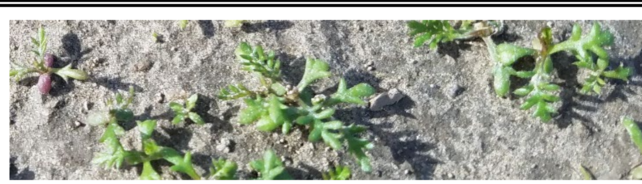
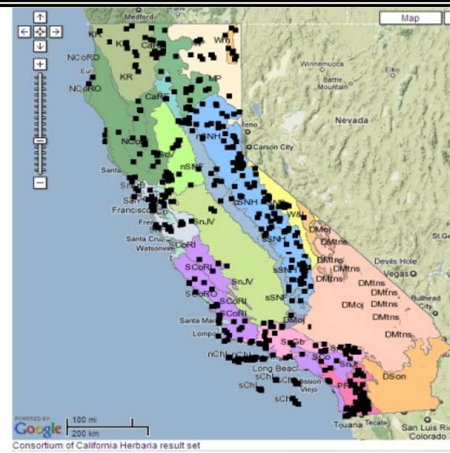
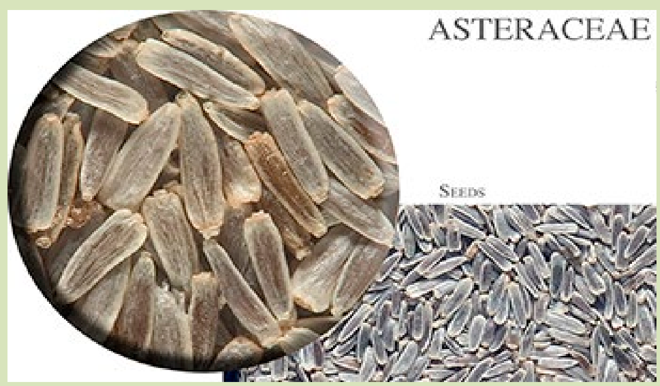
SPECIES	*Achillea millefolium* L.
USDA CODE: **ACMI2** **FEIS CODE:** **ACHMIL**	Tribe: **Anthemideae** Family: **Asteraceae** Order: **Asterales** Subclass: **Asteridae** Class: **Magnoliopsida**  D. Kopp 2009 San Bernardino Mtns.  A. Montalvo 2010 Monterey Co. coast; tripinnate, pubescent form   A. Montalvo 2010 Monterey Co.
Subspecific taxa **NRCS CODES:** **1. ACMIM2** **2. ACMIA** **3. ACMIA2** **4. ACMIC** **5. ACMIG** **6. ACMIO** **7. ACMIP** **8. ACMIP2** **9. ACMIB** **10. ACMIL2** **11. ACMIM5** **12. ACMIN**	JepsonOnline 2010 and FNA 2010 do not recognize subspecific taxa of *A. millefolium* . The USDA PLANTS database (viewed Sept. 24, 2010) recognizes 12 subspecific taxa as occurring in North America: Taxon introduced and naturalized in North America (thought to be native to Europe): 1. *A. m.* L. var. *millefolium* Taxa native to California: 2. *A. m.* L. var. *alpicola* (Rydb.) Garrolt 3. *A. m.* L. var. *arenicola* (Heller) Nobs 4. *A. m.* L. var. *californica* (Pollard) Jepson 5. *A. m.* L. var. *gigantea* (Pollard) Nobs 6. *A. m.* L. var. *occidentalis* (DC.) Hyl. 7. *A. m.* L. var. *pacifica* (Rydb.) G.N.Jones 8. *A. m.* L. var. *puberula* (Rydb.) Nobs. Additional taxa outside California (mostly northerly): 9. *A. m.* L. var. *borealis* (Bong.) Farw. 10. *A. m.* L. var. *litoralis* (Ehrend.) Nobs 11. *A. m.* L. var. *megacephala* (Raup) Bolvin. 12. *A. m.* L. var. *nigrescens* E. Mey.
Synonyms (USDA PLANTS) Taxa numbered as above	2. *A. alpicola* (Rydb.) Rydb.; *A. fusca* Rydb.; *A. lanulosa* Nutt. ssp. *alpicola* (Rydb.) D.D. Keck; *A. l.* Nutt. var. *alpicola* Rydb.; *A. m.* L. var. *fusca* (Rydb.) G.N. Jones; *A. subalpina* Greene 3. *A. arenicola* A. Heller; *A. borealis* Bong. ssp. *arenicola* (A. Heller) D.D. Keck; *A. b.* Bong. var. *arenicola* (A. Heller) J.T. Howell; *A. m.* L. var. *maritima* Jeps. 4. *A. borealis* Bong. ssp. *californica* (Pollard) D.D. Keck; *A. b.* Bong. var. *c.* (Pollard) J.T. Howell; *A. californica* Pollard 5. *A. gigantea* Pollard 6. *A. angustissima* Rydb.; *A. aspleniifolia* auct. non Vent.; *A. eradiata* Piper; *A. gracilis* Raf.; *A. lanulosa* Nutt.; *A. l.* Nutt. ssp. *typica* D.D. Keck; *A. l.* Nutt. var. a*rachnoidea* Lunell; *A. l.* Nutt. var. *eradiata* (Piper) M. Peck; *A. laxiflora* Pollard & Cockerell; *A. m.* L. ssp. *lanulosa* (Nutt.) Piper; *A. m.* L. ssp. *occidentalis* (DC.) Hyl.; *A. m.* L. ssp. *pallidotegula* B. Boivin; *A. m.* L. var. *aspleniifolia* (Vent.) Farw.; *A. m.* L. var. *gracilis* (Raf.) Raf. ex DC.; *A. m.* L. var. *lanulosa* (Nutt.) Piper; *A. m.* L. var. *rosea* (Desf.) Torr. & A. Gray; *A. m.* L. var. *russeolata* B. Boivin; *A. occidentalis* (DC.) Raf. ex Rydb.; *A. rosea* Desf.; *A. tomentosa* Pursh, non L. 7. *A. pacifica* Rydb. 8. *A. puberula* Rydb. 9. *A. borealis* Bong; *A. borealis* Bong. ssp. *typica* D.D. Keck; *A. m.* L. ssp. *atrotegula* B. Boivin; *A. m.* L. ssp. *borealis* (Bong.) Breitung; *A. m.* L. var. f*ulva* B. Boivin; *A. m.* L. var. *parviligula* B. Boivin; *A. m.* L. var. *parvula* B. Boivin 10. none listed 11. none listed 12. *A. nigrescens* (E. Mey.) Rydb.

Common name Taxa numbered as above	yarrow, western yarrow, common yarrow, wooly yarrow; milenrama, milfoil (USDA PLANTS 2009); bloodwort, carpenter's weed, hierba de las cortaduras, plumajillo, thousand leaf (DiTomaso and Healy 2007). The following subspecific taxa have been assigned common names in USDA PLANTS (2009): 1, 2, 3, 8, 12: Common yarrow 4. California yarrow 5. giant yarrow 6. western yarrow 7. Pacific yarrow 9. boreal yarrow 10. coast yarrow
Taxonomic relationships	The Jepson Manual and FNA currently recognize one morphologically variable species of *Achillea* in California. FNA recognizes three more species of *Achillea* outside California within North America, including *A. alpina* L. (ND, AK, MN, Canada, Asia, 2n=36), *A. nobilis* L. (naturalized in MT, introduced from Europe, 2n=18, 27), and *A. ptarmica* L. (naturalized in northern states and Canada, introduced from Eurasia, 2n=18). Ramsey et al. (2008) suggested that the North American *Achillea* species be reassigned to *A. borealis* due to significant divergence from the European lineages of *A. millefolium*; their CpDNA work supports that the North American clades of ACHMI2 are distinct from European clades. Their work also supports that there has been extensive ecological divergence into multiple ecotypes as explained in classic studies of this species (e.g., Clausen et al. 1948, Heisey & Nobs 1970).
Taxonomic issues	The taxonomy for this morphologically diverse species is complex and difficult (Clausen et al. 1940, 1948), as is obvious from the many synonyms and differences among authorities in recognition of subspecific taxa. Populations vary in ploidy and plant stature, and the leaves are extremely variable in size, degree of dissection, and pubescence. Many ecological races and varieties have been designated, but they tend to intergrade. Munz (1974), like USDA PLANTS (2009), recognized several subspecific taxa and that *A. m.* var. *millefolium* is native to Europe. Ramsey et al. (2008) found significant differences in North American and European clades, supporting taxonomic separation. Munz (1974) and USDA PLANTS (2009) recognize five and four varieties, respectively, of *A. millefolium* native to southern California. Munz noted that the various varieties intergrade, and many individuals cannot be assigned to a particular variety. In contrast, treatments in Hickman (1993) and the FNA (2010) recognize a single species without subspecific taxa for the whole of California and do not incorporate ecologically significant morphological differences into the taxonomy. The European plant has escaped cultivation and naturalized in some areas of the US (USDA NRCS PLANT FACT SHEET, Tyrl 1975), which may further confuse the taxonomy. Recognition of subspecific taxa or ecotype designations, however, can increase awareness of the rich, ecologically important variation in this species and help to guide the development and use of appropriate plant materials.
Related taxa in region	USDA PLANTS recognizes five varieties native to southern California including: 3. *A. m.* var. *arenicola* 4. *A. m.* var. *californica* 5. *A. m.* var. *gigantea* (also recognized by Ramsey et al. (2008) as in southern California) 6. *A. m*. var. *occidentalis* (in Munz = *A. m.* var. *lanulosa*) 7. *A. m.* var. *pacifica* Munz recognized all but var. *gigantea* for southern California. Non-native *A. millefolium* var. *millefolium* occurs as an escape in southern California.
Invasive potential	The introduced *A. millefolium* var. *millefolium* from Europe is thought to be invasive. In addition, plants from urban plantings of the European taxon and various horticultural selections are known to escape into the wild and elsewhere (USDA PLANTS 2009: USDA NRCS PLANT FACT SHEETS, USDA NRCS PLANT GUIDES).
Other	This plant may be useful for planted buffers where low flammability is important, because the plants are not highly flammable. Western yarrow scored lowest for potential ignitability in a study of 14 species where ignitability was measured as time to ignition (Aleksoff 1999). Northern yarrow (*A. m.* var. *borealis*) in Maine is a species of Special Concern (Aleksoff 1999). Further collection from distinct ecological regions, seed increase, and use of regionally local seed accessions for restoration would help to preserve the rich variation in this species. Development of official releases from distinct ecological regions would help to realize biodiversity goals in planting projects.
	Seedlings emerging in a water quality basin in January in Riverside, California (A. Montalvo). 

GENERAL	
Map	Data provided by the participants of the Consortium of California Herbaria represent 616 records with coordinate data out of 1230 total records retrieved; data accessed 3/9/10. Data include synonyms of *A. millefolium* as per JepsonOnline because few specimens have variety designated. See Berkeley Mapper: http://ucjeps.berkeley.edu/consortium 
Geographic range	Numbers refer to subspecific taxa listed above. 1. Widespread; north temperate species native to Europe and Asia; thought to be naturalized throughout North America and Canada; also naturalized in Australia and New Zealand (Mabberly 2008). 2. Widespread in western US including AK, CA, OR, WA, MT, AZ, NV, CO, NM, UT 3. Restricted, CA (coastal Santa Barbara Co., north to Humboldt Co.) 4. CA north to WA and ID 5. Restricted, CA 6. Widespread throughout the US and Canada 7. CA north to AK, incl. ID 8. Restricted, CA (coastal north central) 9. WA, Great Lakes states, AK, Canada 10. OR 11. Restricted, central Canada 12. Canada
Distribution in California; Ecological section and subsection	Ecological Subsection (http://www.fs.fed.us/r5/projects/ecoregions/ca_sections.htm): At least one taxon of the species complex occurs in each ecological region of California, except for deserts (322 A,B,C). See "Habitat affinities" section for more detailed distribution information.
Life history, life form	Polycarpic, low growing perennial herb with spreading rhizomes.
Distinguishing traits	The simple, alternate and finely pinnately dissected to tripinnate leaves look "feathery" or "fernlike" and are aromatic and occur mostly in rosettes; the erect, nearly scapose inflorescence bears a flat, to slightly domed cluster (coryumb) of many small heads. Flowers are generally creamy to white, but many color variations occur.
Root system, rhizomes, stolons, etc.	Rhizomatous, sometimes stoloniferous (FNA 2009); Fibrous roots but sometimes with a central taproot (var. *californica*) or deep taproot (var. *gigantea*) (Ramsey et al. 2008).
Rooting depth	Average rooting depth is 5 to 11.5 cm, with maximum penetration to 21.5 cm, and average spread of roots 9.0 cm (Warwick & Black 1982). Spence (1937) found the semi-fibrous root system of *A. lanulosa* exceeded a depth of 100 cm in studies in Idaho.
HABITAT	
Plant association groups	The species complex occurs in many plant communities, including in southern California coastal sage scrub, chaparral, yellow pine forest, mountain grasslands and meadows, wet grasslands, and edges of coastal salt marsh.
Habitat affinity and breadth of habitat	Species as a whole: widespread in many habitats, with separation into many ecological variants (Hickman 1993); found in meadows, roadsides, woodlands, waste grounds, sandy, dry, damp, clay, saline soils (FNA 2009). According to Ramsey et al. (2008), there is some evidence for plants of different ploidy levels to be associated with particular habitats, including: var. *alpicola* (4x) in alpine meadows, var. *lanulosa* (4x) in sagebrush steppe, var. *littoralis* (4x) in northern coastal grasslands, var. *puberula* (4x) in salt marshes, var. *californica* (6x) in oak woodlands, var. *arenicola* (6x) in pine forests, and var. *gigantea* (6x) taprooted and in freshwater ponds.

Habitat affinity and breadth of habitat (…continued)	Munz (1974) notes the following habitat and morphological affinities for the four varieties that he recognized as native to southern California: var. *arenicola* , densely white-villous plants with brown-margined phyllaries of the sandy coastal strands of San Miguel and San Nicolas islands, leaf segments fleshy, tripinnately dissected with primary pinnae perpendicular to main axis, others crowded, with mucronate tips; var. *lanulosa,* gray, often wooly plants of yellow pine forests and with brown-edged phyllaries, with leaf segments finely dissected into linear segments and prominently spine-tipped; var. *pacifica* , plants less grayish than var. *lanulosa* from mountains of San Diego Co., with somewhat clear to straw colored phyllaries, leaf segments as in var. *californica* ; and var. *californica* , a generally greenish plant (sometimes grayish), mostly below 2500 ft. in coastal sage scrub and chaparral, and with brown-margined phyllaries, leaf segments finely dissected, linear, and "spine"-tipped.
Elevation range	Sea level to 3500 m (Hickman 1993)
Soil: texture, chemicals, depth	Plants occupy a range of soils including dry and sandy, gravely loam, silty, serpentine (USDA Plant Guide, Warwick & Black 1982).
Drought tolerance	Some ecotypes are more drought tolerant than others. In southern California lowlands, plants tend to be found in moist swales and meadows. Southern California lowland populations that occur away from water are likely the most drought tolerant. A variety in Canada is drought tolerant and can withstand long periods without precipitation (Warwick & Black 1982).
Precipitation	In southern CA away from the coast, most native populations occur above 3,000 feet where precipitation is higher than in the lowland valleys.
Flooding or high water tolerance	Depends on ecotype.
Wetland indicator status for California	Facultative Upland (all varieties, USDA PLANTS).
Shade tolerance	This colonizing species is generally found in sun (Clausen et al. 1940); plants are not tolerant of dense shade according to Aleksoff (1999). However, plants were found to be somewhat shade tolerant in a New Zealand study (grown in shade houses, Bourdot et al. 1984). The origin of plants in this study was not indicated.
GROWTH AND REPRODUCTION	
Seedling emergence relevant to general ecology	Seedlings emerge quickly once proper temperature and moisture conditions are met. Seedlings are competitive. In tests, seeds germinate in 2 to 8 days, and average is 5 days (USDA PLANT GUIDES available from USDA PLANTS 2009).
Growth pattern (phenology)	Seeds tend to germinate April-May. Plants tend to flower in their second spring to summer, with flowering reported from April to September depending on location: July-Aug (Bostock 1978, Hickman 1993); *A. m.* var. *californica* flowers March-June (Ramsey et al. 2008); in Utah flowering is continuous from May to September, with most flowering May 1 to June 30 (Stevens et al. 1996). Aleksoff (1999) summarized growth and flowering data for different areas; the data show that timing of growth, flowering, and seed maturation follows trends based on elevation and latitude. Ramsey et al. (2008) also noted that timing of flowering and fruiting depends on location and ecotype. Fruits mature May-October (England, Bostock 1978), August-September (Canada, Warwick and Black 1982), or primarily mid August to mid September (Utah, Stevens et al. 1996). Green leaves and growth occur year round in temperate climates, but plants growing in mountain areas with snow will become dormant during the winter (Hiesey 1953).
Vegetative propagation	Extensive in *A. m.* var. *californica* by rhizomes, but absent in var. *puberula* (all stems reproductive) (Ramsey et al. 2008). Studies in England found 97% to 100% of allocation to vegetative reproduction (Bostock & Benton 1979). Many populations spread vegetatively by rhizomes. Container plants are sometimes propagated by divisions.
Regeneration after fire or other disturbance	Pioneer species, regenerates from rhizomes following fire (Aleksoff 1999). Effects depend on severity and timing: late spring and intense fires will reduce this species (Aleksoff 1999).
Pollination	A variety of insects visit the obligately outcrossed flowers. Moldenke (1976) lists many insects with beetles, syrphid flies, muscoid flies, wasps, and bees in the genera *Hyleus, Lasioglossum* as the most important. Most of these are small species and are relatively short distance pollen dispersers relative to honeybees and bumblebees.
Seed dispersal	Wind (Bourdot et al. 1985, Aleksoff 1999). The lightweight achenes do not have specialized hairs or plumes for wind dispersal but are easily captured by wind as they detach from the inflorescences that rise above the leaves.
Breeding system, mating system	Generally an obligate outcrossing species. Self-incompatible; apomixis found in species within the *A. millefolium* complex in Europe (Terziiski 1995, Yurukova-Grancharova et al. 2002). Extent of apomixis is not known.

Hybridization potential	Differentiated populations can be crossed. Hybrids of crosses among cytotypes can be fertile, but crosses among tetraploid and hexaploid forms were less fertile than crosses within cytotype (Hiesey and Nobs 1970). Guo et al. (2005) found molecular DNA evidence for reticulate evolution in the *Achillea millefolium* species complex in Europe (27 taxa from 66 populations studied); evidence suggests many new taxa have formed after hybridization between species followed by polyploidization.
Inbreeding and outbreeding effects	Hybrids among widely divergent populations of tetraploid (n=18) and among hexaploid forms of what was formally called *A. m.* var. *alpicola* were highly fertile, but crosses among cytotypes produced pentaploids of varying fertility (Heisey & Nobs 1970). Some crosses resulted in increased vigor (heterosis) in F1 and F2 generations; some resulted in decreased vigor, and some hybrid breakdown was evident in the F2 generation (outbreeding depression). The results depended on the environment of the common garden. No reference to inbreeding depression was found for North American forms (Rogers & Montalvo 2004).
BIOLOGICAL INTERACTIONS	
Competitiveness	Plants can be highly competitive. In monoculture, they are noted as more resistant to invasion by exotics than other natives examined (field study in Montana, Maron and Marler 2008). In New Zealand, plants are aggressive weeds, negatively affecting yields of food crops, especially those that are widely spaced (Bourdot et al. 1984).
Herbivory, seed predation, disease	Plants may suffer root rot in poorly drained soils (USDA FACT SHEET). A British study found 2.5% to 24.7% of achenes predated by insect larvae (Bostock & Benton 1979).
Palatability, attractiveness to animals, response to grazing	Plants contain terpenes and phenolics (e.g., flavonoids) (Montsko et al. 2008); flavonoids significantly decrease under high UVB radiation (study in e WA, Thines et al. 2008). There are disagreements in the literature regarding palatability as forage: palatable pasture food (Bourdot et al. 1984); considered unpalatable as a forage (Robocker 1977). Sheep and goats utilize leaves, and cows tend to graze the flowers (USDA FACT SHEET). Aleksoff (1999) summarizes the palatability as poor for cattle, and poor to good for a range of domestic and wildlife species (birds and mammals). Cover for bird and mammal wildlife was ranked from poor to good depending on location.
Mycorrhizal?	Seed collected from a reserve in Orange Co., California, were used in studies of colonization by mycorrhizal fungi (Volgelsang et al. 2004). Plants were readily colonized by arbuscular mycorrhizal fungi. Fungal filaments were said to be associated with roots in England (Anderson 1927).
ECOLOGICAL GENETICS	
Ploidy	Autopolyploid complex of tetraploid and hexaploid populations (Ramsey et al. 2008). Among populations, ploidy is extremely variable: 2n=36,45,54,63,72 (Hickman 1993). Because some individuals reproduce asexual seeds (apomictic seeds) and plants can spread vegetatively, polypoids can persist in populations (Ramsey et al. 2008).
Plasticity	Higgins and Mack (1987) observed morphological differences in plants growing in serpentine vs. non-serpentine soils.
Geographic variation (morphological and physiological traits, correlates of genetic variation)	A number of genetically controlled traits have been found to be associated with different habitats. There is high morphological variation throughout CA, and genetic analysis supports there are diverse ecotypes (ecologically differentiated populations that lack intrinsic genetic barriers to reproduction, and typically intergrade in sympatry; Ramsey et al. 2008). When grown under the same conditions, plants known as *A. lanulosa* from higher elevations in Sierra Nevada had higher carbon assimilation than plants from lower elevations (Gurevitch 1992a). There was also variation in leaf morphology between populations from high and low elevations (Gurevtich 1992b). Tyrl (1969, 1975) mapped chromosome numbers for populations in the *A. millefolium* complex from Oregon south to Santa Barbara and found that tetraploids and hexaploids had a complex pattern of distribution. The cytotypes overlapped in range in some areas, and some populations had mixed cytotypes. The evidence suggested repeated origin of hexaploids from tetraploid progenitors. Phenolic composition varied with location for 22 Lithuanian populations encompassing different habitats (Benetis et al. 2008). FNA 2010 reports two general morphological trends: the phyllaries (bracts around the clustered flowers) tend to have darker margins at high latitudes or high elevations; and plants tend to be more densely lanate (wooly hairy) at higher elevation or more extreme desert habitats.

Common garden studies	A classic study of the *A. millefolium* species complex by Clausen, Keck and Hiesey (1940) is a "textbook example" of an experimental common garden study that detected important differences among populations and how populations are differentiated into "ecotypes." Plants were taken from different locations in CA, ranging from coastal Stanford to high altitude timberline in the Sierra Nevada, and grown in uniform common gardens at contrasting elevations. Plants from different populations showed huge variation in size, shape, and stature; plants from the same source population were also noticeably variable, even when grown under common conditions. In another study, Higgins and Mack (1987) found significant differences in a height, rhizome production and biomass of plants produced from seeds from serpentine and non-serpentine soils, but all grew well in serpentine soil.
Genetic variation and population structure	Little genetic structure was associated with geography, variety, and ploidy level in a molecular study on populations from Europe and western US (Ramsey et al. 2008). Genetic variation suggestive of genetic structure in adaptive traits was detected in leaf traits for plants from four different Sierra Nevada populations (used the name *A. lanulosa*) when grown in a greenhouse study (Gurevitch 1988). Purdy and Bayer (1996) studied populations of *A.m.* ssp. *megacephala* and ssp. *lanulosa* in Canada and found that they varied in the degree of genetic differentiation among populations as well as expected heterozygosity (Gst=0.300 and 0.078, He = 0.126 and 0.085; respectively). *A. m.* ssp. *megacephala,* an endemic, showed higher allozyme variability but lower total allelic diversity than *A. m.* ssp. *lanulosa* .
Local adaptation	A study in Denmark found significant effects of seed origin on seed germination; there was increased germination on "home" soil, and juveniles had increased root biomass when grown on "home" soils (Grøndahl and Ehlers 2008). Plants from coastal areas and montane areas of CA grew better with colder nighttime temperatures (6°C vs 17°C), whereas warmer nighttime temperatures favored plants from the San Joaquin Valley (greenhouse experiment in California, Hiesey 1953). Common garden studies (e.g., Clausen et al. 1940) showed that there was a genetic component to the strong ecological differentiation and that ecotypes were best adapted to their home environments.
Translocation risks	Use of distant ecotypes may result in poor success and maladaptation. In southern California, most native populations occur in the local mountains where precipitation is higher. Urban plantings in Orange Co., CA frequently escape into wildlands (Roberts 2008). In the lowland valleys of Riverside Co., plants from revegetation plantings have been found to escape into nearby moist areas (Roberts et al. 2004).
SEEDS	Seed image by John Macdonald: http://www.hazmac.biz/040112a/040112aAchilleaMillefolium.html 
General	Achenes: 2.0 mm long, elongate, ovate, compressed (Wall & Macdonald 2009). Seeds are generally cleaned to 90% or higher purity with viability 85 to 90% (Stevens et al. 1996). Erickson et al. (2003) report average 85% germination and 90% purity for common yarrow. Boyer (2008) reported TZ tests of 84% for western yarrow. American Association of Seed Certifying Agencies (AOSCA) has testing rules.
Seed longevity	Viability drops slowly after 4 to 6 years (Stevens et al. 1996). Seeds stored dry for 9 years had 41% germination, but germinability was lost at a relatively uniform rate (trials in WA state, Robocker 1977). Of four species tested in England, *A. millefolium* had the greatest viability and longevity, especially when stored in soil (Bostock 1978). This is in part why it has become a difficult invasive species in New Zealand.
Seed dormancy	Differences in seed dormancy can be expected based on source population. USDA Fact Sheets report that in western North America, seeds do not require treatment for germination; however, Stevens et al. (1996) report that some sources may require up to 2 weeks cool, moist stratification. After a chilling treatment where seeds were imbibed and chilled 10 days at 4°C, seeds required light to germinate (plants from England in growth chamber experiment, Bostock 1978). Baskin and Baskin (1998) note that *A. lanulosa* (= *A. millefolium* var. *lanulosa*) may have physiological dormancy, whereas *A. millefolium* is considered nondormant.
Seed maturation	In Utah, seeds mature unevenly, but mostly together, and are ready for harvest August 15-September 30 (Stevens et al. 1996). Seeds have short period of after-ripening (Robocker 1977, Bostock 1978).

Seed collecting and harvesting	Utah increase fields: Combine harvest (Stevens et al. 1996).
Seed processing	Dry-harvest material, then use barley debearder, then air screen separator; use gravity table if needed (Stevens et al. 1996). For seed-banking, Wall and MacDonald (2009) recommend rubbing the flower heads over a medium screen before using a #16 sieve and then a #25 sieve, followed by a blower at speed 1.0 (Oregon Seed Blower unit).
Seed storage	Can be stored in open dry warehouse with no special conditions required (Stevens et al. 1996). In cold dry storage (refrigerator), seeds can last at least 10 years.
Seed germination	Maximum viability (85 to 90%) reached in up to a month after harvest in Utah (Stevens et al. 1996). Fresh seeds germinated at a rate of 96.8% in England, and seeds germinated in 2.3 days (Bostock 1978); seeds germinate at significantly greater rates when grown in the light compared with either red, red+far red, or dark treatments (Bostock 1978).
Seeds/lb	Reports for seeds/lb vary among varieties and production sites. Utah: 4,124,000 for western yarrow (Stevens et al. 1996). England: likely *A. m.* var. *millefolium,* seed dry weight was 0.158 mg (Bostock 1978). Oregon: 3,411,818 seeds/lb for western yarrow, *A. m.* var. *occidentalis* , Great Northern Germplasm (NSN 2010); common yarrow 3,000,000 seeds/lb (Erickson et al. 2003); Willamette Valley, western yarrow 1,418,947 seeds/lb (Boyer 2008).
Planting	Stevens et al. (1996) for production fields in UT: seeding rate 10 to 30 pure live seeds per linear foot with row spacing of 36 to 42 inches; plant seeds on surface to 1/16 in. deep; and seed in the fall, but can seed from spring to summer if water is available to establish plants before summer heat or fall frost. Transplants can be used in spring to early summer with irrigation. Space plants 30- 36 inches in rows 3-4 ft apart. Erickson et al. (2003) report initial seeding of 2 lb/ac of common yarrow yielded an average production of 165 lbs/ac for 1st and 2nd year harvests. The Herbert Stone Forest Service Nursery successfully harvested seeds for at least three crop years from one fall planting (Rolle 2004). Appropriate soil for growing may depend on the seed source and planting location. Stevens et al. (1996) recommended loam to clay loam for Utah. The NRCS Plant Guide states "Western yarrow thrives in droughty conditions on gravelly loam and on thin or sandy soils. It is a common component of such ecological sites as shallow, silty, shallow to gravel, and silty steep."
Seed increase activities or potential	Highly successful. High potential for successful development of ecologically regional seed sources. Production per acre varies depending on location and seed source. Production fields in Utah yield up to 350 lbs/acre at 20 to 40% purity, and production fields last 10 to 15 years (Stevens et al. 1996). Production of western yarrow in the Willamtte Valley, OR yields 300-600 lb/ac (Boyer 2008). Agriculturally produced seeds are available for purchase from major seed companies, but information about the source of the seeds is often obscure.
USES	
Revegetation and erosion control	Rapid growth of shallow rhizomes can help to stabilize soil. Plants establish well on disturbed sites and are used for erosion control, water quality bioswales, slopes of water quality basins (A. Montalvo pers. obs.), alpine and subalpine disturbances (USDA PLANTS 2009: USDA NRCS PLANT GUIDES). Care must be taken to prevent invasion of outlying areas (USDA NRCS PLANT GUIDES). Plants grew well in test of a postfire stabilization seed mix (Peterson et al. 2007), but sediment movement was not measured.
Habitat restoration	Used for restoration after control of western juniper; recommended for restoration only if seeds used are adapted to local conditions (study in southern ID, Sheley and Bates 2008). USDA NRCS PLANT GUIDES recommend using sparingly in mixtures.
Horticulture or agriculture	Used as a cover crop in California vineyards (Baumgartner et al. 2008). Long used as an ornamental plant. Used for cut flowers, for naturalistic landscaping and as a water-saving lawn substitute that can be maintained with six to eight mowings a year (Perry 2010). Several color forms (e.g., red, pink, yellow, white flowers) have been selected for use in gardens, including *Achillea millefolium* 'Paprika', Island Pink', 'Cameo', 'Rosea', 'Hoffnung', and 'Lavender Beauty' (Perry 1992, 2010; www.theodorepayne.org). Plants can be invasive in a garden situation, so care is needed in placement. Plants also escape urban plantings (Roberts et al. 2004, Roberts 2008).
Wildlife value	Bighorn sheep, pronghorn antelope, and deer graze plants and sage grouse, utilize foliage of western yarrow as a food source (Aleksoff 1999, USDA Fact Sheet). Plants are an important substrate for spider webs (Pearson 2008). Butterflies and other insects feed on nectar of flowers. A colonizing species that can dominate overgrazed land where it is poor quality forage (Aleksoff 1999).

Plant material releases by NRCS and cooperators	*A. millefolium* var. *occidentalis:* Great Northern Germplasm, selected from among 29 populations based on vigor, height, and seed production, was collected in Flathead Co., MT, from 1100 m elevation and released in 2004 by Bridger Plant Materials Center. This release is adapted for use in northern Idaho and all of Montana and Wyoming, except the Red Desert and Bighorn Basin. A source-identified release, Yakima Germplasm, is a composite of western yarrow from 27 collection sites on the U.S. Army Yakima Training Center in Yakima, Washington and is intended for use in the rehabilitation and restoration of western rangelands. (USDA NRCS PLANT PLANT FACT SHEET, NSN 2010). We are not aware of any releases developed from California populations.
Ethnobotanical	Used by Native Americans as pain reliever and for fevers, headaches, and to improve sleep; flavoring for foods (see: http://herb.umd.umich.edu/ for these and many more uses). Also used to treat domestic pet ear infections (Lans et al. 2008). Its anti-inflammatory activity has been confirmed (Benedek et al. 2007).
ACKNOWLEDGMENTS	Funding for production of this plant profile was provided by the U.S. Department of Agriculture, Forest Service, Pacific Southwest Region Native Plant Materials Program and the Riverside-Corona Resource Conservation District. Deveree Kopp provided photographs and comments on a draft of this profile.
CITATION	Montalvo, A. M., L. K. Goode, and J. L. Beyers. 2010. Plant Profile for *Achillea millefolium.* Native Plant Recommendations for Southern California Ecoregions. Riverside-Corona Resource Conservation District and U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Riverside, CA. Online: https://www.rcrcd.org/plant-profiles.

LINKS TO REVIEWED DATABASES & PLANT PROFILES

(last accessed September 2020)

Fire Effects Information System (FEIS)	https://www.fs.fed.us/database/feis/plants/forb/achmil/all.html
Jepson Flora, Interchange (JepsonOnline)	https://ucjeps.berkeley.edu/cgi-bin/get_cpn.pl?678
Jepson eFlora (JepsonOnline, 2nd ed.)	https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=678
USDA PLANTS	https://plants.usda.gov/core/profile?symbol=ACMI2
USDA NRCS PLANT FACT SHEETS	Common yarrow: https://plants.usda.gov/factsheet/pdf/fs_acmi2.pdf Western yarrow: https://plants.usda.gov/factsheet/pdf/fs_acmio.pdf
USDA NRCS PLANT GUIDES	Common yarrow: https://plants.usda.gov/plantguide/pdf/cs_acmi2.pdf Western yarrow: https://plants.usda.gov/plantguide/pdf/pg_acmio.pdf
Native Plant Network Propagation Protocol Database (NPNPP)	https://npn.rngr.net/propagation
Native Plant Notebook	https://www.fs.fed.us/biology/plants/index.html
Native Seed Network (NSN)	https://nativeseednetwork.org/
GRIN (provides links to many resources)	https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearch.aspx
Flora of North America (online version) (FNA)	http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=200023010
Native American Ethobotany Database	http://naeb.brit.org/
Calflora	https://www.calflora.org/
Rancho Santa Ana Botanic Garden Seed Program, seed photos	http://www.hazmac.biz/040112a/040112aAchilleaMillefolium.html
IMAGES	Seed images by John Macdonald used with permission from Rancho Santa Ana Botanic Garden Seed Program (RSABG Seed Program), with rights reserved by RSABG. Images may not be used for commercial purposes. All other images by may be used freely for non-commercial and not-for-profit use if credit is provided. All other uses require permission of the authors and the Riverside-Corona Resource Conservation District.

Bibliography for *Achillea millefolium*

Aleksoff, K. C. 1999. *Achillea millefolium*. *in* Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: https://www.feis-crs.org/feis/ [Accessed March 3, 2020].

Anderson, V. L. 1927. Studies of the vegetation of the English Chalk: V. The water economy of the chalk flora. The Journal of Ecology **15**:72-129.

Baskin, C. C., and J. M. Baskin. 1998. Seeds: Ecology, Biogeography and Evolution of Dormancy and Germination. Academic Press, San Diego, CA.

Baumgartner, K., K. L. Steenwerth, and L. Veilleux. 2008. Cover-crop systems affect weed communities in a California vineyard. Weed Science **56**:596-605.

Benedek, B., B. Kopp, and M. F. Melzig. 2007. *Achillea millefolium* L. s.l. - Is the anti-inflammatory activity mediated by protease inhibition. Journal of Ethnopharmacology **5**:312-317.

Benetis, R., J. Radušiene, and V. Janulis. 2008. Variability of phenolic compounds in flowers of *Achillea millefolium* wild populations in Lithuania. Medicina (Kaunas) **44**:775-780.

Bostock, S. J. 1978. Seed germination strategies of five perennial weeds. Oecologia **36**:113-126.

Bostock, S. J., and R. A. Benton. 1979. The reproductive strategies of five perennial Compositae. The Journal of Ecology **67**:91-107.

Bourdot, G. W., R. J. Field, and J. G. H. White. 1985. Growth analysis of *Achillea millefolium* L. (yarrow) in the presence and absence of a competitor – *Hordeum vulgare* L. (barley). New Phytologist **101**:507-519.

Bourdot, G. W., D. J. Saville, and R. J. Field. 1984. The response of *Achillea millefolium* L. (yarrow) to shading. New Phytologist **97**:653-663.

Boyer, L. 2008. Providing native plant diversity to the Willamette Valley ecoregion: No-tech, low-tech, and old-tech seed production methods. Native Plants Journal **9**:231-240.

Clausen, J., D. D. Keck, and W. M. Hiesey. 1940. Experimental studies on the nature of species. I. Effect of varied environments on western North American plants. Carnegie Institution of Washington Publication 520, Washington, DC.

Clausen, J., D. D. Keck, and W. M. Hiesey. 1948. Experimental studies on the nature of species. III. Environmental responses of climatic races of *Achillea*. Carnegie Institution of Washington, Publication 581, Washington, DC.

DiTomaso, J. M., and E. A. Healy. 2007. Weeds of California and Other Western States. Vol. 1. University of California, Agriculture and Natural Resources, Oakland, CA.

Erickson, V. J., J. Wood, and S. A. Riley. 2003. Guidelines for Revegetation of Invasive Weed Sites and Other Disturbed Areas on National Forests and Grasslands in the Pacific Northwest. USDA Forest Service, Pacific Northwest Region.

FNA. 2010. Flora of North America North of Mexico. FNA Editorial Committee. 1993+. 10+ volumes. New York and Oxford. Available online: http://hua.huh.harvard.edu/FNA/volumes.shtml. Last accessed August 2010.

Grøndahl, E., and B. K. Ehlers. 2008. Local adaptation to biotic factors: Reciprocal transplants of four species associated with aromatic *Thymus pulegioides* and *T. serpyllum*. Journal of Ecology **96**:981-992.

Guo, Y.-P., J. Saukel, R. Mittermayr, and F. Ehrendorfer. 2005. AFLP analyses demonstrate genetic divergence, hybridization, and multiple polyploidization in the evolution of *Achillea* (Asteraceae-Anthemideae). New Phytologist **166**:273-290.

Gurevitch, J. 1988. Variation in leaf dissection and leaf energy budgets among populations of *Achillea* from an altitudinal gradient. American Journal of Botany **75**:1298-1306.

Gurevitch, J. 1992a. Differences in photosynthetic rate in populations of *Achillea lanulosa* from two altitudes. Functional Ecology **6**:568-574.

Gurevitch, J. 1992b. Sources of variation in leaf shape among two populations of *Achillea lanulosa.* Genetics **130**:385-394.

Hickman, J. C., editor. 1993. The Jepson Manual: Higher Plants of California. University of California Press, Berkeley, CA.

Hiesey, W. M. 1953. Comparative growth between and within climatic races of *Achillea* under controlled conditions. Evolution **7**:297-316.

Hiesey, W. M., and M. A. Nobs. 1970. Genetic and transplant studies on contrasting species and ecological races of the *Achillea millefolium* complex. Botanical Gazette **131**:245-259.

Higgins, S., and R. Mack. 1987. Comparative responses of *Achillea millefolium* ecotypes to competition and soil type. Oecologia **73**:591-597.

JepsonOnline. 2010. The Jepson Manual Higher Plants of California; Online Version with 2nd edition notes. https://ucjeps.berkeley.edu/cgi-bin/get_cpn.pl?678.

Lans, C., N. Turner, and T. Khan. 2008. Medicinal plant treatments for fleas and ear problems of cats and dogs in British Columbia, Canada. Parasitology Research **103**.

Mabberly, D. J. 2008. Mabberley's Plant-Book, third edition. Cambridge University Press, New York, NY.

Maron, J. L., and M. Marler. 2008. Field-based competitive impacts between invaders and natives at varying resource supply. Journal of Ecology **96**:1187-1197.

Moldenke, A. R. 1976. California pollination ecology and vegetation types. Phytologia **34**:305-361.

Montsko, G., B. Boros, A. Takatsy, R. Ohmacht, S. Glasl, L. Krenn, L. Mark, and G. Reznicek. 2008. Separation of sesquiterpenes from yarrow (*Achillea millefolium* L. s. l.) by LC-MS on non-porous columns. Chromatographia **67**:467-470.

Munz, P. A. 1974. A Flora of Southern California. University of California Press, Berkeley, CA.

NSN. 2010. Native Seed Network: Home page https://nativeseednetwork.org/.

Perry, B. 1992. Landscape Plants for Western Regions: An Illustrated Guide to Plants for Water Conservation. Land Design Publishing, Claremont, CA.

Perry, R. C., Jr. 2010. Landscape Plants for California Gardens: An Illustrated Reference of Plants for California Landscapes. Land Design Publishing, Claremont, CA.

Peterson, D., E. Dodson, and R. Harrod. 2007. Assessing the effectiveness of seeding and fertilization treatments for reducing erosion potential following severe wildfires. Pages 465-474 *in* Butler, BW; Cook, W.(compilers). The Fire Environment – Innovations, Management, and Policy; Conference Proceedings. 26-30 March, Destin FL, U.S. Department of Agriculture, Forest Service, Ricky Mountain Research Station. Proceedings RMRS-P-46CD, 662 p. Fort Collins, CO.

Purdy, B. G., and R. J. Bayer. 1996. Genetic variation in populations of the endemic *Achillea millefolium* ssp. *megacephala* from the Athabasca sand dunes and the widespread ssp. *lanulosa* in western North America. Canadian Journal of Botany **74**:1138-1146.

Ramsey, J., A. Robertson, B. Husband, and E. Conti. 2008. Rapid adaptive divergence in New World *Achillea*, an autopolyploid complex of ecological races. Evolution **62**:639-653.

Roberts, F. M., Jr. 2008. The Vascular Plants of Orange County, California: An Annotated Checklist. F. M. Roberts Publications, San Luis Rey, CA.

Roberts, F. M., Jr., S. D. White, A. C. Sanders, D. E. Bramlet, and S. Boyd. 2004. The Vascular Plants of Western Riverside County, California: An Annotated Checklist. F. M. Roberts Publications, San Luis Rey, CA.

Robocker, W. C. 1977. Germination of seeds of common yarrow (*Achillea millefolium*) and its herbicidal control. Weed Science **25**:456-459.

Rogers, D. L., and A. M. Montalvo. 2004. Genetically appropriate choices for plant materials to maintain biological diversity. University of California. Report to the U.S. Department of Agriculture, Forest Service, Rocky Mountain Region, Lakewood, CO. Online publication: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_039080.pdf.

Rolle, W. 2004. Average per-acre seed yields and lifespans of native seed crops grown at J. Herbert Stone Forest Service Nursery. Summary for all native seed crops from 1992 through 2002. U.S. Department of Agriculture, Forest Service.

Sheley, R. L., and J. D. Bates. 2008. Restoring western juniper- (*Juniperus occidentalis*) infested rangeland after prescribed fire. Weed Science **56**:469-474.

Spence, L. E. 1937. Root studies of important range plants of the Boise River watershed. Journal of Forestry **35**:747-754.

Stevens, R., K. R. Jorgensen, S. A. Young, and S. B. Monsen. 1996. Forb and Shrub Seed Production Guide for Utah. Utah State University Extension, Logan, UT.

Terziiski, D., P. Yurukova-Grancharova, T. Daskalova, and P. Robeva. 1995. Apomixis in the morphological complex of *Achillea millefolium* (Asteraceae). Dokladi na B"Lgarskata Akademiya na Naukite **48(3)**:53-56.

Thines, N. J., L. A. Shipley, J. H. Bassman, J. R. Slusser, and W. Gao. 2008. UV-B effects on the nutritional chemistry of plants and the responses of a mammalian herbivore. Oecologia **156**:125-135.

Tyrl, R. J. 1969. Cytogeography of *Achillea millefolium* in western Oregon. Brittonia **21**:215-223.

Tyrl, R. J. 1975. Origin and distribution of polyploid *Achillea* (Compositae) in western North America. Brittonia **27**:187-196.

USDA PLANTS. 2009. The PLANTS Database (http://plants.usda.gov). National Data Center, Baton Rouge, LA 70874-4490 USA. Last accessed September 2010.

Vogelsang, K. M., J. D. Bever, M. Griswold, and P. A. Schultz. 2004. The Use of Mycorrhizal Fungi in Erosion Control Applications, Final Report for Caltrans Contract No. 65A0070.

Warwick, S. I., and L. Black. 1982. The biology of Canadian weeds. 52. *Achillea millefolium* L. Canadian Journal of Plant Science:163-182.

Warwick, S., and D. Briggs. 1979. The genecology of lawn weeds. III. Cultivation experiments with *Achillea millefolium* L., *Bellis perennis* L., *Plantago lanceolata* L., *Plantago major* L. and *Prunella vulgaris* L. collected from lawns and contrasting grassland habitats. New Phytologist:509-536.

Wall, M., and J. Macdonald. 2009. Processing Seeds of California Native Plants for Conservation, Storage, and Restoration. Rancho Santa Ana Botanic Garden Seed Program, Claremont, CA. Available online: http://www.hazmac.biz/seedhome.html.

Yurukova-Grancharova, P., P. Robeva-Davidova, T. Daskalova, and D. Terziiski. 2002. Evolution of embryonal structures and processes in tribe Anthemideae Cass. (Asteraceae). Phytologia Balcanica **8**:81-95.