A. Hitchc.) Barkworth
NRCS CODE: NAPU4	Tribe: Stipeae Family: Poaceae Order: Cyperales Subclass: Commelinidae Class: Liliopsida  Carol W. Witham © 2004
Synonyms	<i>Stipa pulchra</i> Hitchc. (Hickman 1993); <i>S. setigera</i> Calif. (Munz 1974)
Common name	Purple needlegrass. Other names include: purple stipa, purple tussockgrass (Steinberg 2002); purple nassella; California purple needle grass; purple needle stipa (Painter 2009).
Subspecific taxa	None.
Taxonomic relationships	Species of <i>Nassella</i> were once considered part of the genus <i>Stipa</i> and are related to <i>Stipa</i> , <i>Achnatherum</i> , and <i>Hesperostipa</i> (Barkworth 1990). Barkworth & Torres (2001) report that there are at least 116 species of <i>Nassella</i> , most of which occur in South America; seven species are native to North America.
Related taxa in region	<i>Nassella cernua</i> (Stebbins & Love) Barkworth; <i>Nassella lepida</i> (Hitchc.) Barkworth. Amme (2003) provides hints to tell these species apart (see Distinguishing Traits, below). The non-native <i>N. manicata</i> (E. Desv.) Barkworth from South America strongly resembles <i>N. pulchra</i> and is now present in at least three counties in central CA.
Taxonomic issues	Amme (2003) reports that <i>N. pulchra</i> included the species <i>N. cernua</i> up until Stebbins & Love (1941). Not all botanists agree with the separation of the genus <i>Nassella</i> from <i>Stipa</i> , and recent publications sometimes include the name <i>Stipa pulchra</i> (e.g., Roberts et al. 2004, Roberts 2008). Barkworth & Torres (2001) found diagnostic characters to separate <i>Nassella</i> from other species in the tribe Stipeae. The best traits were "a combination of the strongly convolute lemma and short, glabrous palea".
Other	California state grass. One of the most common native grass species in CA (Bartolome & Gemmill 1981).
GENERAL	
Map	Data provided by the participants of the Consortium of California Herbaria represent 384 records with coordinate data out of 793 total records retrieved; data accessed 2/27/10. See Berkeley Mapper: http://ucjeps.berkeley.edu/consortium  Consortium of California Herbaria result set

Geographic range	Widespread in California and extending into Baja California; from the Channel Islands and North Coast east to the western Sierra Nevada foothills in the north, and to the western Transverse and Peninsular Ranges in the south (Munz & Keck 1968).
Distribution in California; Ecological Sections/Subsections	Throughout Southwestern, Central Western, and Great Valley California Floristic Provinces, the Sierra Nevada Foothills, the North Coast, and Channel Islands. Ecological Sections (http://www.fs.fed.us/r5/projects/ecoregions/ca_sections.htm): 261A, B; 262A; M262A,B; 263A; M261A,B,C,F.
Life history, life form	Polycarpic, perennial, cool season bunchgrass; long-lived. Life expectancy 20-200 years (Marty et al. 2005).
Distinguishing traits	Densely tufted bunchgrass with slender leaves and flowering culms 35-100 cm tall; blades of the leaves 10-20 cm long, 0.8 -3.5 mm wide, flat to convolute; top surface of blade and sheath glabrous to hairy; ligules glabrous but with a tuft of hairs at the collar of leaf between the blade and the sheath. The tall, branched inflorescences ("open panicle of spikelets") bear single-flowered florets that detach above the glumes. The portion with flowers is 18-60 cm long; each branch holds 2-6 spikelets with pedicels 3-10 mm long. The glumes are nearly equal in size; the lemmas are hairy between veins when young and at maturity (unlike <i>N. cernua</i> and <i>lepida</i>, which become glabrous at maturity); the awns are 38-100 mm long (Amme 2003 says 70-100 mm), strongly twice bent, and straight in the last segment (FNA Grass Manual, see Barkworth et al. 2003). Clumps expand over time and have been considered by some to be "clone-forming" (Hull & Muller 1977). The FNA Grass Manual and Amme (2003) provide clues for distinguishing the three native California <i>Nassellas</i>. In <i>N. pulchra</i>, the lemmas of the florets are hairy between the veins at maturity and the awns are long and straight after the terminal bend. Both <i>N.cernua</i> and <i>N. lepida</i> have awns that are wavy in the terminal segment, and <i>N. lepida</i> has shorter awns. The awn of <i>N. pulchra</i> is also stiffer and thicker than in the others. <i>N. cernua</i> sometimes has awns as long as 110 mm. The non-native <i>N. manicata</i> can be distinguished from <i>N. pulchra</i> by its shorter florets and strongly developed crowns; unlike <i>N. pulchra</i>, the seeds are mostly glabrous and have a constricted neck at the top of the seed below the awn (FNA Grass Manual, Amme 2003).
Root system, rhizomes, stolons, etc.	Fine, fibrous roots.
Rooting depth	The highest concentration of roots was between 15 cm and 30 cm (Hull & Muller 1977). Most roots were under 0.6 m; maximum depth is expected to be <1 m.
HABITAT	
Plant association groups	Chaparral, coastal sage scrub, pine and oak woodlands (especially in patches of grassland), coastal prairie, valley grassland, mixed evergreen forest (Steinberg 2002).
Habitat affinity and breadth of habitat	Densest stands occur on sandy loam. Plants are most abundant in the coast range, on warmer slopes, in well drained flat areas (Crampton 1974). Historically considered to be a later seral stage species, but this classification is under debate (Steinberg 2002).
Elevation range	Sea level to 1300m / ~5000' (Munz & Keck 1968, Munz 1974).
Soil: texture, chemicals, depth	Adapted to droughty soils (Crampton 1974), and also occurs on soils with high clay content (Steinberg 2002); found in sandy soils with low phosphorus. Tolerant of serpentine and poor soils (Newton & Claassen 2003). Highest occurrence in soils with low N and sand content between 30 and 45% (Guillermo et al. 2007).
Drought Tolerance	Yes, due to inactive regions of cell division near soil level (Hull & Muller 1977). Tolerant of summer drought (Newton & Claassen 2003). Drought induces dry season dormancy (Steinberg 2002).
Precipitation	Plants grow in areas with 8 to 30 inches of rainfall (USDA_NRCS 2009). More rain and lower temperatures have a positive effect on growth (Marty et al. 2005).
Flooding or high water tolerance	Some ecotypes may tolerate infrequent flooding (USDA PLANTS 2009).
Wetland indicator status for California	Upland (USDA PLANTS 2009)

Shade tolerance	Intermediate (USDA PLANTS 2009). Plants grow in full sun and partial shade (Wrysinski 2000, O'Brien et al. 2006).
GROWTH AND REPRODUCTION	
Seedling emergence relevant to general ecology	Germination and seedling emergence occur during the cool rainy season (Nov-March). Seedling emergence tends to be slower than associated non-native annual species, and high seedling mortality is associated with initiation of rapid spring growth by associated annuals (Bartolome & Gemmill 1981). At a study at the University of California, Hopland Research Station, no seedlings were found after April.
Growth pattern (phenology)	Growth is slow in early winter, speeds up with warming, and lags behind annual species (Hull & Muller 1977). Plants can flower in first year under good growing conditions, but most flower in the second year (A. Montalvo, pers. obs.). Mature plants are green and active in the rainy season and become dry and dormant in summer. The clumps expand in girth by branching. Plants flower in March to May depending on location and annual condition and set seeds from late May to early June.
Vegetative propagation	Plants do not produce rhizomes (Barkworth et al. 2007), and clonal reproduction is limited (Dyer & Rice 1997). Very localized vegetative spread occurs, resulting in an increase in clump diameter (Bartolome & Gemmill, 1981). Recruitment is by sexual reproduction rather than asexual (Dyer & Rice 1994) and may be seed limited (Hamilton et al. 1997).
Regeneration after fire or other disturbance	The effect of fire and grazing on survival and plant cover has been examined under a variety of conditions, such as time of year, density of plants, size of plants, and location; results are variable and reviewed by Steinberg (2002). Plants are not highly fire resistant but will resprout after moderate intensity spring and fall burns. Inland populations may have enhanced establishment following fire and light grazing (Hatch et al. 1999; Dyer et al. 1996). However, site specific responses to burn and grazing disturbances have been observed (Hatch et al. 1999): in valley grasslands, positive response to burning and grazing exclusion were found; in coastal populations, there was tolerance to fall burning and moderate grazing, but responses were not consistent. Another study found plants susceptible to mid-summer burns (Wirka 1999). Prescribed fire in the spring has been used as a tool to restore grasslands dominated by <i>N. pulchra</i> in southern California, including the Santa Rosa Plateau in western Riverside Co. Bartolome et al. (2004) examined effects of both the season of grazing and fall burns on the response of a diversity of grassland species in the Coast Ranges. <i>N. pulchra</i> was unaffected by fall burns but was favored by spring grazing.
Pollination	Wind.
Seed dispersal	Primary dispersal by wind, May-July (Bishop 1996). Seeds also have sharp ends and can stick to fur. Secondary dispersal may occur by animals that use seeds for food, e.g., caching by voles (Fehmi & Bartolome 2002).
Breeding system, mating system	All <i>Nassella</i> have spikelets with a single floret, and many produce inflorescences with both open flowers (chasmogamous) together with flowers that never open and that self-pollinate (cleistogamous) (FNA Grass Manual). This can lead to having a mixed mating system, with both selfing and outcrossing possible. Stebbins & Love (1941) report that plants can hybridize with other species, suggesting outcrossing is possible. Larson et al. (2001) report inbreeding in <i>N. pulchra</i> due to the very low nucleotide variation found within populations. They assumed the plants are self-pollinating because they found larger genetic differences among populations of <i>N. pulchra</i> than within populations, an observation that is consistent with inbreeding.
Hybridization potential	Hybridizes with <i>N. cernua</i> (2n= 70, Stebbins & Love 1941) and <i>N. lepida</i> (2n=34, Stebbins & Love 1941); the F1 hybrids exhibited superior growth (heterosis) in "vigor" but were sterile (Love 1946, 1954). Love (1946) notes that The 2n of <i>N. lepida</i> , <i>pulchra</i> , and <i>cernua</i> are 34, 64, and 70, respectively and that all behave cytologically as diploids. Love said the lowest chromosome species, <i>N. lepida</i> , was the best as a maternal parent. Avoid mixed plantings in areas where species do not overlap naturally.
Inbreeding and outbreeding effects	

BIOLOGICAL INTERACTIONS

Competitiveness	Once established, competition with annuals was found to be reduced due to deeper, fibrous roots of this species, and the perennial grasses can even suppress non-native annuals (Corbin & D'Antonio 2004a). However, others have found that plants can be vulnerable to competition from annuals at all phenological stages (Dyer 2003); competition from annual grasses can reduce seed production. Rice & Knapp (2008), found that survival and growth were significantly suppressed when young plants were planted into a matrix of vegetation compared to when planted into plots where vegetation had first been reduced. In addition, response to competitors varied with population. Plants have little effect on neighbors, but they are suppressed by neighbors (Thomsen et al. 2006). Invasive knapweeds such as <i>Centaurea solstitialis</i> (yellow star-thistle) and <i>C. melitensis</i> (tocalote) can form mycorrhizal connections between their roots and the roots of grasses that may influence competitive compensation following herbivory; however, established <i>N. pulchra</i> can be somewhat resistant to invasion by yellow star-thistle (Calloway et al. 2006); the larger the grasses, the lower the reproduction in the star thistle (Morgan & Rice 2005). In a greenhouse study, <i>N. pulchra</i> was grown with yellow star thistle after inoculation with native soil and exposed to clipping and fungicide treatments (Calloway et al. 2006). The two species competed, but tocalote reduced growth of <i>N. pulchra</i> more when tocalote was clipped and when soil fungi were reduced. Such interactions need to be understood if herbivores or mowing are used for control of yellow star thistle and tocalote invasions.
Herbivory, seed predation, disease	Small and medium sized mammals reduce seedling recruitment and plant establishment (Orrock et al. 2009).
Palatability, attractiveness to animals; response to grazing	Somewhat tolerant of grazing (Bartolome & Gemmill 1981), but in valley grasslands, stands increased in response to grazing exclusion (Hatch et al. 1999). Bartolome et al. (2004) found the greatest increase under spring grazing. Response may be timing and site specific.
Mycorrhizal?	Colonized by arbuscular mycorrhizae; inoculation does not overcome competition from <i>Avena barbata</i> (Nelson & Allen 1993).

ECOLOGICAL GENETICS

Ploidy	Diploid; 2n=64 (Stebbins & Love 1941). Study looked at five populations from Santa Barbara north.
Plasticity	In a reciprocal common garden study with coastal and Sierra Nevada foothill populations (Rice & Knapp 2008), culm (flowering stem) production of plants was different when grown in different environments, showing "phenotypic plasticity" for culm production. Progeny from some maternal families (siblings with the same mother) increased in their production of culms while other families did not. This variation in plasticity can be attributed to differences in the evolutionary history of populations, such as bottlenecks (Rice & Knapp 2008).
Geographic variation (morphological/ physiological traits)	In a study of eight populations in a common garden, variation in quantitative morphological traits (potentially adaptive traits) correlated with variation in climatic variables (Knapp & Rice 1998); plants produced from seeds from northern latitudes were taller and had heavier seeds than those from southern California. <i>N. pulchra</i> also responds to fire and grazing differently in different regions (Hatch et al. 1999). These data suggest that climatic and ecological data from the maps for Ecological Sections and Subsections (http://www.fs.fed.us/r5/projects/ecoregions/ca_sections.htm) may be useful for determining how to distribute seed collections for planting projects.
Genetic variation and population structure	Knapp & Rice (1998) studied isozyme variation in 10 populations distributed from San Diego county north to Tehama county to see if patterns might be useful in determining how to distribute seeds in planting projects; population elevations ranged from 15 to 2,000 ft (6-595 m). Northern and southern CA populations differed in allozyme frequencies. Significant levels of population structure were found; 57% of allozyme variation was attributed to differences among populations and 43% to differences within populations (Knapp & Rice 1998). Plants that have significant genetic structure may be most likely to have locally adaptive variation in traits that influence survival and reproduction. The degree of difference in allozyme variation, which is potentially neutral with respect to performance, also correlated with geographic distance between sites (Knapp & Rice 1998). It did not correlate with climatic data, which suggests some of the patterns observed in allozyme variation may be simply due to dispersal: plants closer together tend to be more similar to each other because seed and pollen dispersal influence the pattern of variation in allozymes more than other factors.

Phenotypic or genotypic variation in interactions with other organisms	No data found.
Local adaptation	In a reciprocal common garden study, plants grown from seed survived and performed better at the home site relative to the foreign site when plants were grown in a natural matrix of vegetation (under competition) (Rice & Knapp 2008). This suggests that plants have evolved and adapted to the competitive environment of the home site location.
Translocation risks	This is a widely distributed species that grows in many different environments. As such, there are substantial genetic differences among widely separated populations, some of which have been found to be adaptive (e.g., Knapp & Rice 1998, 2009, Rice & Knapp 2008). The scale of adaptive population differentiation has only been partially worked out. There has been much room for the evolution of adaptive differences among populations from contrasting climatic and biological environments, and common garden studies have revealed evidence for differences in adaptation between coastal and interior foothill populations. However, within population variation is low due to inbreeding, and reproduction is quite plastic. The rate of adaptation to new conditions is thought to be relatively slow, in part due to these factors, yet significant differences in phenotypic plasticity and production of flowering culms has been detected in plants from parents separated by only 3 km (Knapp & Rice 2009). Knapp & Rice (2009) emphasize that sampling of seeds for restoration may need to cover multiple subpopulations within ecologically similar areas within regions to ensure the samples are genetically diverse but not so broad as to be maladaptive. Given that plants can outcross, there is also the potential for mismatched plantings to hybridize and produce offspring that are less adapted than their parents or to suffer other detrimental genetic effects. It may be very important to collect sample seeds across multiple subpopulations to ensure diversity, but to stay within climatic zones and regions of potential adaptation. It may also be important to match the competitive environment of source collections to the recipient site.
SEEDS	Rancho Santa Ana Botanic Garden Seed Program, seed image: http://www.hazmac.biz/020904b/020904bNassellaPulchra.html
General	Standard minimum purity and germination has been reported as 90% purity/ 80% germination (Jody Miller, S&S Seeds, pers. com.), and 90% purity/ 70% germination (Stover Seed Company 2010). The twisting awn and pointed seed assist the seeds in self-burial (Steinberg 2002). Seed survivorship in the field can be as low as 0.7% (Fossum 1990, cited in Stromberg & Griffin 1996). Seeds are much smaller than those of some invasive exotic grasses such as <i>Bromus diandrus</i> and <i>Avena fatua</i> . Smaller seed size is sometimes associated with a decrease in the competitive ability of young plants relative to plants that establish from larger seeds (Stromberg & Griffin 1996).
Seed longevity	Under ambient warehouse conditions in Carpinteria, CA, seed test data for 9 seed lots showed that germination averaged 74.6% the first year and 64.9% the second year, a drop of 10.3% (Jody Miller, S&S Seeds, pers. com.). Seed germination for two seed lots of the related <i>N. cernua</i> was tested for four consecutive years and dropped from 89.5% to 76.0%. (Jody Miller, S&S Seeds, pers. com.).
Seed dormancy	No pre-treatment required for germination (Newton & Claassen 2003).
Seed maturation	Inflorescences become brown when the seeds are mature, and the seeds detach easily; seeds are light grey when mature (NPNPP 2010, A. Montalvo, pers. obs.).
Seed collecting	In the wild, seeds can be hand stripped or combed from inflorescences when seeds are ripe; whole inflorescences with ripe seeds can be cut and collected into open containers or breathable bags and thrashed later (A. Montalvo, pers. obs.).
Seed processing	Wall & Macdonald (2009) recommend rubbing the seeds over a large screen and then on a rubber mat to remove awns, followed by blowing the seeds with an Oregon Blower unit at speed 1.25 to remove chaff. Commercial seed processing facilities can de-awn seeds mechanically.
Seed storage	Cool, dry conditions are best. Longevity is likely to increase under cold, dry storage.
Seed germination	Seeds have slower germination than associated annual species (Bartolome & Gemmill 1981); seeds germinate readily unless under severe moisture stress (Bartolome & Gemmill 1981); germination was reduced on gopher tailings (Stromberg & Griffin 1996).

Seeds/lb	109,747 seeds/lb (Bishop 1996); 115,000 seeds/lb (Stover Seed Company 2010).
Planting	The awned seeds are capable of self-planting as the awn twists the seed into the soil (Steinberg 2002). Seeds planted with other species germinated faster than when alone (Dyer et al. 2001). In an experimental comparison of the effects of seed imprinting, drilling, and hydroseeding in western Riverside Co. near Hemet, plant densities resulting from hydroseeding were significantly lower than densities resulting from drilling and imprinting, methods that place or push seeds into the soil (Montalvo et al. 2002).
Seed increase activities or potential	Yes. Seeds have been in production for many years in Utah and CA and are available on the market. Some commercial seeds do not have source verification. Contracted grow outs of site specific seeds have been successful (A. Montalvo, pers. obs.; S&S Seeds, pers. com.). Two germplasm releases for the Central Valley region and one from more coastal Alameda Co. of CA are currently available from the NRCS, and several private seed companies regularly produce seeds from other original accessions. Isolation distances are needed between seed production plots due to hybridization with relatives (sterile hybrids produced). For this mixed mating, wind pollinated grass, at least 165 feet may be needed.
Other	Seedlings are negatively affected by alien annuals (Dyer & Rice 1997, Hamilton et al. 1999). Survival has been greatest in weeded plots, grazed plots, and in deeper soil plots (Dyer & Rice 1997). Spring burns and solarization have a positive effect on establishment (Moyes et al. 2005).
Seeding rate	Recommended seeding rates are variable and depend on the particular seed mixture and desired habitat outcome. In central California, a seeding rate of about 200,000 live seeds/acre in a 4-grass species mix has been used successfully to vegetate levees by drill seeding methods combined with extensive weed control and seedbed preparation (Anderson & Rominger 1998). Chan (1998) gives some methods for determining seeding rates and warns that rates should be site-specific and calculated on a live seed basis. The condition of the site is critical. Some sites may require 5 times as many live seeds as used in the levee planting, and others may require only a tenth the quantity. Too low a seeding rate may allow invasion of non-native grasses and other weeds, while too high a density is wasteful and can result in crowded plants and high seedling mortality when water or nutrients are limiting. In addition, the planting method can influence optimal seeding rate (Chan 1998, Montalvo et al. 2002). For <i>N. pulchra</i> , hydroseeding requires many more seeds than drilling.
USES	
Revegetation and erosion control	The strong root system is good for erosion control (Bishop 1996). The deep root system is a good soil stabilizer, and plants do well on shallow slopes and flats. Other species of <i>Nassella</i> (<i>N. cernua</i> , <i>N. lepida</i>) are more appropriate for dry slopes in low rainfall regions.
Habitat restoration	Recommended for restoration and land rehabilitation in many areas of California (Newton & Claassen 2003). Can plant as seeds or plugs, usually mixed with other grasses and forbs. If seeding, weed control is important because invasive species deter establishment. Seed drilling was about 6 times more effective than hydroseeding in a controlled study in western Riverside Co. (Montalvo et al. 2002). Rice straw has been recommended as mulch to decrease potential for weeds (Brown et al. 2000). Herbicide-sprayed plots enhanced growth and reproduction and lowered mortality (Marty et al. 2003). In experiments in southern CA, researchers found that broadcast application of glyphosate can be used to control invasive species without significant injury to <i>N. pulchra</i> (Bell et al. 2008).
Horticulture or agriculture	Plants are used in dry landscaping projects (Wasowski & Wasowski 1995, Greenlee 1992, O'Brien et al. 2006).
Wildlife value	Highly palatable to livestock and to wildlife (reviewed by Steinberg 2002). Food source for mule deer, pronghorns, and Tule elk and also used by jackrabbits, ground squirrels, kangaroo rats, and pocket gophers (Steinberg 2002).

Plant Material Releases by NRCS and Cooperators	There is a shortage of releases from southern CA populations; however, private seed companies sometimes produce seeds from collections made in southern CA (e.g., S&S Seeds, pers. com.). The following three releases are from areas that receive higher annual precipitation and shorter day lengths in the winter growing season than experienced by southern CA populations. Releases are listed by the Native Seed Network and their maps show the location of the source of the releases (NSN 2010). LK115d Germplasm; Selected, Tehama Co., CA, 1998. Source from ~ 2300 ft; mean ppt ~ 25 in/yr. LK215e Germplasm; Selected, Colusa Co., CA, 1998. Source from ~1280 ft; mean precipitation 19.8 in/yr. LK315d Germplasm; Selected, Alameda Co., CA, 1998. Source from ~ 2056 ft; mean precipitation 14-35 in/yr.
Ethnobotanical	Seeds used by native Americans as a food source (Marty et al. 2003).
ACKNOWLEDGMENTS	Partial funding for this project was provided by the U.S. Department of Agriculture, Forest Service, Pacific Southwest Region Native Plant Materials Program.
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LINKS TO REVIEWED DATABASES & PLANT PROFILES (last accessed September 2010)	
Fire Effects and Information System (FEIS)	http://www.fs.fed.us/database/feis/plants/graminoid/naspul/all.html
Jepson Flora, Herbarium (JepsonOnline)	http://ucjeps.berkeley.edu/cgi-bin/get_cpn.pl?34420
Jepson Flora, Herbarium 2nd edition Review	http://ucjeps.berkeley.edu/tjm2/review/treatments/poaceae_all.html#34420
USDA PLANTS	http://plants.usda.gov/java/links
Native Plant Network Propagation Protocol (NPNPP)	http://www.nativeplantnetwork.org/network/
Native Seed Network (NSN)	http://www.nativeseednetwork.org/viewtaxon?taxon_code=NAPU4&release_name=
GRIN	http://www.ars-grin.gov/cgi-bin/npgs/html/tax_search.pl
Grass Manual on the Web (FNA Grass Manual)	http://herbarium.usu.edu/webmanual/info2.asp?name=Nassella_pulchra&type=treatment
Plant Materials Release Information	http://www.nativeseednetwork.org/releases
Calflora	http://www.calflora.org/
Rancho Santa Ana Botanic Garden Seed Program, seed photos	http://www.hazmac.biz/rsabghome.html
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