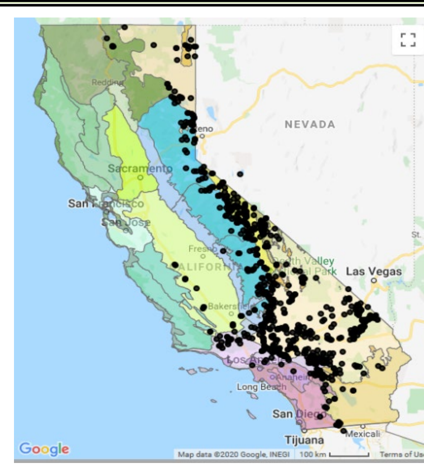
SPECIES	*Achnatherum hymenoides* (Roem. & Schult.) Barkworth **[= *Stipa hymenoides* Roem. & Schult]**
 Jose Hernandez @ USDA-NRCS PLANTS Database **NRCS CODE: ACHY**	Family: **Poaceae** Order: **Cyperales** Subclass: **Commelinidae** Class: **Liliopsida**   A. Montalvo, San Bernardino Mtns.
Subspecific taxa	None.
Synonyms	*Stipa hymenoides* Roem. & Schult., *Eriocoma cuspidata* Nutt., *Fendleria rhychelytroides* Steudel (FNA Grass Manual), *Oryzopsis hymenoides* (Roem. & Schult.) Ricker ex Piper (USDA PLANTS 2010, GRIN)
Common name	Indian ricegrass, mountain-rice; Indian mountain-rice grass, Indian millet, and silky mountain rice (Tirmenstein 1999).
Taxonomic relationships	Jones (1990) reports ACHY is allied with *Stipa arida* M.E. Jones, *S. coronata* Thurber, *S. lettermanii* Vasey, *S. nevadensis* B.L.Johnson, *S. occidentalis* Thurber, *S. pinetorum* M.E.Jones, *S. scribneri* Vasey, *S. speciosa* Trin. & Rupr., *S. thurberiana* Piper, *S. webberi* (Thurber) B.L. Johnson. Most of these species were reassigned to the genus *Achnatherum* (Barkworth et al. 2007).
Related taxa in region	In Barkworth et al. (2007) the following species of *Achnatherum* also occur in s. California: *Achnatherum* x *bloomeri* (Bolander) Barkworth, *A. aridum, A. coronatum, A. diegoense, A. latiglume, A. lemmonii, A. lettermanii, A. occidentale, A. parishii.* In addition, *Stipa* spp. *sensu lato* , *Nassella viridula* , and *Piptatherum micranthum* (Tirmenstein 1999) overlap with ACHY.
Taxonomic issues (3/25/2020 - see new link)	The Jepson Manual is recognizing *Achnatherum* as part of *Stipa* in the 2nd edition and is using the name *Stipa hymenoides* (see Jepson eFlora link).
Other	A hardy, highly drought-tolerant, cool-season bunchgrass that provides early season forage for many species of wildlife and livestock; seeds may look like grains of rice, hence the common name (Tirmenstein 1999).
Other (3/25/2020 note)	Detailed research has determined seed transfer zones for this taxon in the southwestern USA (Johnson et al. 2012). Please refer to this study for recommendations about seed transfer.
GENERAL	
Map (updated 3/25/2020))	Data provided by the participants of the Consortium of California Herbaria represent 1125 records with coordinate data of 1268 records retrieved; accessed 3/25/2020; Berkeley Mapper: https://ucjeps.berkeley.edu/consortium 

Geographic range	Wide distribution in western US east of the Cascade Range, southern Canada (Tirmenstein 1999), and in N. Mexico (Barkworth et al. 2007). Most common from the Rocky Mountains west, and especially common in the Great Basin (distribution mapped in Barkworth et al. 2007). Barkworth et al. (2007) suspect that some of the easternmost populations have been planted.
Distribution in California; Ecological section and subsection	Sierra Nevada Range, San Joaquin Valley, SW CA, Great Basin Floristic Province, Mojave Desert, and generally east of the Cascade Range in the north (Hickman 1993). Present in most Ecological Sections (Goudey & Smith 1994, Cleland et al. 2007), except those of the Central and Northern CA Coasts, Northern CA Coast and Interior Ranges, and Cascade Mountains. Can be dominant to co-dominant in stands within the Great Valley (262Aq), Mojave Desert (322Ai), Northwestern Basin and Range (342Ba, Be), Sierra Nevada (M261Ek) and Southwestern Great Basin (341Fb, Fc, Fe) (Sawyer et al. 2009).
Life history, life form	Polycarpic, perennial, highly tufted bunchgrass.
Distinguishing traits	Bunchgrass from 10-61 cm tall. Unlike most other *Achnatherum* , the inflorescence is an open, loosely branched panicle, 8-15 cm long with single-flowered spikelets at the end of long, slender, wavy, peduncles. The awn of the lemma is deciduous. The lemma is covered with dense, long hairs and is subtended by two, equal glumes that barely exceed the dense hairs of the lemma. The caryopsis falls readily from the spikelet at maturity.
Root system, rhizomes, stolons, etc.	Fibrous roots (Tirmenstein 1999).
Rooting depth	Deeply rooting (Tirmenstein 1999, actual depth not provided)
HABITAT	
Plant Association Groups	Occurs in many plant communities: Ponderosa pine, sagebrush, desert shrub, chaparral-mountain shrub, pinyon-juniper, plains grasslands, prairie, desert grasslands (Tirmenstein 1999). Occurs as a dominant or co-dominant in the *Achnatherum hymenoides* herbaceous alliance in eastern California and in the Great Valley, but such stands are much more common in the Great Basin (Sawyer et al. 2009).
Habitat affinity and breadth of habitat	Dry, well drained, sandy soil in desert shrub, sagebrush shrubland, pinion/juniper (Hickman 1993)
Elevation range	Below 3400 m (Hickman 1993) but generally above 400 m (Sawyer et al. 2009).
Soil: texture, chemicals, depth	Associated with sandy, arid soils; can withstand alkali, salt, and low fertility soils (Tirmenstein 1999). Occasionally found in clay soils (Jones 1990).
Drought tolerance	High (Blank & Young 1992). One of the most drought tolerant native grasses (Tirmenstein 1999).
Precipitation	Low. In ecological regions of California with as low as 4 to 12 inches precipitation.
Flooding or high water tolerance	No.
Wetland indicator status for California	Upland (USDA PLANTS 2010).
Shade tolerance	Full sun.
GROWTH AND REPRODUCTION	
Seedling emergence relevant to general ecology	Seedling emergence is generally in the cool, spring season. Seeds planted in the fall tend to emerge more successfully than those planted later (in Jones 1990).
Growth pattern (phenology)	Cool season bunch grass with green shoots produced when soil temperatures at 15 cm reach 4°C for three to four days (Pearson 1979), but vernalization is not required for initiation of flowering (Jones 1990). Flowering occurs before summer drought, but will continue into the fall if temperatures remain cool (Jones 1990, Tirmenstein 1999). Flowers are produced sequentially over a long season; seeds mature quickly, but their maturation is staggered (Jones 1990). Flowering time varies depending on elevation, latitude, and rainfall patterns. At lower elevations, plants may flower in late winter if precipitation comes early and winter weather has been mild (Montalvo pers. obs.).
Vegetative propagation	
Regeneration after fire or other disturbance	Seedling emergence was higher when seeds were germinated in artificially burned soil or exposed to smoke (Blank & Young 1998); Smoke increases aboveground biomass and shoot to root ratio (Blank & Young 1998). This species was locally abundant the first year after a fire near the upper Kern River, then disappeared (Forest Service unpublished report, Jan Beyers pers. obs.).
Pollination	Pollen is wind dispersed, but flowers may be primarily self-pollinated (Jones and Nielson 1989).

Seed dispersal	Primary dispersal is likely a combination of wind and gravity with secondary dispersal by animals and water (see Tirmenstein 1999). Kangaroo rats scatter-hoard seeds and enhance seedling establishment, whereas seeds cached by ants seldom produce seedlings (enclosure study in NV, Longland et al. 2001).
Breeding system, mating system	Self-compatible, perfect flowers, with some cleistogamy (Jones & Nielson 1989, Jones 1990). Pollination studies of the cultivar 'Paloma' indicate the plants are self-compatible and that flowers may be primarily self-pollinated (Jones & Nielson 1989). Populations show more morphological variation among populations than within populations, suggesting that populations are inbred (Jones & Nielson 1989). Fryxell (1957) had listed *Oryzoposis hymenoides* as self-incompatible.
Hybridization potential	Barkworth et al. (2007) report that numerous hybrids form between ACHY and other members of the Stipeae, many of which are sterile. For example, ACHY hybridizes with *A. occidentale* and other species of *Achnatherum* as well as *Nassella viridula.* It also hybridizes with *Piptatherum micranthum* to make *Achnatherum contractum* (a fertile hybrid) (Tirmenstein 1999). Hybridizes with several species of *Stipa* (*Nassella*) (Johnson & Rogler 1943, Johnson 1963), but most hybrids are sterile.
Inbreeding and outbreeding effects	Seed production in 'Paloma' was not inhibited by self-pollination relative to open-pollination (Jones & Nielson 1989).
BIOLOGICAL INTERACTIONS	
Competitiveness	Presence of non-native *Bromus madritensis* ssp. *rubens* has negative effect on relative growth rate (field experiment in southern NV, DeFalco et al. 2007).
Herbivory, seed predation, disease	Seed predation by ants, birds, and rodent granivores (Kelrick et al. 1986, Longland et al. 2001). Longland & Bateman (1998) examined seed caching of ACHY by rodents and examined if millet could be used as a decoy food resource during rangeland restoration. ACHY was preferred and cached more frequently than millet, therefore millet was not likely to serve as a decoy.
Palatability, attractiveness to animals; response to grazing	Highly palatable to livestock (Jones 1990). Heavy grazing does not have a significant effect on root and shoot biomass of native plants (field experiment in NM, Orodho & Trlica 1990). History of grazing does not negatively affect seed production (Orodho et al. 1998). Other studies have found increase when grazing was eliminated (Tirmenstein 1999).
Mycorrhizal? Nitrogen nodules?	Plants are mycorrhizal (Jones 1990; Allen 2001, Hawkes et al. 2006). There is also a nitrogen fixing soil layer (rhizosheaths) on roots (Wullstein 1980).
ECOLOGICAL GENETICS	
Ploidy	2n=46,48 (Hickman 1993).
Plasticity	
Geographic variation (morphological and physiological traits)	Plants from different source populations varied in seed shape, palatability, and leaf shape in common gardens planted in NE and WY with seeds collected from 106 locations in western North America (Bohmont & Lang 1957). There was no obvious geographic pattern to degree of palatability or growth habit.
Genetic variation and population structure	Polymorphisms in seed size were found for T-593 population collected in 1988, NM; 'Rimrock' was nonpolymorphic (Jones & Nielson 1999). Heritable genetic variation for seed dormancy exists in 'Rimrock' (Jones & Nielson 1999) and there is a seed size and color polymorphism for 'Paloma' and 'Nezpar' (Young & Evans 1984). Both polymorphic (T-593 population in NM) and nonpolymorphic ('Rimrock') variation in seed size influence variance associated with seed dormancy (Jones & Nielson 1999). Elongate seeds had higher rates of germination than the more round (globose) seeds (Jones & Nielson 1999).
Phenotypic or genotypic variation in interactions with other organisms	Bohmont and Lang (1957) studied variation in palatability among 50 geographic strains from 106 seed accessions from 14 states and Canada. The strains were grown in experimental field plots located in NE and WY. Many morphological variations, including growth habit, height, leaf margins, leaf size, and seed size and shape were observed among the 12 strains monitored for these traits. Palatability to rabbits was found to vary considerably among strains.
Local adaptation	The cultivars 'Nezpar' and 'Paloma' (from ID and CO populations, respectively) produced fewer roots than a native strain in a local study in NM (Orodho & Trlica 1990). There was greater seed viability in native compared to cultivated plants of 'Paloma', but not for 'Nezpar' (test plots in Chaco Canyon, NM and Cortez, CO, Orodho et al. 1998). In a study that focused on palatability, seeds were collected from 106 locations in western North America, and 50 strains were grown in common gardens in both NE and WY (Bohmont & Lang 1957). The ranking of 12 strains as to palatability to rabbits was very similar for tests done in both locations, suggesting that differences may be under genetic control. The adaptive significance was not examined.

Translocation effects/risks (note added 3/25/2020)	Seed dormancy and seed shattering may be important adaptive traits. Studies are needed to see if there are detrimental effects to translocating low seed dormancy and low seed shattering populations into areas where seed dormancy and seed shattering of native populations is high. See Johnson et al. (2012 for seed transfer zones for the southwestern United States.
SEEDS	Rancho Santa Ana Botanic Garden Seed Program images by John Macdonald, http://www.hazmac.biz/seedphotoslistgenus.html see also: https://npgsweb.ars-grin.gov/gringlobal/uploads/images/npgs/w6/native_pic05/27070s.jpg 
General	Plants tend to produce a high proportion of empty seeds (in Jones 1990). High rates of seed dormancy had hindered the production of plant materials and success of many planting projects but seed increase fields have been becoming successful in recent years. Farmed seeds can be cleaned to high purity and germination percentages.
Seed longevity	Seed can remain viable at least 14-20 years when kept cool and dry (Tirmenstein 1999); > 30% germination reported for seeds up to 26 years old, but <10% germination after 12 years also reported (Jones 1990). Monsen et al. (2004c, v.3, p.731) reports 49% germination after 14 years of storage in an open warehouse. Hassen and West (1986) reported viable seeds in the natural soil seed bank after fire in sagebrush scrub in Utah.
Seed dormancy	High. Breaking the combination of mechanical and physiological seed dormancy has proven difficult and variable. Baskin and Baskin (1998) report that Clark and Bass (1970) had improved germination for seed testing under alternating day length and temperature (15°C/5°C; light longer than dark). Rogler (1960) found germination increased with age of seeds up to six years. Jones (1990) reviewed the treatment times and effectiveness of a variety of dormancy-breaking treatments. Variation among populations in seed size and lemma thickness may influence the amount of time needed for various treatments, such as soaking in sulfuric acid. Scarification (mechanical or sulfuric acid treatment) can reduce physical (mechanical) dormancy, and cold stratification, gibberellic acid or kinetin can reduce the physiological (embryo) dormancy (Jones 1990, Jones & Nielson 1992). There is heritable variation in seed dormancy, and dormancy can be selected for or against (study using 'Rimrock', Jones & Nielson 1999); Seed dormancy phenotype is an important adaptive trait for natural populations, so it is important to find ways to break seed dormancy for seeds planted for agricultural increase and possibly for initial wildland plantings if seeds are to be used in erosion control.
Seed maturation	Inflorescences shatter when seeds are mature. The empty seeds tend to stay on plants longer than the heavy, filled seeds (Jones 1990).
Seed collecting (wild)	McDonald et al (1977) developed a simple hand-made tool for seed gathering. Using the tool, in one day a single person can field-collect enough material to clean to 3-5 lbs. The method reduces the amount of screening and air separation by about two thirds compared to other bulk-collection methods.
Seed harvesting	The Las Lunas Plant Materials Center (PMC) in NM harvested 2008 production fields with a flail vacuum harvester (USDA_NRCS 2008). Aberdeen PMC has harvested seeds from production fields with direct combining (Cornforth et al. 2001). Wildland seeds can be hand-collected into paper bags or other open containers.
Seed processing	Wall and MacDonald (2009) recommend rubbing floral material over a medium screen and then a #10 sieve and then using a blower at speed 1.25 to 2.0 (Oregon Seed Blower unit speed) to remove remaining chaff. The Bend Seed Extractory in OR (NPNPP, Barner 2007) used a brush machine and then air screened seeds.
Seed storage	Seeds store well under open warehouse conditions (Monsen et al. 2004 v.3, p.731), but cool (33-38ºF) dry storage may increase duration of seed viability (NPNPP, Barner 2007) .
Seed germination	Prechilling improves germination (Jones & Nielson 1999). Scarification improves germination (Griffith & Booth 1988). Germination rates are higher for elongate seeds compared with globose seeds (Jones & Nielson 1999); germination rates increase with time since harvest (Jones & Nielson 1999); germination of 'Rimrock' relatively was low (~20%, Jones & Nielson 1999); germination rates increased when sown in soils that were not saturated or oversaturated (Blank & Young 1992); <50% germination was achieved for 'Nezpar' and 'Paloma' (Young & Evans 1984); and germination is higher in light conditions (Baskin & Baskin 2002).
Seeds/lb (note corrected PLS/lb)	161,920 seeds/lb (NSN 2010). There may be variation in seed weight associated with seed morphology. S&S Seeds (2010) lists 110,000 seeds/ pure live seed lb. Barner (2007) reported 105,240 seeds/lb for 84% filled seeds at 99% purity.

Planting	Aberdeen PMC recommends: plant in dormant season (generally late October to December) to allow natural cold stratification of seeds over winter (Cornforth et al. 2001); seeding rate of 3.5 lbs of pure live seed (PLS)/ac, in rows with about 25 to 30 PLS per linear foot; plant seeds 2 to 3 inches deep; space rows from 36 inches to 48 inches depending on average rainfall (wider for lower rainfall if dry farming). Average depth of seed germination was 2.3 inches (depth of seed germination for 250 seedlings determined by excavation (NV, Kinsinger 1962). Thompson et al. (2006) note that ACHY emerges from greater depths than most other species and has been shown to emerge best from an average depth of 5 cm and up to 15 cm in sandy soil. Porous, well drained substrates increase rates of seed germination (Blank & Young 1992). Seeds have been planted with a rangeland drill or by broadcasting, including aerial seeding followed by chaining. Plantings of 'Nezpar' were highly successful when drilled into sandy soils of big sagebrush communities after fire (Thompson et al. 2006). 'Secar' also emerged well in the aerial seeded plots.
Seed increase activities or potential	Potential is high. Jones (1990) reported that seeds can be relatively expensive, primarily due to practical difficulties associated with seed dormancy, indeterminate flowering, and poor seed retention. Some difficulties have been overcome with knowledge about how to break seed dormancy for seed production fields. Most seed production studies have been in the Great Basin and in New Mexico. A 0.3 ac irrigated field planted by Las Lunas PMC for the Organ Pipe National Monument produced 64.14 lbs of healthy and vigorous cleaned seed, and a 0.5 ac field for Zion National Park produced 79.04 lbs of bulk seed (USDA_NRCS 2008). Aberdeen PMC reports an average seed yield of 100 lbs/ac (dryland farmed) and 250 lbs/ac (irrigated field) after seeding with 3.5 PLS lb/ac (Cornforth et al. 2001). The Upper Colorado PMC planted seed into 0.24 ac (1.42 lbs of seeds with about 30 seeds/linear ft. in 8 rows) in Nov. 1997. Seeds harvested in July of 1999 to 2007 as lbs cleaned seed/yr were: 1.24, 0.97, 0.97, 3.6, 8.0, 10.0. 12.0, 5.6, and 8.0 lb. (Noller 2007). The % pure live seed (PLS) for 8 harvests averaged 46.2% and ranged from 30.9 to 67.9% (testing method and age of tested seeds not provided). The Boise Plant Materials Center reported an average seed yield in irrigated fields of 200 lbs/ac (irrigated) and 100 lb/ac (dry land). Seed increase of seed accessions from southern California desert regions and the eastern edges of the South Coast Region needs to be explored.
Other	Breeder stock field of 'Nezpar' Indian ricegrass from ID was established in 1997 (St. John 1998). Seed was stratified under cool, moist conditions (40ºF) for 30 days before planting into "Jiffy-pellets" in a greenhouse. Emergence rate was not reported. Fields were successfully established in mid May by transplanting the pellets after about 2.5 months of greenhouse growth. Plants were spaced 3 x 3 foot centers and irrigated. By late July 16% had died. Plants were then further selected by culling another 19% during evaluation. A total of 35% of the plants either died or were removed in the highly selected process.
USES	
Revegetation and erosion control	Desirable in past for revegetation of mines (Jones 1990). Used successfully in Utah studies of postfire rehabilitation seeding of big sagebrush areas in 1999 (Thompson et al. 2006). Good for soil erosion control in disturbed areas with dry, porous soil (Hickman 1993, Newton & Claassen 2003), but according to Tirmenstein (1999) not able to stabilize sandy areas.
Habitat restoration	Used in past for revegetation of inland dunes (Jones 1990). This species is on many seed palettes for dry land restoration and rehabilitation in the southwestern US and is listed by Newton and Claassen (2003) for rehabilitation of Californian disturbed lands with dry, sandy soil in desert shrub, sagebrush scrub, and pinyon-juniper within the Mojave Desert, Sonoran Desert, and Great Basin Floristic Province.
Horticulture or agriculture	See planting and seed harvesting above. Dryland farming is recommended only if annual rainfall averages at least 16 in/yr (Cornforth et al. 2001). At Aberdeen PMC, Cornforth and others applied approximately 3 in water per application 3 to 4 times (based on soil traits) before the flowering season. Farming in southern California may require irrigation to ensure at least 16 inches of precipitation during the season of vegetative growth.
Wildlife value	Forage (Jones 1990, Abella 2008). Barkworth et al. (2007) report that ACHY is one of the most palatable native grass species for livestock. Important winter forage plant for a variety of livestock and wildlife; plants produce green leaves early in the season used by livestock, pronghorn, desert bighorns, elk, bushy-tailed wood rats, spotted ground squirrels, black-tailed prairie dogs, and jackrabbits (Tirmenstein 1999). Grazing by wild burrows can decimate desert reserve populations (Loope et al. 1988). Seeds are eaten, and often preferred, by a variety of birds, heteromyid rodents, deermouse, Uinta ground squirrel, and least chipmunk (Kelrick et al. 1986, Tirmenstein 1999).
Plant material releases by NRCS and cooperators	There is natural genetic variation in seed shattering and seed dormancy in this species that is selected against in production of cultivars. Both traits may be adaptive in natural populations and important when doing ecological restoration. Some cultivars may be more appropriate for use in pastures. 'Bonneville', selected UT, population at 4375 ft elevation, released 2004, UT, not currently available 'Nezpar', collection from ID, selected from 152 accessions, released 1978 by PMC ID 'Paloma', collection from CO, released 1974 with SCS and NM and CO AESs 'Rimrock', source Yellowstone Co., MT, released 1996, Bridger PMC 'Star Lake', selected, source NM, released in 2004, USDA UT, not currently available (Jones et al. 2005) 'White River', selected, CO, released 2004, USDA UT, not currently available Ribstone germplasm released in 2003, highly selected class of certified seed, source UT (Jones et al 2004)

Ethnobotanical	Seeds commonly used for food by native Americans (Barkworth et al. 2007). The common names for this species allude to its use for food. Many different tribes utilized the seeds (see NAE database: http://naeb.brit.org).
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LINKS TO REVIEWED DATABASES & PLANT PROFILES

(urls updated 3/25/2020)

Fire Effects Information System (FEIS)	https://www.fs.fed.us/database/feis/plants/graminoid/achhym/all.html
Jepson Flora, Herbarium (JepsonOnline) updated taxonomy	https://ucjeps.berkeley.edu/cgi-bin/get_cpn.pl?45649
Jepson Flora, Herbarium, 2nd Edition Review (JepsonOnline 2nd Ed)	Link no longer active. See Jepson eFlora, below
Jepson eFlora	https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=45649
USDA PLANTS	https://plants.usda.gov/core/profile?symbol=ACHY
USDA PLANTS plant guide	https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/idpmcpg11641.pdf
Native Plant Network Propagation Protocol Database (NPNPP)	https://npn.rngr.net/propagation/protocols
Native Seed Network (NSN)	https://nativeseednetwork.org/
GRIN	https://npgsweb.ars-grin.gov/gringlobal/search.aspx?
Grass Manual on the Web (FNA Grass Manual)	http://herbarium.usu.edu/Webmanual_details (not available-- see FNA link below)
Flora of North America (FNA) (online version)	http://beta.floranorthamerica.org/Achnatherum_hymenoides
Native American Ethnobotanical Database (NAE)	http://naeb.brit.org/uses/search/?string=Achnatherum
Calflora	https://www.calflora.org//
Rancho Santa Ana Botanic Garden Seed Program, seed photos	http://www.hazmac.biz/rsabghome.html
Images	

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