Department of Defense
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PROJECT NUMBER (04-1703)

Development of a Categorized List of Invasive Non-native Plants That Threaten Wildlands in Arizona: Individual Plant Assessments by Species

Final Report of the Arizona Wildland Invasive Plant Working Group
Vol 1. *Acroptilon repens* to *Euryops multifidus*

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Acroptilon repens* (L.) DC. (USDA 2005)
Synonyms:	*Centaurea picris* Pallas ex Willd., *Centaurea repens* L. (USDA 2005)
Common names:	Russian knapweed, Turkestan thistle, creeping knapweed, mountain bluet, hardheads
Evaluation date (mm/dd/yy)**:**	02/02/04
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List committee members:	06/23/04: W. Albrecht, D. Backer, J. Brock, J. Busco, J. Hall, C. Laws, L. Moser, B. Phillips, K. Watters 08/06/04: W. Albrecht, W. Austin, D. Backer, J. Hall, F. Northam, L. Moser, B. Phillips, J. Schalau, K. Watters
Committee review date:	06/23/04 and 08/06/04
List date:	08/06/04
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**B**	Observational	**“Impact”** **Section 1 Score:** **A**	**“Plant Score”** **Overall Score:** **High** **Alert Status:** **None**
1.2	Impact on plant community	**A**	Reviewed scientific publication		
1.3	Impact on higher trophic levels	**A**	Other published material		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Reviewed scientific publication	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **17 pts** **Section 2 Score:** **A**	
2.2	Local rate of spread with no management	**A**	Observational		
2.3	Recent trend in total area infested within state	**B**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**A**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Other published material		
2.7	Other regions invaded	**B**	Other published material		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**A**	Observational	**“Distribution”** **Section 3 Score:** **B**	
3.2	Distribution	**C**	Observational		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **B** *Doc'n Level:* **Obs.**

Identify ecosystem processes impacted: Russian knapweed's extensive root system can alter the soil water table level, and change soil chemistry due to allelopathy, especially in fine-textured soils. Dense infestations of Russian knapweed may change the fire regime by changing the fuel characteristics and fire return interval at a given site.

Rationale: Russian knapweed has a well-developed root system, which functions as the major means of propagation and spreading. Stands of Russian knapweed can grow to densities of 100–300 shoots/m^2, The plant extends radially in all directions and can cover an area of 12 m^2 within two years. The roots of Russian knapweed can extend more than 7 meters below the soil surface with 2 to 2.5 meters of growth occurring the first year and 5 to 7 meters in the second year (Watson 1980). This deep and dense root system can change the levels of the soil water table. Russian knapweed contains an allelopathic polyacetylene compound which inhibits the growth of competing plants (Watson 1980). This compound can remain in the soil at some level for several years and tends to dominate on fine-textured soils, while forming a persistent mixture with other species on coarse soils. Allelopathy is likely to have more impact on fine-textured soils (Goslee et al. 2001). The hypothesis that allelopathic chemicals metabolized by soil microorganisms could release compounds into the soil affecting plant species has not been tested, yet soil scientists hypothesize that there are indirect interactions that might affect (positively or negatively) the plant species. Neither have the effects of allelopathy on mycorrhizal systems, which allow plant species to explore more soil resources (Pellissier 1998).

Information regarding fire adaptations of Russian knapweed is not available in the literature. The historic fire regimes of the more native communities in which Russian knapweed sometimes occurs are of varied frequency and severity. Russian knapweed did not occur in these communities at the time in which historic fire regimes were functioning, but has established since fire exclusion began. It is unclear how historic fire regimes might affect Russian knapweed populations. It is also unclear how the presence of Russian knapweed might affect these fire regimes. Dense infestations of Russian knapweed may change the fire regime by changing the fuel characteristics and fire return interval at a given site. Research in this area is needed.

Sources of information: See cited literature; also see Whitson (1999), Stevens (1986), Carpenter and Murray (Undated), and U.S. Forest Service Weed Info Sheets for *Acroptilon repens*. Score based on inference drawn from the literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Identify type of impact or alteration: Russian knapweed's rapidly spreading root system compete with native vegetation for soil moisture and nutrients. Russian knapweed forms dense stands through allelopathic effects that occlude native canopy and reduce and inhibit the growth of native plant communities in disturbed and undisturbed habitats.

Rationale: Stands of Russian knapweed can grow to densities of 100–300 shoots/m^2, which can completely crowd out competing native plant species. Russian knapweed's spreading root system can spread as much as 14.4 square yards (12 m^2) in only two seasons, thus successfully out competing native vegetation for water and nutrient resources (Whitson 1999). Plants can survive indefinitely through rhizomatous systems; stands of Russian knapweed have been reported to survive for more than 75 years (Watson 1980), which may interrupt the natural succession of a native plant community. Russian knapweed invades disturbed grassland and shrubland communities, as well as riparian forests. Examples of some perennial grass species that are commonly driven out by Russian knapweed include rough fescue (*Festuca scabrella*), Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Agropyron spicatum*), western needlegrass (*Stipa occidentalis*), and Richardson's needlegrass (*Stipa richardsonii*)

(Rice et al. 1992). Russian knapweed has been found to have allelopathic effects that inhibit the growth of crops and other plants. The examination of soil surrounding Russian knapweed roots revealed the presence of an inhibitor in sufficient concentration to have an appreciable effect on the surrounding plant community (Watson 1980). In a study done by Stermitz et al. (2003), root exudates of in vitro-grown Russian knapweed plants were tested for their effect on *Gaillardia aristata* Pursh, *Linaria dalmatica* (L.) Mill, *Centaurea. diffusa*, *C. maculosa* and the model plant *Arabidopsis thaliana* (L.) Heynh. All the species showed mortality on the seventh day after addition of root exudates from Russian knapweed. Plants showed wilting symptoms prior to senescence with reduced shoot and root differentiation after administration of the root exudates. In a modeling study done by Goslee (2001) in Colorado grassland communities, simulation results showed that Russian knapweed dominated the aboveground biomass on a plot only if native species were affected by allelopathic interactions. At moderate levels of plant sensitivity, Russian knapweed became dominant faster and reached a higher proportion of the total biomass on fine, rather than on coarse-textured soils. Community composition and rate of Russian knapweed dominance were more affected by the sensitivity of plant growth to allelochemicals than the sensitivity of species recruitment. Allelopathic interactions therefore proved to be an important component of the invasion dynamics (Goslee 2001). Grant et al. (2003) found that in several sites in Colorado seedling survival of *Bouteloua gracilis, Kohleria cristata, and Sporabulous cryptandrus* were suppressed by the presence of Russian knapweed over a 5 to 7 week period at several sites (Grant et al. 2003).

Sources of information: See cited literature; also see Carpenter and Murray (Undated).

Question 1.3 Impact on higher trophic levels *Score:* **A** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Russian knapweed greatly reduces biodiversity for wildlife forage and lowers habitat quality.

Rationale: By replacing native plants that are preferred as forage by big game species and as habitat by smaller wildlife species, Russian knapweed has negative effects on wildlife (Kurtz et al. 1995). Populations of Russian knapweed have drastically reduced the availability of key winter range for wildlife in the Disappointment Creek area in Colorado (FICMNEW 1998). Russian knapweed is avoided by grazing animals due to its bitter taste. It is so bitter that as little as 0.01% contamination by weight reduces the quality of flour and other grain products. Russian knapweed is poisonous to horses and can cause a neurological disorder called "chewing disease." Birds and rodents eat the seeds. (Zouhar 2001). Russian knapweed is considered a serious habitat invader and a single patch or infestation of Russian knapweed can grow quite rapidly. Once established, it can form dense infestations that reduce desirable vegetation through a combination of competition and allelopathy. The presence of Russian knapweed can thereby reduce forage for livestock and biodiversity for wildlife habitat (Whitson 1999, Zouhar 2001). Although two studies of white-tailed deer in north-central Montana and Rocky Mountain bighorn sheep in British Colombia showed that wildlife species utilize Russian knapweed as an element of their forage, it is unclear whether the animals are showing a preference, or they are utilizing it when other native species are not available. More information is needed to determine this (Allen 1968, Balfour 1988).

Sources of information: See cited literature.

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub.**

Identify impacts: No known hybridization

Rationale: In neither of the genera of *Acroptilon* or its former genus, *Centaurea*, has there been any report of hybridization between non-native and native species, despite a number of studies that have investigated these occurrences.

Sources of information: Kearney and Peebles (1960). Also considered personal communication with R. Scott (Professor, Biological Sciences, Northern Arizona University, Flagstaff, Arizona, 2004).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Describe role of disturbance: Russian knapweed establishes readily in open lands disturbed by grazing, and along roadsides and in cultivated fields and waste places. It also invades riparian habitats with natural flooding disturbance.

Rationale: Russian knapweed invades many disturbed western grassland and shrubland communities, as well as riparian forests. Russian knapweed readily occupies disturbed sites previously dominated by annual grasses (DiTomaso 1999). Russian knapweed invades open, disturbed land but because Russian knapweed produces few seeds and has poor dispersal mechanisms, it does not colonize new sites efficiently (Watson 1980, Goslee et al. 2001).

Sources of information: See cited literature; also see Carpenter and Murray (Undated).

Question 2.2 Local rate of spread with no management *Score:* **A** *Doc'n Level:* **Obs.**

Describe rate of spread: Increases, rapidly-potential to double in <10 years.

Rationale: Bureau of Land Management estimated the average annual rate of spread to be 8% in the northwestern U.S. Wyoming infestations have increased annually by an 11% average rate (Whitson 1999). The Working Group reached consensus that Arizona's infestations are similar to those of other western states.

Sources of information: See cited literature. Score based on Working Group consensus.

Question 2.3 Recent trend in total area infested within state *Score:* **B** *Doc'n Level*: **Obs**.

Describe trend: Increasing, but less rapidly. Russian knapweed is reported from all but five of Arizona's 15 counties; however, there are several ecotypes that have been invaded in other states, that have not yet been invaded in Arizona, suggesting that populations have the potential to spread and increase.

Rationale: Committee agrees that all niches are filled within the state.

Sources of information: Southwest Exotic Plant Mapping Program (SWEMP) data (available online at: http://www.usgs.nau.edu/SWEPIC/swemp/swempA.asp), Whitson (1999), and Esser (1994). Score based on Working Group consensus.

Question 2.4 Innate reproductive potential *Score:***A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: Russian knapweed reproduces by seed and by adventitious buds on horizontally spreading roots.

Rationale: A patch of Russian knapweed may have 9 to 27 shoots per square foot (100–300/m^2). Little or no information is known about seed viability and germination in the field. Most literature notes that it primarily reproduces vegetatively. There is some disagreement over seed viability. A study by Watson (1980) revealed they were viable for three years, while another by Selleck (1964) showed they could be viable up to eight years. Russian knapweed is probably top-killed by fire, while the roots are likely to remain unharmed (Zouhar 2001).

Sources of information: See cited literature; also see Carpenter and Murray (Undated).

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Seed is present as a contaminant in hay; Russian knapweed spread is hastened by cultivation. It can spread via root fragments or seeds transported by farm machinery or along travel corridors by other vehicles.

Rationale: There are numerous opportunities for dispersal to new areas as infestations are common on disturbed rangelands and because it is in so many alfalfa fields.

Sources of information: See Zouhar (2001) and Carpenter and Murray (Undated).

Question 2.6 Potential for natural long-distance dispersal *Score:* ***B*** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Russian knapweed propagules (root fragments) are dispersed in flowing water or flooding events.

Rationale: Various studies have also shown that entire plants can move downstream in river systems during the event of a flood. These plants then become established in the disturbed soils of the riverbank and form new, isolated infestations.

Sources of information: See Zouhar (2001) and Carpenter and Murray (Undated).

Question 2.7 Other regions invaded *Score:* ***B*** *Doc'n Level:* **Other pub.**

Identify other regions: Russian knapweed is native to Mongolia, western Turkestan, Iran, Turkish Armenia, and Asia Minor. In the Western states of Utah, Colorado and Nevada, New Mexico, Russian knapweed occupies several semiarid portions. It is found in sagebrush, semi-desert grassland, montane conifer forest, pinyon juniper, and desert scrub as well as riparian areas in all of those habitat types. In Colorado the most severe infestations of Russian knapweed occur in mountain and western slope counties, with lighter infestations associated with blue grama on the eastern plains. According to Weber and Whittman (1996) roadsides in the Colorado-Gunnison River valleys are dominated with populations of Russian knapweed and on roadsides of the San Luis Valley. Habitats in which Russian knapweed may be found include riparian woodlands dominated by cottonwood (*Populus* spp.), skunkbush sumac, and willow; riparian shrubland; and sagebrush/fourwing saltbush (*Atriplex canescens*) shrublands. In Utah, Russian knapweed is found in cottonwood/willow and tamarisk (*Tamarix* spp.) communities. Russian knapweed is found in all Utah counties except Washington, Sevier, Piute, Wayne, Sevier and Juab. In Nevada, Russian knapweed can be found with creosotebush (*Larrea tridentata*) and saltgrass, and it may threaten plants found in ash (*Fraxinus* spp.) meadows.

Rationale: According to SWEMP observations and Zouhar (2001), Russian knapweed invades two ecotypes in Nevada (Mohave desertscrub and southwest interior wetlands) that have not yet been invaded in Arizona.

Sources of information: See cited literature. Also considered SWEMP data (available online at: http://www.usgs.nau.edu/SWEPIC/swemp/swempA.asp). Also see the Atlas of the Vascular Plants of Utah (accessed online on February 10, 2004 at: http://www.gis.usu.edu/Geography-Department/utgeog/utvatlas/ut-vascatlas.html.)

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: First collection of Russian knapweed in Arizona was from Holbrook in 1934. Russian knapweed was first introduced into Canada around 1900 and was introduced to the United States as a result of impure Turkestan alfalfa seed, and possibly sugarbeet seed (Maddox et al. 1985). It was first introduced in California between 1910 to 1914. Since then it has become widespread in the United States and is currently found in at least 412 counties in 21 states (Maddox et al. 1985). It is most common in the semi-arid portions of the western U.S. and adjacent Canada, but infestations have also been reported in South Dakota, Minnesota, and Virginia (Maddox et al. 1985). The worst-infested states are California, Idaho, Montana, Oregon, and Washington. In Arizona it is found in Great Basin habitat types, Chihuahuan desert scrub, and plains and Great Basin grassland as well as semidesert grassland, pinyon-juniper and montane forests and riparian drainages. Russian knapweed thrives in clay soils in its native habitat. In the U.S. it tolerates both saline and alkaline soils and tends to dominate drier, fine-textured soils while forming a persistent mixture with other species on coarse soils. Found from 1430 to 2280 m in Utah and up to 2165 m in Arizona. In New Mexico it is reported from 1370 to 1828 m in elevation.

Rationale: This species is widespread and invades 5 major ecological types and 9 minor types.

Sources of information: See cited literature.

Question 3.2 Distribution *Score:* **C** *Doc'n Level:* **Obs.**

Describe distribution: In Arizona infestations are densest in Coconino, Apache and Navajo counties.

Rationale: Russian knapweed is reported from National Park species databases of 11 parks on the Colorado Plateau including Grand Canyon

Sources of information: Welsh et al. (1987), Kearney and Peebles (1960), SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; February 10, 2004), and SWEMP-Cain Crisis map (available online at: http://cain.nbii.gov/cgibin/mapserv?map=../html/cain/crisis/crisismaps/crisis.map&mode=browse&layer=state&layer=county; accessed February 10, 2004).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ Yes]	No	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	[✓ Yes]	No	**2 pt.**
Populations of this species produce seeds every year.	[✓ Yes]	No	**1 pt.**
Seed production sustained for 3 or more months within a population annually	[✓ Yes]	No	**1 pt.**
Seeds remain viable in soil for three or more years	Yes	[✓ No]	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	Yes	[✓ No]	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	[✓ Yes]	No	**1 pt.**
Fragments easily and fragments can become established elsewhere	[✓ Yes]	No	**2 pt.**
Resprouts readily when cut, grazed, or burned	[✓ Yes]	No	**1 pt.**
	Total pts: 9 Total unknowns: 0		
	Score : A		

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	**D**
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	**D**
	Mohave desertscrub	
	Chihuahuan desertscrub	**D**
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	**C**
	semi-desert grassland	**D**
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	**D**
	southwestern interior riparian	**D**
	montane riparian	**D**
Woodlands	Great Basin conifer woodland	**C**
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Aegilops cylindrica* Host (USDA 2005)
Synonyms:	*Aegilops cylindrica* Host var. *rubiginosa* Popova, *Aegilops tauschii* auct. non Coss., *Cylindropyrum cylindricum* (Host) A. Löve, *Triticum cylindricum* (Host) Ces., Pass. & Gib. (USDA 2005)
Common names:	Jointed goatgrass, jointgrass
Evaluation date (mm/dd/yy)**:**	12/17/04
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Committee review date:	12/17/04 and 03/02/05
List date:	03/02/05
Re-evaluation date(s):	

Table 2. Criteria, Section, and Overall Scores

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**C**	Observational	**“Impact”** **Section 1 Score:** **C**	**“Plant Score”** **Overall Score:** **Low** **Alert Status:** **None**
1.2	Impact on plant community	**C**	Observational		
1.3	Impact on higher trophic levels	**D**	Observational		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**C**	Observational	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **13 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**C**	Observational		
2.3	Recent trend in total area infested within state	**C**	Observational		
2.4	Innate reproductive potential	**A**	Reviewed scientific publication		
2.5	Potential for human-caused dispersal	**A**	Reviewed scientific publication		
2.6	Potential for natural long-distance dispersal	**C**	Observational		
2.7	Other regions invaded	**A**	Observational		RED FLAG **YES** Something you should know.
3.1	Ecological amplitude	**A**	Observational	**“Distribution”** **Section 3 Score:** **B**	
3.2	Distribution	**D**	Observational		

Red Flag Annotation

Above 1,220 meters (4,000 feet) elevation, *Aegilops cylindrica* can replace native herbaceous and shrub vegetation subsequent to its removal on highly disturbed soil surfaces. *Aegilops cylindrica* infestations alter natural fire regimes during the summer months when wildfires are most likely to occur by increasing fine-fuel loads relative to native vegetation. Roadside populations of *A. cylindrica* connect rights-of way that serve as fire corridors to wildlands and, as a result, increase the risk of wildfires in the wildland-urban interface. Because *A. cylindrica* can occur as a contaminant in revegetation seed lots, seed mixes should be checked for the presence of this species.

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **C** *Doc'n Level:* **Obs.**

Identify ecosystem processes impacted: Because of dense litter production, wildfire frequency increases at wildland sites where the natural integrity of soil surfaces have been drastically altered by ground disturbances such as road construction/maintenance, grazing animal trampling, fire abatement operations, timber harvesting or hiking/camping activities (F. Northam, personal communication, 2005).

Rationale: A literature review by Donald and Ogg (1991) reported jointed goatgrass infestations in Oregon winter wheat fields ranging from 54 to 86 plants/m^2. Anderson (1993) reported plants averaged 23 tillers (stems)/plant in a Colorado wheat field having 18 plants/m^2. White et al. (2004) reported typical jointed goatgrass tiller densities ranging from 260 to 370/m^{2}in Kansas winter wheat following a wet summer fall and spring. Therefore, jointed goatgrass is capable of producing multi stemmed, plants and population densities that exceed one plant per square foot in intensely disturbed soil such as crop land.

Arizona jointed goatgrass populations ranging from 10 to 20 plants/m^{2}with15 to 30 tillers/plant have been observed along Arizona rights-of-ways (Northam, personal communication, 2005). If populations of *Aegilops cylindrica* establish in intensely disturbed wildland soil, we infer this grass will produce sufficient litter to carry fire from infested sites into adjacent native plant communities.

Sources of information: See cited literature. Also considered personal communication with F. Northam (Weed Biologist, Consultant, 2005; field observations made while serving as the Arizona Department of Agriculture, Noxious Weed Program Coordinator during 2000 to 2003) and inference by Working Group members.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **C** *Doc'n Level:* **Obs.**

Identify type of impact or alteration: Alteration of native plant community composition and structure may occur where dense jointed goatgrass populations add a litter layer to the soil surface and provides fuel for wildfire movement into adjacent vegetation.

Rationale: Most Arizona jointed goatgrass herbarium specimens were collected from areas subjected to periodic soil disturbance such as road rights-of-way, urban land, vehicle parking areas, public parks and other recreational sites (SIENet 2004).

Recent observations of established *A. cylindrica* populations in northern Arizona highway rights-of-way, vacant lots and abandoned cultivated ground indicate this species is capable of becoming a predominate herbaceous species at sites where soil surfaces are intensely modified (F. Northam, personal communication, 2005). Thus, wildland sites where soils are severely degraded by construction machinery, animal hooves, reclamation/ restoration implements, off-road recreational vehicles, mining debris disposal, logging operations or wildfires are favorable environments for jointed goatgrass infestations. By inference it was determined *A. cylindrica* populations in Arizona may establish fire hazards due to dead plants becoming a combustible litter/thatch layer in June and July.

Sources of information: SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed December 10, 2004), personal communication with F. Northam (Weed Biologist, Consultant, 2005; field observations made while serving as the Arizona Department of Agriculture, Noxious Weed Program Coordinator during 2000 to 2003), and inference by Working Group members.

Question 1.3 Impact on higher trophic levels *Score:* **D** *Doc'n Level:* **Obs.**

Identify type of impact or alteration: Possible forage for grazing animals.

Rationale: Donald and Ogg (1991) reported herbage of jointed goatgrass in Oklahoma winter wheat used for cattle pasture was grazed along with wheat herbage. Possibly roadside populations in northern Arizona will provide forage for elk and deer. However, since *A. cylindrica* populations currently cover small areas, it is inferred that the impact is minimal.

Sources of information: See cited literature. Working Group members also applied inference in determining the appropriate score.

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub.**

Identify impacts: No native plants in the same genus are known to exist in Arizona (Kearney and Peebles 1960).

Rationale: Jointed goatgrass is known to hybridize with wheat (*Triticum aestivum* L.), but field crosses produce sterile spikelets (Donald and Ogg 1991). No information was found indicating cross-pollination between native Arizona plants and jointed goatgrass.

Sources of information: See cited literature.

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **C** *Doc'n Level*: **Obs.**

Describe role of disturbance: Disturbances that disrupt the integrity of soil surfaces and eliminate most plant cover is needed for jointed goatgrass propagules to produce enough litter to become wildfire hazards (F. Northam, personal communication, 2005).

Rationale: Donald and Ogg (1991) estimated 2.5 to 3 million acres of U.S. winter wheat cropland was infested with jointed goatgrass. Likewise, they reported rangeland adjacent to infested wheat fields were also infested and previous croplands planted to native grasses for the Conservation Reserve Program were infested. Beck et al. (1995) reported germination of weed seed from previous cropping operations impaired perennial grass establishment in grass restoration plantings on Colorado wheat cropland.

Observations of established jointed goatgrass populations in Arizona indicated this species infests sites where soil surfaces were altered by human activities. Numerous activities can produce this type of alteration in wildland soils including road/trail maintenance, homestead abandonment, livestock watering facilities, bulldozed fire lines, saltcedar / juniper removal, cultivating revegetation sites, ATV races, timber removal, hazardous material cleanup, etc. In other words, small areas within wildlands where anthropogenic activities damage soil, the ground is opened up to *A. cylindrica* infestations and possible wildfire damage (F. Northam, personal communication, 2005).

Sources of information: See cited literature. Also considered personal communication with F. Northam (Weed Biologist, Consultant, 2005; field observations made while serving as the Arizona Department of Agriculture, Noxious Weed Program Coordinator during 2000 to 2003).

Question 2.2 Local rate of spread with no management *Score:* **C** *Doc'n Level:* **Obs.**

Describe rate of spread: Stable

Rationale: Roadside infestations are increasing, but less than doubling in 10 years; no populations are known to be spreading into natural areas where minor or no disruption of soil surfaces has occurred (F. Northam, personal communication, 2005).

Sources of information: Personal communication with F. Northam (Weed Biologist, Consultant, 2005; field observations made while serving as the Arizona Department of Agriculture, Noxious Weed Program Coordinator during 2000 to 2003).

Question 2.3 Recent trend in total area infested within state *Score:* **C** *Doc'n Level:* **Obs.**

Describe trend: Herbarium collections began in 1940, and all were in the northern 1/3 of the state except for two in Ramsey Canyon area (Huachuca Mountains) of southwest Cochise County (SEINet 2004). Recent surveys have not reported new populations (F. Northam, personal communication, 2005).

Rationale: Herbarium collections are from sites above 4000 feet and most are in northern Arizona and above 5000 feet. Only two of 42 *A. cylindrica* specimens are farther south than northern Gila County (SEINet 2004).

Observations during Arizona Department of Agriculture Noxious Weed surveys from 2000 to 2003 did not find populations in any other counties (F. Northam, personal communication, 2005). No reports, specimens or surveys have discovered jointed goatgrass below 3000 feet.

Sources of information: SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed December 10, 2004)and personal communication with F. Northam (Weed Biologist, Consultant, 2005; field observations made while serving as the Arizona Department of Agriculture, Noxious Weed Program Coordinator during 2000 to 2003).

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Describe key reproductive characteristics: Seeds (caryopses) are the only way this winter annual species reproduces. No vegetative reproduction or multi-season seed crops.

Rationale: Gealy (1988) reported *A. cylindrica* plants grown in the field without competition produced 69 spikes (seedheads) per plant and 8.9 spikelets (joints) per spike which totaled approximately 600 spikelets per plant. Nine accessions from eight western states were evaluated. Anderson (1995) grew jointed goatgrass plants in Colorado winter wheat crops which averaged 20 tillers and 170 spikelets per plant. Arizona populations densities exceeding 10 plants per m^2 and 8 tillers per plant averaging 8 "joints" per tiller with two seed per joint can easily produce >1000 seed per m^2 (F. Northam, personal communication, 2005).

Sources of information: See cited literature. Also considered personal communication with F. Northam (Weed Biologist, Consultant, 2005; field observations made while serving as the Arizona Department of Agriculture, Noxious Weed Program Coordinator during 2000 to 2003).

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Identify dispersal mechanisms: Contaminated planting seed of winter wheat and winter grass seed used for restoration projects, contaminated wheat straw used for mulch in reseeding projects such as fire rehabilitation, contaminated grain transported in uncovered trucks, contaminated farm and restoration/ reclamation equipment (combines, drills, root plows, etc.), and contaminated hay harvested from pastures seeded with winter grass forages.

Rationale: Jointed goatgrass spikes (tillers) can grow up to 70 cm tall in low density pure stands (Gealy 1988) and up to 1.2 meters tall in winter wheat crops. Donald and Ogg (1991) described the economic impact of *A. cylindrica* contamination in harvested wheat grain and contaminated transport equipment. Many seed production fields for perennial winter grasses and cover crop species used to combat soil erosion following wild fires are grown in states where *A. cylindrica* is a major winter cereal crop weed; normal plant heights of this species are tall enough to be harvested with grain or planting seed (F. Northam, personal communication, 2005). Likewise, straw used as reclamation mulch from jointed goatgrass infested wheat regions is another potential source of importation of this weed into Arizona (F. Northam, personal communication, 2005). Several patches of *A. cylindrica* on Arizona highway rights-of-way exhibit distribution patterns that would be expected if contaminated seed or straw mulches were spread on roadside restoration projects (F. Northam, personal communication, 2005).

Sources of information: See cited literature. Also considered personal communication with F.

Northam (Weed Biologist, Consultant, 2005; field observations made while serving as the Arizona Department of Agriculture, Noxious Weed Program Coordinator during 2000 to 2003)

Question 2.6 Potential for natural long-distance dispersal *Score:* **C** *Doc'n Level:* **Obs.**

Identify dispersal mechanisms: Movement by runoff water following precipitation events.

Rationale: Dry, mature jointed goatgrass joints float in water and can move >1 km in rain runoff or irrigation water shortly after spikes disarticulate in June and July (F. Northam, personal communication, 2005).

Sources of information: Personal communication with F. Northam (Weed Biologist, Consultant, 2005; field observations made while serving as the Arizona Department of Agriculture, Noxious Weed Program Coordinator during 2000 to 2003).

Question 2.7 Other regions invaded *Score:* **A** *Doc'n Level:* **Obs.**

Identify other regions: Land with notable soil surface alteration (such as winter grain fields, road rights-of-way, vacant urban lots, pastures or grassland restoration plantings) are the predominate habitats for *A. cylindrica* infestations within the following regions: Pacific Northwest Palouse Prairie; Central Plains Shortgrass Prairie; Midwestern Tall Grass Prairie; Eastern Deciduous Forest and Great Basin Deserts (Welsh et al. 1987).

Rationale: Semi-arid regions with 10 to 20 inches of annual precipitation appear to be highly susceptible to *A. cylindrica* encroachment (Donald and Ogg 1991). Based on observations of current jointed goatgrass presence in Arizona, land above 4000 feet with at least 10 inch/year precipitation and having soil surfaces disrupted to the point that most native herbaceous plant species are absent appear to be susceptible to intrusion by this non-native plant (F. Northam, personal communication, 2005).

Based on the preceding information, it can be inferred future that soil disturbance in several non-infested vegetation zones of southeast Arizona will open potential sites for *A. cylindrica* colonization including: Chihuahuan desertscrub; montane riparian, Maderan evergreen woodlandm, and semi-desert grasslands. Two herbarium specimens from the Huachuca Mountains in southwest Cochise County support this deduction.

Sources of information: See cited literature. Working Group members also applied inference in determining the appropriate score.

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: According to the SEINet (2004) website, Arizona jointed goatgrass collections have come from southwestern interior chaparral, Great Basin desertscrub, semi-desert grassland, Great Basin conifer woodland, and montane conifer forest minor ecological types.

Rationale: Collections and observations of established jointed goatgrass populations in wildland areas have been on sites in which native vegetation has been subjected to intense disturbance by wildfires, road construction / maintenance operations, restoration / reclamation projects, abusive grazing or public recreational construction. No sites are known where jointed goatgrass has moved into mostly undisturbed vegetation (F. Northam, personal communication, 2005; SEINet 2004).

Sources of information: SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed December 10, 2004)and personal communication with F. Northam (Weed Biologist, Consultant, 2005; field observations made while serving as the Arizona Department of Agriculture, Noxious Weed Program Coordinator during 2000 to 2003).

Question 3.2 Distribution *Score:* **D** *Doc'n Level:* **Obs.**

Describe distribution: Collections and observations of established *A. cylindrica* populations in wildland areas have been on sites in which native vegetation has been disturbed by wildfires, road construction / maintenance operations, restoration / reclamation projects, abusive grazing, logging activities, or public recreational construction. As a result, distribution within individual ecological types has been limited to date.

Rationale: Arizona *A. cylindrica* populations ranging from 10 to 20 plants/m^2 with15 to 30 tillers/plant have been observed along rights-of-ways adjacent to wildlands. In other words, this species has been observed producing sufficient litter in disturbed areas to be a wildfire threat to native plants adjacent to litter patches. However, no sites are known where jointed goatgrass has encroached into mostly undisturbed vegetation (F. Northam, personal communication, 2005).

Sources of information: SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed December 10, 2004)and personal communication with F. Northam (Weed Biologist, Consultant, 2005; field observations made while serving as the Arizona Department of Agriculture, Noxious Weed Program Coordinator during 2000 to 2003).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**[✓ Yes] No 1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**[✓ Yes] No 2 pt.**
Populations of this species produce seeds every year.	**[✓ Yes] No 1 pt.**
Seed production sustained for 3 or more months within a population annually	**Yes [✓ No] 1 pt.**
Seeds remain viable in soil for three or more years	**[✓ Yes] No 2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes [✓ No] 1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes [✓ No] 1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes [✓ No] 2 pt.**
Resprouts readily when cut, grazed, or burned	**Yes No 1 pt.**
	Total pts: 6 Total unknowns: 1
	Score : A

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	**D**
Desertlands	Great Basin desertscrub	**D**
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	**D**
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	
	montane riparian	
Woodlands	Great Basin conifer woodland	**D**
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

Literature Cited

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White, A.D., P.W. Stalhman, and F.E. Northam. 2004. Impact of integrated management systems on jointed goatgrass (*Aegilops cylindrica*) populations. Weed Science 52:1010–1017.

Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Ailanthus altissima* (P. Mill.) Swingle (USDA 2005)
Synonyms:	*Ailanthus glandulosa* Desf. (USDA 2005)
Common names:	Tree of heaven, Chinese sumac, paradise-tree, copal-tree, stink tree
Evaluation date (mm/dd/yy)**:**	08/02/04
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Committee review date:	09/24/04
List date:	09/24/04
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		**Score**	**Documentation Level**	**Section Scores**	**Overall Score & Designations**
1.1	Impact on abiotic ecosystem processes	**B**	Reviewed scientific publication	**“Impact”** **Section 1 Score:** **B**	**“Plant Score”** **Overall Score:** **Medium** **Alert Status:** **None**
1.2	Impact on plant community	**A**	Reviewed scientific publication		
1.3	Impact on higher trophic levels	**U**	Other published material		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Other published material	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **13 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Observational		
2.3	Recent trend in total area infested within state	**C**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**B**	Other published material		
2.6	Potential for natural long-distance dispersal	**C**	Reviewed scientific publication		
2.7	Other regions invaded	**B**	Other published material		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**A**	Observational	**“Distribution”** **Section 3 Score:** **B**	
3.2	Distribution	**C**	Observational		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Identify ecosystem processes impacted: Changes local soil chemistry in the top 10 cm through allelochemicals.

Rationale: *Ailanthus altissima* produces the highly phytotoxic quassinoid compound ailanthone (Heisey 1996), which is detectable in the surrounding soil in concentration and negatively correlated to distance from young *A. altissima* plants (Lawrence et al. 1991).

Sources of information: See cited literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Identify type of impact or alteration: Alters forest structure and natural successional processes by invading natural gaps in forests and persisting. Through allelopathy *A. altissima* could reduce emergence and shoot biomass of neighboring plants.

Rationale: Ailanthus has invaded and is persistent in naturally occurring forest gaps, in New York (Knapp and Canham 2000) and West Virginia (Kowarik 1995). It typically has a greater height and diameter than those of the tallest native competitors within those gaps leading to a change in forest structure (Heisey 1996). *Ailianthus altissima* frequently forms dense self-perpetuating clonal clumps through root sprouting (Rabe 1985 in Howard 2004).

Mergen (1959) first demonstrated that concentrated extracts of *A. altissima* are toxic to 35 species of gymnosperms and 10 species of angiosperms including the following Arizona natives: *Pinus cembroides, Pinus flexilis, Pinus ponderosa, Picea engelmannii, Abies concolor, Populus tremuloides,* and *Salix bebbiana*, with the negative effect proportional to the concentration (Mergen 1959). In more recent greenhouse studies, application of low levels of aquaeous extracts of *A. altissima* reduced emergence and shoot biomass of plants (Heisey 1996) and resulted in the mortality of five of seven species tested (Heisey 1990). In a natural environment Lawrence et al. (1991) found that *Teucrium canadense* plants growing near (<1 m away) young *A. altissima* plants had significantly higher levels of *A. altissima* toxins compared to plants growing further away (>10 m), suggesting that adjacent plants uptake *A. altissima* toxins from the soil.

Sources of information: See cited literature.

Question 1.3 Impact on higher trophic levels *Score:* **U** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: No formal studies of higher trophic level impacts in Arizona found. May compete for pollinators. May be avoided by herbivores.

Rationale: The large flower display of *A. altissima* is reported to attract numerous pollinators (Miller 1990) but ecological impact on these pollinators is unknown.

White-tailed deer may avoid *A. altissima* suggested by lack of significant difference in seedling establishment between open and exclosed plots (Forgione 1993 cited in Howard 2004). The bark and leaves contain saponins, quassinoids, and other bitter compounds that may discourage consumption (Heisey 1996).

Sources of information: See cited literature.

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub.**

Identify impacts: No known hybridization.

Rationale: No closely related native (or non-native) species occur in Arizona (Kearney and Peebles 1960).

Sources of information: See cited literature.

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Other pub.**

Describe role of disturbance: *Ailanthus altissima* establishes most often in areas of anthropogenic disturbance but can establish in areas opened up by natural disturbance.

Rationale: Observations in Arizona indicate that *A. altissima* primarily establishes in severely disturbed areas such as abandoned mines, industrial parks, and areas of other major human disturbance (F. Northam, personal communication, 2004). In addition to human disturbed areas near where it was planted as a landscape tree; however, *A. altissima* is found in naturally disturbed riparian areas (Tellman 1997; B. Phillips, personal communication, 2003). These local observations are consistent with reports from other states (Hu 1979, Santamour 1983, Rabe and Bassuk 1984, Miller 1990) and throughout North America. *Ailanthus altissima* is recognized as a shade intolerant (Grime 1965), gap-obligate (Knapp and Canham 2000) early seral species.

Sources of information: See cited literature. Also considered personal communications with F. Northam (Weed Biologist, Tempe, Arizona, 2004) and B. Phillips (Botanist, U.S. Department of Agriculture, Forest Service, Coconino, Kaibab, and Prescott National Forests, 2003).

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Obs.**

Describe rate of spread: Increasing slowly.

Rationale: In naturally disturbed areas, *A. altissima* is likely to spread relatively quickly for a tree due to a rapid growth rate and clonal growth through root sprouting (Howard 2004). Despite the potential for rapid local spread, F. Northam (personal communication, 2004) has not observed any spread of *A. altissima* in areas that are not disturbed by humans. For the purposes of this assessment, the Working Group considered human-mediated disturbance a management activity and thus excludes observations of spread in areas heavily disturbed by humans. Based on the potential for natural disturbance to enable the spread of this species, the Working Group considered the rate of spread without management to be low but not stable.

Sources of information: See cited literature. Also considered personal communication with F. Northam (Weed Biologist, Tempe, Arizona, 2004).

Question 2.3 Recent trend in total area infested within state *Score:* **C** *Doc'n Level:* **Obs.**

Describe trend: Stable.

Rationale: Francis Northam (personal communication, 2004) reports that *A. altissima* is almost exclusively confined to severely disturbed sites and besides these large disturbances he has observed no current expansion of *A. altissima* in Arizona.

In California, where the behavior of *A. altissima* is likely more similar to Arizona than northeastern states, establishment by seed is reportedly low (Hunter 2000). This factor may be responsible for the apparent stable rate of spread to new areas in Arizona.

Sources of information: See cited literature. Also considered personal communication with F. Northam (Weed Biologist, Tempe, Arizona, 2004).

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: Dominate reproduction is vegetative by root sprouts. Trees are primarily dioecious; females produce an abundance of short-lived (<1 year), wind-dispersed, samaras.

Rationale: See also Worksheet A. Asexual reproduction is by vegetative sprouting from stumps or root portions (Hu 1979, Kowarik 1995, Howard 2004). Individual trees can produce 325,000 or more seeds per year (Bory and Clair-Maczulajtys 1980 cited in Hoshovsky 1988). *Ailanthus altissima* seeds retain dormancy for less than a year and do not build up a long-term seed bank (Hunter 2000).

Sources of information: See cited literature.

Question 2.5 Potential for human-caused dispersal *Score:* **B** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Planted for commercial and domestic landscape beautification and reclamation.

Rationale: Available for purchase over the internet. Proposed for use to stabilize mine tailings, but not recommended (Hunter 1995 cited by Howard 2004).

Sources of information: See cited literature.

Question 2.6 Potential for natural long-distance dispersal *Score:* **C** *Doc'n Level:* **Rev. sci. pub.**

Identify dispersal mechanisms: Dispersed by wind vis-à-vis winged fruit.

Rationale: Matlack (1987) developed a formula to estimate lateral distance of released diaspore from a given height in 10 km/hr wind and estimated a lateral dispersal for *A. altissima* to be about 110 m per 10 km wind.

Sources of information: See cited literature.

Question 2.7 Other regions invaded *Score:* **B** *Doc'n Level:* **Other pub.**

Identify other regions: Overall *A. altissima* is widespread in the continental U.S. from New York, south to Florida, west to California and north to Oregon; however, it has not been documented in Montana, Minnesota, New Hampshire, North Dakota, South Dakota, Vermont, and Wyoming (USDA 2005). In California it occurs in riparian areas and other naturally disturbed habitats at elevations below 6,600 feet (2000 m) (Hunter 2000).

Rationale: In California it occurs in riparian woodland and riparian forest ecological types, which are roughly comparable to Arizona's montane riparian ecological type. Observations have not yet been made of *A. altissima* in montane riparian in Arizona.

Sources of information: See cited literature.

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: According to F. Northam (personal communication, 2004), *A. altissima* is limited in Arizona to areas above 3000 feet (for example, near Camp Verde and Globe) to about 7,000 feet (for example, near Jerome). Ecological types infested are some areas of southwestern interior chaparral, but *A. altissima* occurs mainly in forested areas—Ponderosa pine and Madrean evergreen woodland, especially in proximity to disturbed areas. It also is reported from riparian areas (Tellman 1997).

As reported in Howard (2004):

Soils/topography: Tree of heaven tolerates a wide range of soil conditions (Duncan and Duncan 1988, Miller 1990). For example, in oak-hickory woodland of Sussex County, New Jersey, tree of heaven occurs in permanently swampy, ridge bottom soils of an abandoned Boy Scout camp (Barringer and Pannaman 2003). At the other moisture extreme, large, water-storing roots enable tree of heaven to tolerate dry, rocky soils and extended drought. Even seedlings show drought tolerance, often volunteering in pavement cracks and other dry sites (Graves et al. 1989). Best growth occurs on nutrient-rich, loamy soils such as those in the Central Valley of California, but tree of heaven tolerates nutrient-poor soils (Feret and Bryant 1974, Miller 1990, Kentucky Exotic Pest Plant Council 2001, Zasada and Little 2002). In reclamation studies, tree of heaven tolerated acid mine spoils better than calcareous spoils and grew on low-phosphorus soils (Miller 1990). Tree of heaven can grow on soils as low as 4.1 pH, in soluble salt concentrations of 0.25 mmhos/cm, and in soils with phosphorus levels as low as 1.8 ppm (Plass 1975). It tolerates compacted soils (Pan and Bassuk 1985). Tree of heaven's spreading root system permits establishment and growth on cliff faces and other steep inclines (Almeida et al. 1994).

Climate: Tree of heaven is the only species in its genus that tolerates cold climates (Hu 1979). Climate within tree of heaven's North American distribution varies widely, from subtropical and wet in Florida, arid in the Great Plains and Great Basin, to cold and wet in the Northeast. Tree of heaven tolerates as little as 14 inches (360 mm) of annual precipitation under eight months of drought in the arid West and as much as 90 inches (2,290 mm) annual precipitation in the Appalachian Mountains. Annual mean maximum and minimum temperatures are 15 and 97°F (-9 and 36°C). Large, water-storing roots confer drought tolerance. Extreme cold and prolonged snow cover restrict its occurrence to lower slopes in mountainous regions, as seedlings are not cold resistant. Tree of heaven may be able to colonize cold regions that experience several successive years of mild climate (Miller 1990).

Elevation: Tree of heaven grows from 4,900 to 5,900 feet (1,500 to 1,800 m) elevation in China (Hu 1979).

Germination: Flowers from April to May (or later depending on climate) with fruit maturing in the early fall. Flowering can occur as early as six weeks after germination, which is rare in woody angiosperms (Feret 1973). Germination rate is about 60% in a nursery setting.

Rationale: Occurs in four major and four minor ecological types.

Sources of information: See cited literature. Also considered personal communication with F. Northam (Weed Biologist, Tempe, Arizona, 2004).

Question 3.2 Distribution *Score:* **C** *Doc'n Level:* **Obs.**

Describe distribution: Limited frequency of occurrence (<20%) within each infested ecological type.

Rationale: According to F. Northam (personal communication, 2004), *A. altissima* is limited in Arizona to areas above 3000 feet (for example, near Camp Verde and Globe) to about 7,000 feet (for example, near Jerome). Ecological types infested are some areas of southwestern interior chaparral, but *A. altissima* occurs mainly in forested areas—Ponderosa pine and Madrean evergreen woodland, especially in proximity to disturbed areas. It also is reported from riparian areas (Tellman 1997).

Sources of information: See cited literature. Also considered personal communication with F. Northam (Weed Biologist, Tempe, Arizona, 2004).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ **Yes**]	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	[✓ **Yes**]	**No**	**2 pt.**
Populations of this species produce seeds every year.	[✓ **Yes**]	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**Yes**	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	**Yes**	[✓ **No**]	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes**	[✓ **No**]	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	[✓ **Yes**]	**No**	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	[✓ **No**]	**2 pt.**
Resprouts readily when cut, grazed, or burned	[✓ **Yes**]	**No**	**1 pt.**

Total pts: 6 Total unknowns: 1

Score : A

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	**D**
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	**C**
	montane riparian	
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	**C**
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Alhagi maurorum* Medik. (USDA 2005)
Synonyms:	*Alhagi camelorum* Fisch., *Alhagi pseudalhagi* (Bieb.) Desv. ex B. Keller & Schaparenko (USDA 2005)
Common names:	Camelthorn
Evaluation date (mm/dd/yy)**:**	11/17/03
Evaluator #1 Name/Title:	Katherine Darrow, Botanist
Affiliation:	Wild About Wildflowers (biological consultant)
Phone numbers:	(623) 582–1525
Email address:	Wild_kat@cox.net
Address:	25821 N. 41st Drive, Glendale, Arizona 85310
Evaluator #2 Name/Title:	
Affiliation:	
Phone numbers:	
Email address:	
Address:	

List committee members:	12/17/03: W. Albrecht, W. Austin, D. Backer, J. Crawford, B. Phillips, K. Watters 02/17/04: W. Albrecht, W. Austin, D. Backer, J. Crawford, L. Moser, F. Northam, T. Olson, B. Phillips, K. Watters 04/16/04: W. Albrecht,, D. Backer, J. Crawford, H. Folger, J. Hall, R. Hiebert, F. Northam, T. Olson, K. Watters
Committee review date:	12/17/03, 02/17/04, and 04/16/04
List date:	02/17/04; revised 04/16/04
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

<table>
<tr><th colspan="2">Question</th><th>Score</th><th>Documentation Level</th><th>Section Scores</th><th>Overall Score & Designations</th></tr>
<tr><td>1.1</td><td>Impact on abiotic ecosystem processes</td><td>B</td><td>Observational</td><td rowspan="4">“Impact”
Section 1 Score:
B</td><td rowspan="11">“Plant Score”
Overall Score:
Medium
Alert Status:
None</td></tr>
<tr><td>1.2</td><td>Impact on plant community</td><td>A</td><td>Other published material</td></tr>
<tr><td>1.3</td><td>Impact on higher trophic levels</td><td>B</td><td>Other published material</td></tr>
<tr><td>1.4</td><td>Impact on genetic integrity</td><td>D</td><td>Other published material</td></tr>
<tr><td colspan="4"></td><td></td></tr>
<tr><td>2.1</td><td>Role of anthropogenic and natural disturbance</td><td>B</td><td>Other published material</td><td rowspan="7">“Invasiveness”
<i>For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:</i>
17 pts
Section 2 Score:
A</td></tr>
<tr><td>2.2</td><td>Local rate of spread with no management</td><td>A</td><td>Other published material</td></tr>
<tr><td>2.3</td><td>Recent trend in total area infested within state</td><td>B</td><td>Observational</td></tr>
<tr><td>2.4</td><td>Innate reproductive potential</td><td>A</td><td>Other published material</td></tr>
<tr><td>2.5</td><td>Potential for human-caused dispersal</td><td>B</td><td>Other published material</td></tr>
<tr><td>2.6</td><td>Potential for natural long-distance dispersal</td><td>A</td><td>Other published material</td></tr>
<tr><td>2.7</td><td>Other regions invaded</td><td>B</td><td>Other published material</td><td rowspan="4">RED FLAG
NO
Something you should know.</td></tr>
<tr><td colspan="4"></td><td></td></tr>
<tr><td>3.1</td><td>Ecological amplitude</td><td>A</td><td>Other published material</td><td rowspan="2">“Distribution”
Section 3 Score:
A</td></tr>
<tr><td>3.2</td><td>Distribution</td><td>B</td><td>Other published material</td></tr>
</table>

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **B** *Doc'n Level:* **Obs.**

Identify ecosystem processes impacted: *Alhagi maurorum* may cause moderate alteration of ecosystem processes related to water availability, erosion, and bank and dune stabilization.

Rationale: *Alhagi maurorum* has deep, penetrating, and massive roots that are opportunistic water users which decreases soil moisture making water less available to other plants (Kerr et al. 1965). Extensive root system can tap water up to 15m below surface (NAWC 2002). *Alhagi maurorum* may have an effect on erosion, in that it creates dense stands with a network of rhizomes on dunes and sandbars in areas that may otherwise not support a lot of vegetation, thus holding soils in place thereby stabilizing soils in areas that naturally migrate (floodplains, dunes, sandbars, etc.). This is most notable along rivers and waterways where *Alhagi maurorum* is well established in Arizona, especially in drainages, waterways and disturbed areas in the Holbrook and Winslow (Little Colorado River) and Colorado River areas. This also suggests contributions toward altered hydrological regime. It has also been suggested (B. Phillips, personal communication, 2004) that *Alhagi maurorum* may have effects on the nitrogen cycle in areas where it is dense, as it is a legume and likely has nitrogen fixing bacteria associated with its roots. However, there is no known documentation of this. Effects on soil salinity and alkalinity have been suggested but unknown or undocumented (Kerr et al. 1965). *Alhagi maurorum* acts as a sediment trap, which can be perceived as having both a positive and negative impact (B. Phillips, personal communication, 2004).

Sources of information: Score based on inference from the literature and observations. See cited literature. In addition to B. Phillips (Zone Botanist, U.S. Department of Agriculture, Forest Service, Coconino, Kaibab and Prescott National Forests, 2004), additional observations are by K. Darrow and F. Northam (Weed Biologist [former Arizona Department of Agriculture Noxious Weed Coordinator], Tempe, Arizona).

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **A** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: *Alhagi maurorum* can cause severe alterations of plant community composition.

Rationale: *Alhagi maurorum* forms dense stands that usurp space, light, nutrient, and water resources from other plant species. Where *A. maurorum* occurs in dense stands, its ability to uptake water due to its extensive root structure, gives it the ability to be highly competitive for resources. From observations of these dense stands, little other native vegetation is found (F. Northam, D. Backer). The deep and extensive root system allows *A. maurorum* to tap into water table up to 15 m below the surface (NAWC 2002). *Alhagi maurorum* also produces small amounts of litter (Kerr et al. 1965 and F. Northam, personal communication, 2004).

Sources of information: See cited literature; also see O'Connell and Hoshovsky (2000). Observations/personal communications are by B. Phillips (Zone Botanist, U.S. Department of Agriculture, Forest Service, Coconino, Kaibab and Prescott National Forests), F. Northam (Weed Biologist [former Arizona Department of Agriculture Noxious Weed Coordinator], Tempe, Arizona), and D. Backer (Conservation Ecologist, The Nature Conservancy, Tucson, Arizona).

Question 1.3 Impact on higher trophic levels *Score:* **B** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Moderate alteration of higher trophic level populations, communities, or interactions. Has both positive and negative impacts on higher trophic levels.

Rationale: *Alhagi maurorum* is grazed by cattle, sheep, goats, [all non-native to this ecosystem] and bighorn sheep and mule deer, especially when young and tender; however, also may be harmful to some wildlife when mature and thorny. The vegetation is not palatable when mature but the seed pods are frequently browsed by cattle and horse (CDFA Undated, Kerr et al. 1965). *Alhagi maurorum* is also recognized as an important honey plant in its native range, and was imported to southern Arizona in the 1920s for that purpose. Although not a natural setting, *A. maurorum* will take over croplands rendering the land useless for agriculture if not controlled.

Sources of information: See cited literature; also see O'Connell and Hoshovsky (2000) and NAWC (2002).

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub.**

Identify impacts: No known hybridization.

Rationale: No congeners exist in Arizona. No hybridization with other legumes has been documented (Kearney and Peebles 1960).

Sources of information: See cited literature.

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Other pub.**

Describe role of disturbance: *Alhagi maurorum* may occasionally establish in undisturbed areas but can readily establish in areas with natural and anthropogenic disturbances. Some level of disturbance is important for establishment, as is a natural or anthropogenic scarification of the seed. Invasion beyond areas of disturbance is minimal.

Rationale: *Alhagi maurorum* thrives on roadsides, agricultural fields (both anthropogenic disturbances), and along drainages where moisture is most available. Establishment is generally in disturbed areas that also receive a moderate amount of moisture. Thus, natural disturbances that are far from drainages, for instance, are not likely to be colonized.

Sources of information: See O'Connell and Hoshovsk (2000). Score rationale includes personal observations based on personal communications from November to December 2003: D. Evans (Range Specialist, U.S. Department of Agriculture, Forest Service, Prescott National Forest), T. Eckler (Arizona Department of Transportation), and M. Kearsley (Grand Canyon Research and Monitoring).

Question 2.2 Local rate of spread with no management *Score:* **A** *Doc'n Level:* **Other pub.**

Describe rate of spread: Increases rapidly, capable of doubling area of colonization in less than 10 years.

Rationale: *Alhagi maurorum* spreads primarily by rhizomes which can spread up to 20-25 feet from the parent plant another account is that rhizomes can grow up to 15 meter deep and up to 12 meters horizontally from the parent plant (various authors, see below). Infestations can spread at a rate of about 10 meters per year (CDFA Undated). Seeds and rhizome fragments are readily carried in drainages and subsequently establish along waterways. "In less than 20 years, the infestation along the canals near Gillespie Dam (Maricopa County) has become continuous for more than 15 miles" (Parker 1972). Rhizomes fragment easily and seeds have made there way from Winslow (thought to be the place of AZ origin in hay) into the Little CO River and to the Colorado River. Seedling growth is relatively slow (Kerr et al. 1965).

Sources of information: See cited literature; also see Kearney and Peebles (1960), O'Connell and Hoshovsky (2000), and NAWC (2002). An additional source is a personal communications with T. Eckler (Arizona Department of Transportation, 2003).

Question 2.3 Recent trend in total area infested within state *Score:* **B** *Doc'n Level:* **Obs.**

Describe trend: Increasing, but less rapidly than doubling every 10 years.

Rationale: *Alhagi maurorum* is found along highways, in agricultural areas, and in drainages throughout the state. However, the species is currently listed as a noxious weed in the state of Arizona, so there are concentrated efforts to eradicate it by the ADOT and in agricultural areas. Infestations and occurrences of camelthorn continue are moving south (and downstream) in Arizona (observational).

Sources of information: See Parker (1972), NAWC (2002), and Chambers and Hawkins (Undated). In addition, see USGS/Southwest Exotic Plant Information Clearinghouse, data for Grand Canyon National Park, available online at: http://usgssrv1.usgs.nau.edu/swepic/asp/aprs/. Additional sources are personal communications, November to December 2003: D. Evans (Range Specialist, U.S. Department of Agriculture, Forest Service, Prescott National Forest), T. Eckler (Arizona Department of Transportation), M. Kearsley, (Grand Canyon Research and Monitoring), B. Phillips (Zone Botanist, U.S. Department of Agriculture, Forest Service, Coconino, Kaibab and Prescott National Forests), and F. Northam (Weed Biologist [former Arizona Department of Agriculture Noxious Weed Coordinator], Tempe, Arizona).

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: Sexual and asexual reproduction; seedlings rare; seeds germinate most readily after scarification or passing through digestive tract; will resprout easily from underground rhizomes if not fully removed.

Rationale: Begins flowering in May through July; pods persist until October or November (Parker 1972). Low percentage (~ 20%) of flowers set seeds (CDFA) and seeds remain viable in semi-arid soil for several years (NAWC 2002). Some points here differ from Joe DiTomaso's assessment for California in that California plants are relatively young and small and the populations in California have been mostly eradicated. (See Questions 2 and 3 on Worksheet A). Plants in Arizona are abundant and large by comparison, and therefore produce more seed, more frequently.

Sources of information: See cited literature; also see Kerr et al. (1965), O'Connell and Hoshovsky (2000), CDFA (Undated), and USGS/Southwest Exotic Plant Information Clearinghouse, data for Grand Canyon National Park (available online at: http://usgssrv1.usgs.nau.edu/swepic/asp/aprs/. An additional source is a personal communication with J. DiTomaso (Professor, University of California, Davis, 2003).

Question 2.5 Potential for human-caused dispersal *Score:* **B** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Hay, livestock and transportation corridors.

Rationale: Human dispersal occurs, not at a high level. *Alhagi maurorum* is sometimes accidentally transported in hay and in fill dirt from contaminated roadsides. Secondary human dispersal occurs when livestock eat contaminated hay or plants and disperse seeds in their manure. *Alhagi maurorum* can also spread along highways and canals. The species was originally introduced to the U.S. in packing material for date palms from its native Mediterranean region. In Arizona, *A. maurorum* is monitored through the USDA as a listed noxious weed, thus limiting its intentional dispersal by humans.

Sources of information: See O'Connell and Hoshovsky (2000) and NAWC (2002).

Question 2.6 Potential for natural long-distance dispersal *Score:* **A** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Potential for natural long-distance dispersal is high; frequent long-distance dispersal by animals or abiotic mechanisms.

Rationale: Transportation of seed in manure of grazers, seed remains viable after passing through digestive system; scarification either through digestion or by sand seems to be a necessary requirement for germination (Kerr et al. 1965). Transportation of seeds, rhizomes and rhizome fragments in drainages by water and by wind (CDFA Undated, NAWC 2002).

Sources of information: See cited literature; also see O'Connell and Hoshovsky (2000) and USGS/Southwest Exotic Plant Information Clearinghouse, data for Grand Canyon National Park (available online at: at: http://usgssrv1.usgs.nau.edu/swepic/asp/aprs/).

Question 2.7 Other regions invaded *Score:* **B** *Doc'n Level:* **Other pub.**

Identify other regions: Invades in California in semi-desert grasslands and playas, 2 ecological types not invaded in Arizona (see draft California assessment by DiTomaso 2003). The species has spread throughout the desert southwest, into Washington, Idaho, Nevada, Utah, Arizona, Colorado, New Mexico, and Texas, as well as California (where it first introduced into the west [see authors in Kerr et al. 1965] has been effectively eradicated). It has also established in other countries outside of its native region, including South Africa and Australia.

Rationale: *Alhagi maurorum* invades elsewhere on this continent and on other continents, but mostly in ecological types that it has already invaded in the state of Arizona. Grasslands and playas were colonized in California, but populations in these ecotypes have not been noted in Arizona. Although *A. maurorum* has been found in many ecotypes, many populations are restricted to roadsides, especially in Great Basin conifer woodland (pinyon-juniper), montane conifer forest (ponderosa pine), and on dunes. Kerr et al. (1965) reported that in Egypt, West Pakistan, Palestine, Nepal and India, *A. maurorum* stands occur on river terraces or flood plains where the water table was near the surface but where precipitation was relatively low. Based on studies in Washington, *A. maurorum* appears to be frost intolerant (Kerr et al. 1965).

Sources of information: See cited literature; also see O'Connell and Hoshovsky (2000). Additional sources are personal communications, November to December 2003: D Evans (Range Specialist, U.S. Department of Agriculture, Forest Service, Prescott National Forest) and T. Eckler (Arizona Department of Transportation). Also considered the draft California plant assessment for *Alhagi maurorum* by J. DiTomaso (latest committee review date: August 1, 2003; available online at: http://www.caleppc.org).

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Other pub.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Widespread: the species invades at least three major and at least 5 minor ecological types in Arizona. *Alhagi maurorum* has colonized in Navajo, Coconino, Gila, Maricopa, and Yuma counties, from 100 to 5,000 feet in elevation. One focal point of introduction is Winslow, AZ, from where all drainages below there have been colonized. *Alhagi maurorum* was introduced to California in 1915 (various authors in Kerr et al. 1965). Introduced into southern Arizona in the early 1900's with the introduction of contaminated alfalfa and packing material from the Middle East.

Rationale: Occurs in Navajo, Coconino, Gila, Maricopa and Yuma counties; 100 to 5000 feet in elevation (Parker 1972).

Sources of information: See cited literature; also see Phillips et al. (1987) and NAWC (2002). Additional sources are personal communications: D. Evans (Range Specialist, U.S. Department of Agriculture, Forest Service, Prescott National Forest), T. Eckler (Arizona Department of Transportation), M. Kearsley (Grand Canyon Research and Monitoring), L. Makarick (Below the Rim Vegetation Program Manager, Grand Canyon National Park Science Center, Flagstaff, Arizona), and B. Phillips (Zone Botanist, U.S. Deaprtment of Agriculture, Forest Service, Coconino, Kaibab and Prescott National Forests).

Question 3.2 Distribution *Score:* **B** *Doc'n Level:* **Other pub.**

Describe distribution: The distribution of *A. maurorum* is broad, being found all around the state of Arizona along streams, canals, roadways, and riparian corridors from 100 to 5000 ft. elevation.

Rationale: *Alhagi maurorum* has infested somewhere between 20% and 50% of the LCR and Colorado river drainage system. Extensive in moist areas, especially in disturbed areas and where there is better runoff (roadside). Large areas of the Navajo Reservation are infested. Along a canal below Gillespie Dam in Maricopa County, there is a continuous infestation for 15 miles which grew in less than 20 years. Common from Winslow to Holbrook along I-40—what could see was mainly along I-40.

Sources of information: See Parker (1972) and NAWC (2002). Additional sources are personal communications: D. Evans (Range Specialist, U.S. Department of Agriculture, Forest Service, Prescott National Forest), T. Eckler (Arizona Department of Transportation), M. Kearsley (Grand Canyon Research and Monitoring), L. Makarick (Below the Rim Vegetation Program Manager, Grand Canyon National Park Science Center, Flagstaff, Arizona), and B. Phillips (Zone Botanist, U.S. Deaprtment of Agriculture, Forest Service, Coconino, Kaibab and Prescott National Forests).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ **Yes**]	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	[✓ **Yes**]	**No**	**2 pt.**
Populations of this species produce seeds every year.	[✓ **Yes**]	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**Yes**	[✓ **No**]	**1 pt.**
Seeds remain viable in soil for three or more years	[✓ **Yes**]	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes**	**No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	[✓ **Yes**]	**No**	**1 pt.**
Fragments easily and fragments can become established elsewhere	[✓ **Yes**]	**No**	**2 pt.**
Resprouts readily when cut, grazed, or burned	[✓ **Yes**]	**No**	**1 pt.**

Total pts: 10 Total unknowns: 1

Score : A

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	**D**
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	**B**
	Mohave desertscrub	**D**
	Chihuahuan desertscrub	**D**
	Sonoran desertscrub	**D**
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	**C**
	southwestern interior riparian	
	montane riparian	**B**
Woodlands	Great Basin conifer woodland	**D**
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Arundo donax* L. (USDA 2005)
Synonyms:	*Arundo donax* L. var. *versicolor* (P. Mill.) Stokes, *Arundo versicolor* P. Mill. USDA (USDA 2005)
Common names:	Giant reed, giant cane
Evaluation date (mm/dd/yy)**:**	04/23/04
Evaluator #1 Name/Title:	Dana Backer, Conservation Ecologist
Affiliation:	The Nature Conservancy
Phone numbers:	(520) 622–3861 x3473
Email address:	dbacker@tnc.org
Address:	1510 E. Fort Lowell, Tucson, Arizona 85713
Evaluator #2 Name/Title:	Katie Brown
Affiliation:	The Nature Conservancy
Phone numbers:	Same as above
Email address:	
Address:	

List committee members:	06/24/03: W. Austin, D. Backer, J. Busco, P. Guertin, J. Hall, R. Haughey, L. Moser, F. Northam, R. Paredes, B. Phillips, K. Thomas, K. Watters 08/26/03: W. Albrecht, W. Austin, D. Backer, R. Hiebert, L. Makarick, L. Moser, T. Olson, B. Phillips, T. Robb, K. Thomas, K. Watters
Committee review date:	06/24/03 and 08/26/03
List date:	08/26/03
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		**Score**	**Documentation Level**	**Section Scores**	**Overall Score & Designations**
1.1	Impact on abiotic ecosystem processes	**A**	Other published material	**“Impact”** **Section 1 Score:** **A**	**“Plant Score”** **Overall Score:** **High** **Alert Status:** **None**
1.2	Impact on plant community	**A**	Other published material		
1.3	Impact on higher trophic levels	**A**	Other published material		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Other published material	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **13 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Other published material		
2.3	Recent trend in total area infested within state	**B**	Observational		
2.4	Innate reproductive potential	**B**	Other published material		
2.5	Potential for human-caused dispersal	**B**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Other published material		
2.7	Other regions invaded	**C**	Other published material		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**B**	Observational	**“Distribution”** **Section 3 Score:** **B**	
3.2	Distribution	**B**	Observational		

Table 3. Documentation

Note: Information is based primarily on studies from California unless otherwise noted.

Question 1.1 Impact on abiotic ecosystem processes *Score:* **A** *Doc'n Level:* **Other pub.**

Identify ecosystem processes impacted: Natural regeneration of riparian communities (Riegar and Kreager 1989), suspected to reduce groundwater availability (Dudley 2000); channel modification (Newhouser et al. 1999, Dudley 2000); alter fire regime (Scott 1994, Gaffney and Cushman 1998); increase water temperatures (lower oxygen; Chadwick and Associates 1992); decreases water quality (Chadwick and Associates 1992); increased erosion (Newhouser et al. 1999); and water loss (DiTomaso and Healy 2003). Hillslope erosion stabilization-positive effect (Horton 1949).

Rationale: Periodic floods of large magnitude and migration of the river channel are essential to depositing fresh alluvium where seeds and vegetative propagules of *Baccharis*, *Salix*, and *Populus* can germinate and take root (Gregory et al. 1991; Richter and Richter 1992). Stabilization of banks and instream channel by *Arundo*, inhibits the natural flood disturbance necessary for natural regeneration. Root masses can stabilize stream banks and terraces (Zahran and Willis 1992).

From Bell (1996): *Arundo donax* is also highly flammable throughout most of the year, and the plant appears highly adapted to extreme fire events (Scott 1994). While fire is a natural and beneficial process in many natural communities in southern California it is a largely unnatural and pervasive threat to riparian areas [the same would be true for AZ]. Because *A. donax* is extremely flammable, once established within a riparian area it redirects the history of a site by increasing the probability of the occurrence of wildfire, and increasing the intensity of wildfire once it does occur. If *A. donax* becomes abundant it can effectively change riparian forests from a flood-defined to a fire-defined natural community, as has occurred on the Santa Ana River in Riverside County, California [potential to occur in AZ]. *Arundo donax* rhizomes respond quickly after fire, sending up new shoots and quickly out-growing any native species which might have otherwise taken root in a burned site.

Dense growth presents fire hazards, more than doubling the available fuel for wildfires and promoting post-fire regeneration of even greater quantifies of *Arundo* (Scott 1994, Gaffney and Cushman 1998). Giant reed develops a tangled mass of flammable shoots and dry leaves at maturity. Its underground rhizomes, however, survive most fires (Horton 1949).

From Bell (1996): Recent studies by the Santa Ana Watershed Project Authority (Chadwick and Associates 1992) suggest that *A. donax* also lacks the canopy structure necessary to provide significant shading of bank-edge river habitats, resulting in warmer water than would be found with a native gallery forest of *Populus* or *Salix*. As a result, riverine areas dominated by *A. donax* tend to have warmer water temperatures, which results in lower oxygen concentrations and lower diversity of aquatic animals, including fishes (Dunne and Leopold 1978). This lack of stream-side canopy structure may also result in increased pH in the shallower sections of the river due to high algal photosynthetic activity. In turn, high pH facilitates the conversion of total ammonia to the toxic unionized ammonia form which further degrades water quality for aquatic species and for downstream users (Chadwick and Associates 1992).

Higher water temperatures foster algae blooms and non-native fish (Newhouser et al. 1999).

From Newhouser et al. (1999): Root masses of *Arundo* clumps are large but brittle. The lack of long roots makes the root masses susceptible to under-cutting by streamflows. It is common to see thick mats of rhizome hanging precariously over the stream. When the root mass gives way, it frequently pulls a chunk of stream bank with it. Not only does this process cause erosion onsite, it spreads the rhizomes downstream where they can take root again. Large dense colonies of cane act as filters, collecting sediment carried in by the stream. The surface under the *Arundo* colony can rise enough to force water into new paths which may collide with streambanks across from or downstream of the *Arundo* infestation. The result is accelerated erosion of the streambanks.

Although it is an aggressive and oftentimes undesirable species, giant reed can be planted on landslide scarred areas to prevent soil erosion. Horton (1949) recommended planting it on steep slopes with shallow soil in sunny areas. Channel morphology is altered by retaining sediments and constricting flows (Lake, personal communication, in Dudley 2000). Large stands can significantly increase water loss from underground aquifers in semiarid regions due to a high evapotranspiration rate, which is many times greater than that of native vegetation (DiTomaso and Healy 2003).

Sources of information: See cited literature. Horton (1949) was the only primary literature cited regarding the positive effects of *Arundo*. Other citations were from various review articles; as a result, the overall level of documentation is other published material.

References cited from Bell (1996): Dunne and Leopold (1978), Gregory et al. (1991), Chadwick and Associates (1992), Richter and Richter (1992), Zahran and Willis (1992), and Scott (1994).

References cited from Dudley (2000): Scott (1994) and Gaffney and Cushman (1998).

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **A** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Impact is on community structure, interactions, and composition.

Rationale: *Arundo* is an aggressive competitor within its introduced range (Bell 1996), has the ability to outcompete and completely suppress native vegetation (Hoshovsky 1986); competes with native species such as *Salix, Populus, and Baccharis (*Bell 1996); competition with native species has been shown to result from monopolization of soil moisture and by shading (Dudley unpubl., Dudley 2000).

From Newhouser et al. (1999; review article, no original citations): *Arundo* grow packed together, crowding out native trees, shrubs, vines, grasses, and wildflowers by out-competing them for light, soil moisture and nutrients. Mature *Arundo*'s dense shade prevents the germination and development of emerging native plants. Over time the weed converts the formerly diverse riparian vegetation into a pure stand of *Arundo*.

Recent studies by the Santa Ana Watershed Project Authority suggest that *A. donax* also lacks the canopy structure necessary to provide significant shading of bank-edge river habitats (Chadwick and Associates 1992). *Arundo* grows vertically as compared to arching (Bell 1996, Gaffney and Cushman 1998, Newhouser et al. 1999). The physical presence of *Arundo* can inhibit to some degree the establishment or growth rate of native species often resulting in pure stands of *Arundo* (Rieger and Kreager 1989). Also impacts marsh communities-composition alteration (cat tails, sedges, emergent vegetation)-personal observation in and around Lower Colorado River; Theresa Olsen, BOR, August 2003).

Sources of information: See cited literature.

Question 1.3 Impact on higher trophic levels *Score:* **A** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Alters/reduces native nesting habitat (Bell 1996, Gaffney and Cushman 1998); transforms fish habitat (temp) and reduces habitat quality for aquatic wildlife (Franklin 1996) reduces forage and habitat (Frandsen and Jackson 1994, Dudley and Collins 1995); contains undesirable toxic chemicals (Chandhuri and Ghosal 1970; Ghosal *et al.* 1972; Zuñiga *et al.* 1983).

Rationale: Many of the fish and bird species mentioned below (from California) are also present in Arizona (or very similar species) which also have the occurrence of *Arundo*. Although this work was conducted in California (primarily southern CA), the committee agrees that these impacts also occurring in Arizona. By competing with native species (Salix, Baccharis, and Populus) which provides nesting habitat for the federally endangered bird, the least Bell's vireo (*Vireo bellii pusillus*), the federally threatened bird, the willow flycatcher (*Empidonax traillii eximus*) and other native species (inferred to be replacing nesting habitat, Bell 1996).

Santa Margarita and San Luis Rey Watersheds WMA (http://smslrwma.org/*Arundo*1.htm, accessed 08/18/03): Although it has often been stated that *Arundo* provides no benefit for native wildlife, *Arundo* has in fact been found to be used by some wildlife. However, *Arundo* still provides little value for native wildlife in comparison to native vegetation, especially when it forms large, monotypic stands. Wildlife such as woodrats and coyotes, and many bird species have been found using *Arundo* for cover and nesting (Greaves). Two endangered bird species, Least Bell's vireo and the southwestern willow flycatcher, have been found to use *Arundo* as a nest host. Least Bell's vireos have been found nesting on *Arundo* along the Santa Clara River and the San Luis Rey River. On the Santa Clara River from 1994 to 1999 approximately 5% of the vireo nests were recorded on *Arundo* (Greaves, pers. comm.), and on the San Luis Rey River from 1988 to 2000 there were approximately 0.5% on *Arundo* (5 out of a total of 906 nests) (Kus, pers. comm.). Although *Arundo* may provide a nest site or nest concealment, the entire territory of these birds encompasses areas with native vegetation. More data is needed to fully understand the use of *Arundo* by native wildlife in comparison to the native habitat, and the degree of *Arundo* usage in proportion to its abundance. Data is also needed on the use of *Arundo* by arthropods, the main food source for many bird species.

From Bell (1996): All evidence indicates that *A. donax* provides neither food nor habitat for native species of wildlife. *Arundo donax* stems and leaves contain a wide array of noxious chemicals, including silica (Jackson and Nunez 1964), tri-terpines and sterols (Chandhuri and Ghosal 1970), cardiac glycosides, curare-mimicking indoles (Ghosal et al. 1972), hydroxamic acid (Zuñiga *et al.* 1983), and numerous other alkaloids which probably protect it from most native insects and other grazers (Miles et al. 1993, Zuñiga et al. 1983). Areas taken over by *A. donax* are therefore largely depauperate of wildlife.

From Bell (1996): As a result, riverine areas dominated by *A. donax* tend to have warmer water temperatures, which results in lower oxygen concentrations and lower diversity of aquatic animals, including fishes (Dunne and Leopold 1978). In the Santa Ana River system this lack of streambank structure and shading has been implicated in the decline of native stream fishes including *Gila orcuttii* (arroyo chub), *Gasterosteus aculatus* (three-spined stickleback), *Rhinichthys osculus* (speckled dace), and *Catostomus santaanae* (Santa Ana sucker). This lack of stream-side canopy structure may also result in increased pH in the shallower sections of the river due to high algal photosynthetic activity. In turn, high pH facilitates the conversion of total ammonia to the toxic unionized.

"Although a few bird species have been observed utilizing the plant for nesting purposes (Kreger, pers. obser.), the presence of *Arundo* essentially creates a zone devoid of wildlife" Rieger and Kreager (1989). *Arundo* provides nesting and hiding cover for waterfowl and shorebirds (Schmidly et al. 1979 in Snyder 1991) but outcompetes native riparian vegetation that may be more important to wildlife (Rieger and Kreager 1989). Higher water temperatures foster algae blooms and non-native fish (Newhouser et al. 1999) and provides little shading to in-stream habitat (thus inc. temperature), reducing habitat quality for aquatic wildlife (Franklin 1996). Provides no food or habitat to native species of wildlife (Newhouser et al. 1999).

Sources of information: See cited literaure.

References cited from Dudley (2000): Frandsen and Jackson (1994), Dudley and Collins (1995), and Franklin (1996).

References cited from Bell (1996): Chandhuri and Ghosal (1970), Ghosal et al. (1972), Dunne and Leopold (1978), Miles et al. (1993), and Zuñiga et al. (1983).

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub.**

Identify impacts: None

Rationale: *Arundo* does not reproduce sexually and there are no native *Arundo* species. Does not produce viable sees in most areas where it is apparently well-adapted, although plants have been grown in scattered locations from seed collected in Asia (Perdue 1958 in Hoshovsky 1986).

Sources of information: See cited literature.

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Can establish with or without disturbance.

Rationale: Spreads by rhizomes during natural flooding cycles; fragments and floats downstream; infest undisturbed habitat. Horticulture propagation is routinely done by planting rhizomes (Dudley 2000). Spreads into bare newly graded or disturbed areas (Rieger 1987).

Sources of information: See cited literature, also see Hoshovsky (1986) and Benton et al. (1998).

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Other pub.**

Describe rate of spread: Increasing, but less rapidly.

Rationale: Increases particularly where flooding causes fragmentation; growth rates up to 0.7 meters/week (Hoshovsky 1986). Growth rates [height] from established rhizomes averaged 2.46 inches (6.25 cm) per day after 40 days growth and 1.05 inches (2.67 cm) per day after 150 days growth (Rieger and Kreager 1989)—results from restoration project on San Luis Rey River and San Diego River. Established colonies are those with previously established rhizomes. Growth rate and ability to attain heights of between 2.5 and 4.0 meters in less than a complete growing season assures a competitive advantage over slower growing native species (Rieger and Kreager 1989).

From Rieger and Kreager (1989): It is known that distribution and development of riparian vegetation is regulated by erosion, deposition and lateral channel migration and the currents create a constant process of erosion with deposition of eroded material occurring further downstream. Flooding, scouring and debris sedimentation serve to promote expansion of *Arundo* colonies along this zone of frequent inundation.

Sources of information: See cited literature.

Question 2.3 Recent trend in total area infested within state *Score:* **B** *Doc'n Level:* **Obs.**

Describe trend: Increasing, but less rapidly.

Rationale: Observational-increasing in areas had not previously seen it in the last 10 years
Recent survey work (Enviro System Management Inc. 2003) along the Verde River indicated presence of *Arundo* from Beasley Flats to approximately 0.5 miles below Childs. Observed along the banks, some substantial patches at times up to 50% cover.

Sources of information: Observations by F. Northam (Arizona Department of Agriculture Noxious Weed Coordinator), P. Warren and D. Turner (The Nature Conservancy, Tucson, Arizona), and B. Phillips (Zone Botanist, U.S. Department of Agriculture, Forest Service, Coconino, Kaibab and Prescott National Forests,) and Enviro System Management Inc. (2003; report to Prescott National Forest; from personal communication with B. Phillips).

Question 2.4 Innate reproductive potential *Score:* **B** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: No sexual reproduction, rapid spread with fragmentation of plant parts above and below ground (rhizomes or fragmentation).

Rationale: Rapid establishment due to rhizome growth.

Sources of information: Perdue (1958), Hoshovsky (1986), and Dudley (2000). Because I was not able to obtain Perdue (1958), which was cited in both Hoshovsky and Dudley, the level of documentation is other published material.

Question 2.5 Potential for human-caused dispersal *Score:* **B** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Sold as ornamental; escapes from cultivation; used in light construction.

Rationale: Once cultivated in commercial plantations in CA (Dudley 2000) and musical instruments (Perdue 1958). Commonly available for gardens or erosion control (Sunset 1967); used as wind breaks and shade screens; used along ditches for erosion control (Benton et al. 1998).

Sources of information: See cited literature; also see Kearney and Peebles (1960) and Hoshovsky (1986). In addition, F. Northam (Arizona Department of Agriculture Noxious Weed Coordinator) provided personal observations. Because Hoshovsky (1986) and Dudley (2000) are review articles, the overall level of document is other published material.

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Fragmentation of rhizomes and dispersal by flood events along streams and floodplains.

Rationale: Natural disturbance of flooding can cause fragmentation and transport.

Sources of information: Hoshovsky (1986), Dudley (2000), and Bell (1996) (all review articles).

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Other pub.**

Identify other regions: Giant reed is naturalized and invasive in many regions, including southern Africa, subtropical United States through Mexico, Bermuda and Bahamas (Perdue 1958, Kearney and Peebles 1960, Pacific Islands, Australia and Southeast Asia [native] (Hafliger and Scholz 1981).

From Bell (1996): This species is believed to be native to freshwaters of eastern Asia (Polunin and Huxley 1987), but has been cultivated throughout Asia, southern Europe, north Africa, and the Middle East for thousands of years and has been planted widely in North and South America and Australia in the past century (Perdue 1958, Zohary 1962).

From http://www.hort.purdue.edu/newcrop/duke_energy/*Arundo_donax*.html, accessed 04/11/03: Said to be native to the circummediterranean area to the Lower Himalayas from Kashmir to Nepal and Assams the Nilgiris and Coorg; introduced to many subtropical and warm temperate regions, where it is grown as an ornamental and is often found as a stray from cultivation.

From Duke (1983): Adapted to tropical, subtropical and warm temperate climates of the World. Often found on sand dunes near seashores. Tolerates some salt. Grows best along river banks and in other wet places, and is best developed in poor sandy soil and in sunny situations. Said to tolerate all types of soils, from heavy clays to loose sands and gravelly soils. Ranging from Cool Temperate Wet through Tropical Dry to Wet Forest Life Zones, giant reed is reported to tolerate annual precipitation of 3 to 40 dm (mean of 112 cases = 13.0) annual temperature of 9 to 28.5°C (mean of 112 cases = 23.6) and pH of 5.0 to 8.7 (mean of 48 cases = 6.9) (Duke 1975, 1979).

Several sources indicate *Arundo donax* can not tolerate high elevations where regular freezing occurs.

Sources of information: See cited literature; also see Zahran and Willis (1992).

Question 3.1 Ecological amplitude *Score:* **B** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Introduced in 1820 in California (Los Angeles River) for roofing material (Robbins et al. 1951 in Hoshovsky 1986) and fodder. Other sources say brought into California in 1890s by French immigrants for windbreaks (Taylor 1971, Dudley 2000). Introduced to Arizona in 1932 in Pima County (SEINet 2004).

Rationale: Observations documented by F. Northam: well distributed throughout Arizona at elevation < 4000 feet; seen in Superior, Camp Verde, Marana, Ehrenberg (La Paz County), Verde River floodplain, Santa Cruz River banks (Pima County), Pecks Lake (Yavapai County), Lo Piano Bosque Natural Area and Agua Fria River (Maricopa County). Lower Colorado River from Bull City to border. Found along drainages and wet areas in Coconino, Kaibab, and Prescott National Forests (NAWC).

Sources of information: Observations on distribution: Working Group members P. Warren, D. Turner, and D. Backer (The Nature Conservancy, Tucson, Arizona) and F. Northam (Arizona Department of Agriculture Noxious Weed Coordinator). “Where it is it is bad, but on a landscape scale it is not that detrimental” (F. Northam, 04/29/03). Contacted D. Roth of Navajo Nation Natural Heritage Program (08/16/03): does not know it to exist on Nation; it could possibly be in the Little Colorado River. Lower Colorado River (personal observation from T. Olson, Wildlife Biologist, Bureau of Reclamation, Boulder City, Nevada, 2003). Also considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed January 2004).

Question 3.2 Distribution *Score:* **B** *Doc’n Level:* **Obs.**

Describe distribution: See Worksheet B.

Rationale: Observations. See Question 3.1.

Sources of information: Observations and personal opinion. See Question 3.1 for sources.

Research Needs (identified in Hoshovsky 1986)

Much more information on seed biology, seedling establishment, growth patterns, and synecology needs to be gathered about *Arundo*. Of great interest is the importance of sexual reproduction over vegetative propagation in the establishment of the plant in new locations. Does *Arundo* produce viable seed in California?

Management Research Needs

What are the most appropriate means of controlling *Arundo* in riparian areas with minimal disturbance to the surrounding native vegetation?

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ **Yes**]	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**Yes**	[✓ **No**]	**2 pt.**
Populations of this species produce seeds every year.	**Yes**	[✓ **No**]	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**Yes**	[✓ **No**]	**1 pt.**
Seeds remain viable in soil for three or more years	**Yes**	[✓ **No**]	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes**	[✓ **No**]	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	[✓ **Yes**]	**No**	**1 pt.**
Fragments easily and fragments can become established elsewhere	[✓ **Yes**]	**No**	**2 pt.**
Resprouts readily when cut, grazed, or burned	[✓ **Yes**]	**No**	**1 pt.**

Total pts: 5 Total unknowns: 0

Score : B

Note any related traits: Resprouts after fire (Bell 1996); does not produce viable seeds (Perdue 1958, Dudley 2000). See also Hoshovsky (1986): wind dispersal of seeds is facilitating by having a dense seed head (assuming they are not viable). The importance of sexual reproduction to the species, as well as seed viability, dormancy, germination and seedling establishment, have yet to be studied and published (Hoshovsky 1986).

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	**B**
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	**C**
	southwestern interior riparian	**D**
	montane riparian	
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial):	*Asphodelus fistulosus* L. (USDA 2005)
Synonyms:	*Asphodelus tenuifolius* Cav. (USDA 2005)
Common names:	Onionweed, pink asphodel
Evaluation date (mm/dd/yy):	04/22/05
Evaluator #1 Name/Title:	Dr. Francis E. (Ed) Northam
Affiliation:	Private weed biology consultant
Phone numbers:	(480) 947–3882
Email address:	fnortham@msn.com
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Evaluator #2 Name/Title:	
Affiliation:	
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Address:	

List committee members:	P. Fenner, J. Hall, L. Making, F. Northam, T. Olson, G. Russell
Committee review date:	04/22/05
List date:	04/22/05
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**C**	Observational	**"Impact"** **Section 1 Score:** **C**	**"Plant Score"** **Overall Score:** **Low** **Alert Status:** **None**
1.2	Impact on plant community	**C**	Observational		
1.3	Impact on higher trophic levels	**U**	No information		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Observational	**"Invasiveness"** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **12 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**U**	No information		
2.3	Recent trend in total area infested within state	**B**	Observational		
2.4	Innate reproductive potential	**B**	Observational		
2.5	Potential for human-caused dispersal	**A**	Observational		
2.6	Potential for natural long-distance dispersal	**U**	No information		
2.7	Other regions invaded	**A**	Observational		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**D**	Observational	**"Distribution"** **Section 3 Score:** **D**	
3.2	Distribution	**D**	Observational		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **C** *Doc'n Level:* **Obs.**

Identify ecosystem processes impacted: Alters nutrient and moisture content of soil.

Rationale: Growth of onionweed plants results in tufts of leaves originating from plant crowns supported by dense fibrous root systems. In other words, their foliage growth form resembles a 20 to 30 cm tall bunchgrass. Well developed plants (second growing season) produce root systems that can impair growth of other plants up 3 to 4 cm around onionweed crowns (F. Northam, personal observations, 2005). Total surface area dominated can be at least 200 to 300 cm^2 per mature plant (a 6 x 6 inch area is approximately 230 cm^2). As a result, it is assumed natural soil productivity is altered by removal of nutrients and moisture. Likewise, soil near basal areas of onionweed is densely shaded due to the thick mats of leaves attached to onionweed crowns that probably intercept a major portion of available sunlight immediately surrounding these weeds.

Observations of onionweed growth habits suggest that dense stands of this species cause at least minor alterations of soil moisture, mineral nutrients, and sunlight intensity.

Sources of information: Personal observations of onionweed populations near Tombstone, Arizona by F. Northam (Weed Biology Consultant, Tempe, Arizona, 2005). Score based on inference drawn from the preceding observations.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **C** *Doc'n Level:* **Obs.**

Identify type of impact or alteration: Reduce establishment of native plant seedlings.

Rationale: Abiotic impacts listed in question 1.1 may reduce seedling establishment of other species because onionweed roots can remove soil moisture and nutrients that would normally be available for native seedling growth. Also physical space occupied by onionweed foliage may block sunlight to the point of inhibiting seedling growth of other plants. Parsons (1973) quoted rancher estimates of 75% depletion of forage in southern Australian grazing lands infested by dense populations of onionweed, but this weed does not intrude into areas with abundant perennial plant roots near the surface (i.e. grasslands). Recovery of palatable and productive grazing species was slow in southern Australian rangelands dominated by onionweed (Stretch 2002).

Sources of information: See cited literature. Score based on inference drawn from the literature.

Question 1.3 Impact on higher trophic levels *Score:* **U** *Doc'n Level:* **No info.**

Identify type of impact or alteration: No information.

Rationale: No information.

Sources of information: None.

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub.**

Identify impacts: No known hybridization.

Rationale: No native species of *Asphodelus* occur in Arizona (Kearney and Peebles 1960).

Sources of information: See cited literature.

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Obs.**

Describe role of disturbance: Natural or anthropogenic disturbance is necessary for onionweed establishment.

Rationale: Intense grazing and trampling (as around livestock watering facilities or along animal trails) can cause bare ground where onionweed may establish. Natural disturbance due to periodic floods in normally dry washes create open, vegetation-free soil conditions suitable for onionweed colonization. Grazing disturbance has been noted as an important factor for onionweed encroachment into Australian grazing lands (Parsons 1973, Stretch 2002). An onionweed population in southeast Tombstone has moved from a highway right-of-way into a native rangeland wash adjacent to Highway 87 (F. Northam, personal observations, 2005)

Sources of information: See cited literature. Also considered personal observations of onionweed populations near Tombstone, Arizona by F. Northam (Weed Biology Consultant, Tempe, Arizona, 2005).

Question 2.2 Local rate of spread with no management *Score:* **U** *Doc'n Level:* **No info.**

Describe rate of spread: Several populations of onionweed have been confirmed during the past two years in roadside rights-of-way, landscaped urban sites and private flower gardens (Russell 2004), but only one site has had verified movement into wildlands (see question 2.1). The local rate of spread, however, at this site has not been documented.

Rationale: Only one site has had verified movement into wildlands (see question 2.1). The local rate of spread, however, at this site has not been documented; as a result, no information is available to predict how rapidly Arizona wildland populations of this species will expand in the absence of control measures.

Sources of information: See cited literature. No information available in regard to rate of spread with no management.

Question 2.3 Recent trend in total area infested within state *Score:* **B** *Doc'n Level:* **Obs.**

Describe trend: Increasing, but not doubling in <10 years.

Rationale: Arizona Department of Agriculture observation and abatement records at eight sites from October 1989 to March 1994 indicated onionweed presence in nurseries and gardens in Cochise, Maricopa and Pima Counties (F. Northam, personal observations, 2000–2003). Since 2001 many onionweed sites have been verified including additional infestations in Santa Cruz and Yavapai Counties (Russell 2004; F. Northam, personal observations, 2005); however, only one site indicates dispersal into natural plant communities.

Sources of information: See cited literature. Also considered personal observations of (1) onionweed distribution in Arizona by F. Northam (while acting as the Arizona Department of Agriculture Noxious Weed Program Coordinator, 2000–2003) and (2) onionweed populations near Tombstone, Arizona by F. Northam (Weed Biology Consultant, Tempe, Arizona, 2005).

Question 2.4 Innate reproductive potential *Score:* **B** *Doc'n Level:* **Obs.**

Describe key reproductive characteristics: Herbaceous perennial, but reproduces only by seed.

Rationale: See Worksheet A. Answers based on field observations at Tombstone, Arizona (F. Northam, personal observations, 2005).

Sources of information: Personal observations of onionweed populations near Tombstone, Arizona by F. Northam (Weed Biology Consultant, Tempe, Arizona, 2005).

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Obs.**

Identify dispersal mechanisms: Human dispersal occurs.

Rationale: Onionweed seed are spread: (1) along transportation corridors by vehicles, road maintenance activities and mining gravel for building material (Russell 2004) and (2) through dispersal by home gardeners as suggested by numerous residential sites identified in Tombstone and Serra Vista (Russell 2004).

Sources of information: See cited literature. Score based on inference drawn from the literature.

Question 2.6 Potential for natural long-distance dispersal *Score:* **U** *Doc'n Level:* **No info.**

Identify dispersal mechanisms: No reports of animal or abiotic dispersal mechanisms found during this investigation.

Rationale: No information.

Sources of information: None

Question 2.7 Other regions invaded *Score:* **A** *Doc'n Level:* **Obs.**

Identify other regions: Western Australia's southern rangelands.

Rationale: Even though onionweed is widely distributed in Australia, its injurious status is expressed mostly in western Australia rangelands where disturbance by human activities remove native plant communities (Parsons 1973, Stretch 2002).

Since onionweed has moved into Chihuahuan desertscrub at Tombstone, these Australian observations support an inference that three climatically comparable Arizona minor ecological types may be potential habitat for onionweed including: plains and Great Basin grassland, semi-desert grassland, and Sonoran desertscrub (upper elevations only). Washes, arroyos, and ephemeral stream channels in these types are probably the most susceptible habitats because coarse textured soils are favored colonizing sites in Australia.

Sources of information: See cited literature. Score based on inference drawn from the literature.

Question 3.1 Ecological amplitude *Score:* **D** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: One minor ecological type: Chihuahuan desertscrub.

Rationale: Arizona's oldest herbarium specimen (April 1980) was described as an escape at Desert Botanical Garden, Phoenix, Arizona. A similar collection in 2002 noted onionweed as once cultivated at Desert Botanical Garden (SEINet 2005). These records indicate a 25-year presence in Arizona as a cultivated species.

Onionweed distribution as an ecological pollutant in Australia is limited to rangelands that receive winter rainfall in the 10 to 16 inch precipitation zones (Parsons 1973). Furthermore, plant community disturbance by grazing activities or other human-induced vegetation removal that severely reduced native plant cover was necessary for onionweed to encroach into those grazing lands (Stretch 2002). Colonies on light sandy soils establish the highest densities of onionweed populations (Parsons 1973). Because, however, onionweed has colonized roadsides, landscaped sites, and residential gardens from 1700 to 4700 feet, this weed is not limited to coarse textured desert soils (Russell 2004, F. Northam, personal observations, 2000–2003).

Sources of information: See cited literature. Also considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed 2005) and personal observations of onionweed distribution in Arizona by F. Northam (while acting as the Arizona Department of Agriculture Noxious Weed Program Coordinator, 2000–2003).

Question 3.2 Distribution *Score:* **D** *Doc'n Level:* **Obs.**

Describe distribution: As an escaped species into Arizona's wildlands, only one small site (<5 acres) in Chihuahuan desertscrub is known (Russell 2004, F. Northam, personal observations, 2005).

Rationale: Current distribution in Arizona ranges from Sedona in Yavapai to Hereford in Cochise County, approximately eight miles north of the Arizona-Mexico border. Herbarium and field observations indicate onionweed survives at elevations above 1000 feet to about nearly 5000 feet. Dozens of infestations are documented on private home sites, rights-of-way, and municipal lands.

With a 20+ year history in Arizona, however, onionweed escape into wildlands is at present extremely slow.

Sources of information: See cited literature. Also considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed 2005) and personal observations of onionweed populations near Tombstone, Arizona by F. Northam (Weed Biology Consultant, Tempe, Arizona, 2005).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**[✓ Yes]**	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**[✓ Yes]**	**No**	**2 pt.**
Populations of this species produce seeds every year.	**[✓ Yes]**	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**Yes**	**No**	**0 pt.**
Seeds remain viable in soil for three or more years	**Yes**	**No**	**0 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes**	**No**	**0 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes**	**[✓ No]**	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	**[✓ No]**	**2 pt.**
Resprouts readily when cut, grazed, or burned	**[✓ Yes]**	**No**	**1 pt.**
	Total pts: 5 Total unknowns: 3		
	Score : B		
Note any related traits:			

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	**D**
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	
	montane riparian	
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

Literature Cited

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Avena fatua* L. (USDA 2005)
Synonyms:	*Avena fatua* L. var. *glabrata* Peterm., *Avena fatua* L. var. *vilis* (Wallr.) Hausskn., *Avena hybrida* Peterm. ex Reichenb. p.p.(USDA 2005)
Common names:	Wild oat
Evaluation date (mm/dd/yy)**:**	07/08/04
Evaluator #1 Name/Title:	Christopher Laws, Conservation Biology Intern
Affiliation:	University of Arizona
Phone numbers:	(520) 572–3994
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Evaluator #2 Name/Title:	Dana Backer, Conservation Ecologist
Affiliation:	The Nature Conservancy
Phone numbers:	(520) 622–3861
Email address:	dbacker@tnc.org
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List committee members:	07/16/04: P. Warren, J. Hall, D. Backer, G. Ferguson, C. Laws, M. Van Gilder 11/19/04: J. Hall, D. Backer, G. Ferguson, K. Klemontowski, P. Guertin, H. Messing
Committee review date:	07/16/04 and 11/19/04
List date:	11/19/04
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**U**	Observational	**“Impact”** **Section 1 Score:** **C**	**“Plant Score”** **Overall Score:** **Medium** **Alert Status:** **None**
1.2	Impact on plant community	**C**	Other published material		
1.3	Impact on higher trophic levels	**U**	No information		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Other published material	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **14 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Observational		
2.3	Recent trend in total area infested within state	**C**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**A**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Other published material		
2.7	Other regions invaded	**C**	Observational		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**A**	Observational	**“Distribution”** **Section 3 Score:** **A**	
3.2	Distribution	**B**	Observational		

Table 3. Documentation

Note: Most all of the research literature conducted on *Avena fatua* is based in agriculture settings and as it relates to crops.

Question 1.1 Impact on abiotic ecosystem processes *Score:* **U** *Doc'n Level:* **Obs.**

Identify ecosystem processes impacted: Possibly depletes soil resources, alters fire frequencies

Rationale: The following information is paraphrased from Guertin and Halvorson (2003). In an agricultural setting, *Avena fatua* is a common weed, reducing yields and quality of harvested crops (Sharma and Vanden Born 1978). It was found to effectively compete for light by producing greater height than the crop, subsequently reducing growth of the crop (Cudney et al. 1991 in Radosevich et al. 1997). Competition gets more rigorous even before *Avena fatua* reaches the 2 to 3 leaf stage (Chancellor and Peters 1976 and Sharma and Hunter 1975, both cited in Sharma and Vanden Born 1978). In a study focusing on root growth, *Avena fatua* plant grown free from competition had 54 miles of root system tissue after 80 days of growth and another study showed that when in competition with crop species, *Avena fatua* produced 90 times less root matter (Pavlychenko 1937 in Radosevich et al. 1997). Resource allocation for roots infers an apparent ability to harvest soil environment resources, which seemingly would improve a plant's competitive ability (Radosevich et al. 1997).

Based on the above information, the extensive root system may lead to a depletion of soil resources (inference).

Observational increase in fire frequency due to senescent plant litter, especially during dry hot months of June through August (personal communications with F. Northam and B. Munda, 2004). B. Munda has observed this over the past twenty years at a site near I-17 and south of Cordes Jct. These observations are predominately along right-of-ways and road sides where there tends to be: a) higher densities of *A. fatua*, likely due to increases in available water, and b) increased potential for ignitions.

Most all of the research literature conducted on *A. fatua* is based in agriculture settings and as it relates to crops. There are no known studies of *A. fatua* impacts on natural areas. The Working Group did not feel comfortable inferring any of the above information to wildlands.

Sources of information: See cited literature. Additional information based on Working Group discussions and observations by F. Northam (Weed Biologist [former Arizona Department of Agriculture Noxious Weed Coordinator], Tempe, Arizona, 2004) and B. Munda (Plant Resource Specialist, Plant Materials Center. U.S. Department of Agriculture, Natural Resources Conservation Service, Tucson, Arizona, 2004).

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **C** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Minor alteration. Inhibits germination and seedling growth. More competitive (primarily in crop settings).

Rationale: Most of the competition studies have been conducted on crops and various agricultural weeds.

From Sharma and Vanden Born (1978): The competitive success of wild oats depends on the plants with which they are competing. Pavlychenko and Harrington (1934) studied the competing abilities of certain weeds, including wild oats and crops. Based on the development of the root system, development of assimilation surface and stomatal number, the authors concluded that wild oats were the most vigorous competitors among weeds studied.

The following information is paraphrased from Guertin and Halvorson (2003). *Avena fatua* is far less competitive with its growth very restricted when growing in a crop versus growing alone (Chancellor 1976). *Avena fatua* has allelopathic phenolic compounds, which impact other plants, inhibiting germination and seedling growth (Sharma and Vanden Born 1978). In California annual grasslands *Avena fatua* in California has demonstrated strong allelopathic effects (Tinnin and Muller 1971a, b in Wilken and Hannah 1998). *Avena fatua* is suited to open, sunny sites, exhibiting reduced growth and diminished competitive ability when under shade (Maranon and Bartolome 1993 in Wilken and Hannah 1998).

A. fatua does not appear to be displacing native plants and usually responds only in wet years (P. Guertin, pers. comm., 2004). It is persistent in natural communities (F. Northam, personal communication, 2004). Coronado NF is using *Avena sativa* in revegetation sites post-burn at lower elevations. It has not been observed persisting more than 1 to 2 years post-planting because it seems to be out-competed (R. Lefever, personal communication, 2004).

Sources of information: See cited literature citations. Observations by F. Northam (Weed Biologist [former Arizona Department of Agriculture Noxious Weed Coordinator], Tempe, Arizona, 2004) and R. LeFever (Forester, USDA Forest Service, Coronado National Forest, Tucson, Arizona, 2004).

Question 1.3 Impact on higher trophic levels *Score:* **U** *Doc'n Level:* **No info**

Identify type of impact or alteration: Possibly competes with native plants that are used for forage.

Rationale: No known studies of impact on higher trophic levels in Arizona or elsewhere.

Sources of information: No information.

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub.**

Identify impacts: Hybridizes with other *Avena* species, but none that are native.

Rationale: Although natural hybridization occurs between *Avena fatua* and *A. sativa (*Sharma and Vanden Born 1978), *A. sativa* is not native to Arizona. *A. sativa* is readily used in post-fire revegetation seed mixes. Furthermore, there are no native congeners in Arizona (Kearney and Peebles 1960).

Sources of information: See cited literature; also see Rajhathy and Thomas (1974).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Other pub.**

Describe role of disturbance: *Avena fatua* establishes readily in disturbed areas, most common in cultivated fields (Sharma and Vanden Born 1978) and occasionally establishes in areas that are undisturbed (Working Group consensus and personal observations).

Rationale: The following is paraphrased from Guertin and Halvorson (2003). On the North American continent: *Avena fatua* is found in valleys and on open slopes of foothill ranges, on cultivated soils, disturbed soils in waste places, and along roadsides (Stubbendieck et al. 1992). *Avena fatua* is presently noted to be scattered and rare on disturbed sites along roads and washes at the Desert Laboratory in Tucson, Arizona (Burgess et al. 1991).

Observed numerous areas where *Avena fatua* populations have moved from disturbed areas are mainly highway right-of-ways into semidesert grasslands and interior chaparral (F. Northam, personal communication, 2004)

Sources of information: See cited literature. Observations by F. Northam (Weed Biologist [former Arizona Department of Agriculture Noxious Weed Coordinator], Tempe, Arizona, 2004).

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Obs.**

Describe rate of spread: Increasing, but less rapidly.

Rationale: Observations by plant ecologists (B. Munda, P. Guertin, and E. Northam) suggest *Avena fatua* is still spreading without management control. Where wild oat is found in natural areas it is spreading but not doubling (AZ-WIPWG, July 16, 2004 meeting).

Sources of information: Observations by B. Munda (Plant Resource Specialist, Plant Materials Center. U.S. Department of Agriculture, Natural Resources Conservation Service, Tucson, Arizona, 2004), P. Guertin (Research Specialist, U.S. Geological Survey Sonoran Desert Research Station, Tucson, Arizona, 2004), and F. Northam (Weed Biologist [former Arizona Department of Agriculture Noxious Weed Coordinator], Tempe, Arizona, 2004).

Question 2.3 Recent trend in total area infested within state *Score:* **C** *Doc'n Level:* **Obs.**

Describe trend: Stable

Rationale: *Avena fatua* is documented as being present in Arizona as of 1902 (Thornber; unnumbered collection in Burgess et al. 1991). Appears to be widespread throughout AZ and has reached the extent of its range (AZ-WIPWG, July 16, 2004 meeting).

Sources of information: Inference based on observations and Working Group discussion.

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: In dense infestations can produce seeds at densities >1000 per meter, which are viable for more than 3 years; self and cross pollination; reaches reproductive maturity in 2 years.

Rationale: The following is summarized from Sharma and Vanden Born (1978). *Avena fatua* plants commonly produce between 100-150 seeds/plant. Dadd (1953) reports up to 500 seeds/plant. When under more intense competition in a crop, *Avena fatua* may only produce 1–2 inflorescence/panicles, having 20–30 seeds/plant (Chancellor and Peters 1976). Seeds will persist for 3 to 6 years in cultivated soil (Banting 1962). Seeds in undisturbed soil or under sod survive longer than in soil cultivated annually (Banting 1974).

From Guertin and Halvorson (2003): In California, *Avena fatua* plants produce seeds from April through June (Elkhorn Slough National Estuarine Research Reserve 2000, University of California 1998). *Avena fatua* seeds can stay dormant in the soil for 7-8 years, and occasionally over 10 years, but 85-95% of the seeds germinate within 2 years (Manitoba Agriculture 2001, Ministry of Agriculture and Food 2001). Variability has been noted between plants from different geographic regions having different habitat; differences have been found in seed dormancy, germination, emergence, and growth (Sharma and Vanden Born 1978, Thurston and Phillipson 1976).

The following is summarized from Holm et al. (1991). No generalizations can be made about the dormancy of the species of wild oats. There are many factors that lead to seed dormancy and the literature has many contradictions. The seed dormancy is perhaps the prime reason for the difficulties encountered in the cereal fields of the world. Most tests indicate seeds in farm soils do not survive beyond 4 to 7 years.

Sources of information: See cited literature.

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Other Pup.**

Identify dispersal mechanisms: Contaminant of hay, vehicles, and farm machinery.

Rationale: *Avena fatua* is a common contaminant in seed, animal feed and silage, in or on farm machinery, and in manure (Thurston and Phillipson 1976 in Guertin and Halvorson 2003, Holm et al. 1991). Several authors noted that California cultivates wild oats for hay and as a range grass;

approximately 16,000 ha are harvested annually (Sharma and Vanden Born 1978, Holms et al. 1991). It is not known if it is still cultivated in California. Seeds are commercially available via the internet and in the UK (http://www.scs.leeds.ac.uk/pfaf/Links_3.html).

Sources of information: See cited literature.

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Wind, birds, and animals.

Rationale: Seeds usually fall to the ground in the immediate vicinity of the parent plant upon maturity (Sharma and Vanden Born 1978). Also dispersed by wind, birds and animals (forage or attachment to fur) (Thurston and Phillipson 1976 in Guertin and Halvorson 2003).

Sources of information: See cited literature.

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Obs.**

Identify other regions: No other ecological types in other regions that do not already occur in Arizona.

Rationale: Based on presence in nearly every U.S. state (USDA PLANTS database [USDA 2005] and Grass Manual on the Web [Barkworth et al. 2003]), primarily as an agriculture weed. On the North American continent *Avena fatua* is found in valleys and on open slopes of foothill ranges, on cultivated soils, disturbed soils in waste places, and along roadsides (Stubbendieck et al. 1992 in Guertin and Halvorson 2003).

From Holm et al. (1991): *A. fatua* is found as a weed in Iceland and Alaska and at higher elevations at the equator. Species is troublesome wherever cereals are grown at 375 to 750 mm annual precipitation. Cold temperatures do not hinder plant growth. On a world basis, it is one of the 12 most successful colonizers among the noncultivated plants (Allard 1965).

Sources of information: Inference based on cited literature and databases.

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: *Avena fatua* is native to Africa (Algeria, Egypt, Ethiopia), temperate Asia (Middle East, to China), tropical Asia (India, Nepal, Pakistan), and Europe (GRIN 2005). *Avena fatua* was introduced into North America as a contaminant in crop seed and feed by the early European settlers (Sharma and Vanden Born 1978). Records indicate that *Avena fatua* has been present in Canada for more than three centuries (Baum 1968 in Sharma and Vanden Born 1978). *Avena fatua* was established in California by 1824 (Frenkel 1977 in Burgess et al. 1991). It was present in Arizona by 1902 (Thornber unnumbered collection in Burgess et al. 1991). *Avena fatua* was first collected at the Desert Laboratory in Tucson, Arizona in 1983 by Bowers and Turner (Burgess et al. 1991). *Avena fatua* occurs at elevations up to 8250 feet (2515 m) in Arizona (Parker 1972).

Environmental and site preferences summarized by Guertin and Halvorson (2003): *Avena fatua* prefers temperate climates, cool weather and moist soil (Manitoba Agriculture 2001, Sharma and Vanden Born 1978); these conditions promote the highest emergence (Sharma and Vanden Born 1978). In crop fields, it can often be found on the lower, moister areas of the fields (Uva et al. 1997)….*Avena fatua* is suited to open, sunny sites, exhibiting reduced growth and diminished competitive ability when under shade (Maranon and Bartolome 1993 in Wilken and Hannah 1998)….*Avena fatua* can adapt to many different soil types (Elkhorn Slough National Estuarine Research Reserve 2000) and can typically be found on heavy clay and clay-loam soils (Uva et al. 1997).

Rationale: Present in four major ecological types.

Sources of information: See cited literature. Score based on observations of Working Group members and information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed July 16 2004).

Question 3.2 Distribution *Score:* **B** *Doc'n Level:* **Obs.**

Describe distribution: Arizona by county (from Guertin and Halvorson 2003): Coconino County (Kearney and Peebles 1960, McDougall 1973), Apache, Mohave counties (Gould 1951, Kearney and Peebles 1960, McDougall 1973), Navajo (Barkworth et al. 2003), and Yavapai County (Kearney and Peebles 1960, McDougall 1973), south (Kearney and Peebles 1960) to Gila, Pinal, Cochise, and Pima counties (Gould 1951, Kearney and Peebles 1960), and Santa Cruz county (Barkworth et al. 2003).

Rationale: Observed in localized heavy infestations in Sonoran Uplands, desert scrub (desert having saguaro, with many shrubs), and even though it covers whole hillsides (seeming to prefer a south aspect unless in a riparian setting), it seems very dependent each year on sufficient rains in this type of vegetation. Observed several years without any new green plants in an infested area; germination dependent on enough rain at the right times to support it (its remnants stand for years as senesced biomass; P. Guertin, personal communication, 2004).

From Arizona State University Vascular Plant Herbarium, University of Arizona Herbarium, and Northern Arizona University Vascular Plant Herbarium via SEINet (2004):

Cochise County: San Pedro Riparian National Conservation Area, Upper San Pedro River floodplain, near Lewis Springs ~1/2 mile north of Highway 90
Maricopa County: Tonto National Forest, Seven Springs campground, about 0 to 0.5 upstream from road.
Graham County: Bureau of Land Management lands, Black Rock Wash. Near Forest boundary. Below Fisher Canyon junction. Also on National Forest lands.
Maricopa County: Tonto National Forest, Barpit Tank, about 1.1 miles down from summit of Humboldt Mountain.
Maricopa County: South Mountain Park, Alta Trail
Maricopa County: Southeastern Crater Range, 2.2 km ENE of Crater Mountains, about 4.2 km NW of Deadman Gap.
Maricopa County: White Tank Mountains Regional Park, East side of White Tank Mountains. Rocky wash rising from desert floor south of peak 2094 into high walled canyon between peaks 2995 and 3032 up to ridgeline East of Beacon at peak 4083.
Pinal County: Tonto National Forest. Superstition Wilderness Area. Heiroglyphic Spring and Miles Ranch Trailhead.
Coconino County, Grand Canyon National Monument, Grand Canyon National Park, along North Kaibab Trail.
Gila County: Tonto National Forest, Tonto National Forest; Sierra Ancha Wilderness Area
Yuma County: Theba, Arizona.
Coconino County: Grand Canyon, Tapeats Creek,
Pima County: Saguaro National Park; Rincon Mountains
Pima County: rare on mid-slopes of Pontatoc Ridge, Santa Catalina Mountains
Pima County: lower Bear Canyon
Pima County: Buenos Aires National Wildlife Refuge
Pinal County: Antelope Peak area (Table Top Mountains)

Sources of information: Based on cited literature, observations by P. Guertin (Research Specialist, U.S. Geological Survey Sonoran Desert Research Station, Tucson, Arizona, 2004), and information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed July 16 2004).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**[✓ Yes]**	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**[✓ Yes]**	**No**	**2 pt.**
Populations of this species produce seeds every year.	**[✓ Yes]**	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**[✓ Yes]**	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	**[✓ Yes]**	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**[✓ Yes]**	**No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes**	**[✓ No]**	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	**[✓ No]**	**2 pt.**
Resprouts readily when cut, grazed, or burned	**Yes**	**No**	**1 pt.**

Total pts: 8 Total unknowns: 1

Score : A

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	**B**
Desertlands	Great Basin desertscrub	**D**
	Mohave desertscrub	**D**
	Chihuahuan desertscrub	
	Sonoran desertscrub	**D**
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	**D**
	semi-desert grassland	**C**
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	**D**
	southwestern interior riparian	**D**
	montane riparian	
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Brassica tournefortii* Gouan (USDA 2005)
Synonyms:	*Brassica tournefortii* Gouan var. *sisymbrioides* (Fisch.) Grossh. (USDA 2005)
Common names:	Sahara mustard, African mustard, Morrocan mustard, Asian mustard, Mediterranean mustard, wild turnip
Evaluation date (mm/dd/yy)**:**	11/11/2003
Evaluator #1 Name/Title:	Curt McCasland
Affiliation:	U.S. Fish and Wildlife Service, Cabeza Prieta NWR
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Evaluator #2 Name/Title:	
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List committee members:	D. Backer, C. Barclay, K. Brown, D. Casper, P. Guertin, F. Northam, R. Paredes, W. Sommers, J. Ward, P. Warren
Committee review date:	09/19/03
List date:	09/19/03
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**B**	Observational	**"Impact"** **Section 1 Score:** **B**	**"Plant Score"** **Overall Score:** **Medium** **Alert Status:** **None**
1.2	Impact on plant community	**B**	Observational		
1.3	Impact on higher trophic levels	**U**	No information		
1.4	Impact on genetic integrity	**U**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Other published material	**"Invasiveness"** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **16 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**A**	Observational		
2.3	Recent trend in total area infested within state	**B**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**B**	Other published material		
2.6	Potential for natural long-distance dispersal	**A**	Other published material		
2.7	Other regions invaded	**C**	Observational		RED FLAG **YES** Something you should know.
3.1	Ecological amplitude	**A**	Other published material	**"Distribution"** **Section 3 Score:** **A**	
3.2	Distribution	**A**	Observational		

Red Flag Annotation

Abundant rainfall during the latter part of 2004 and early 2005 resulted in an undocumented response by *Brassica tournefortii* in terms of number of individuals and total biomass. These increases potentially contributed to the altered fire regimes (that is, increased number and areal extent of fires) that occurred in Arizona at lower elevations during 2005. Should these trends persist in future years, then the scores and rank reported here for *B. tournefortii* should be revisited.

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **B** *Doc'n Level:* **Obs.**

Identify ecosystem processes impacted: Fire regime, microclimates.

Rationale: Possible increase in fuel abundance along roadsides and in heavily disturbed areas. During years with favorable precipitation, *B. tournefortii* along with a suite of other annuals native to Mediterranean areas that are pre-adapted to the winter rainfall climate and fire regimes of the chaparral vegetation in the Mohave Desert can alter the fuel loads and fire frequency of tropical desertscrub, thornscrub, and tropical deciduous forest As they move into the Mojave Desert, they directly compete with the native spring flora and introduce fire. As they move eastward into the bi-seasonal climatic regimes of the Sonoran Desert, their ecological interactions are more complex (Van Devender et al. 1997). Increase in fuel loads and continuity in inter-spaces creates a new type of fuel bed that may promote fire and change fire regimes (Matt Brooks, personal observations made within the California Plant Assessment Form for this species, 2003)

Sahara mustard increases fuel loads and fire hazard in desert scrub and coastal sage scrub [did not cite any studies nor were any found during a literature search]. It also establishes from a soil seedbank after fire (Minnich and Sanders 2000). Individuals are amazingly variable in size, depending upon the availability of soil moisture. Drought-stressed plants can reproduce with leaves as small as 8 cm long. On sandy soils with sufficient moisture the leaves can grow to more than 50 cm long, giving the plant a 1 m spread, making it the largest herbaceous rosette plant in the region (Van Devender et al. 1997).

Sources of information: Inferred from the cited literature and personal observations by C. McCasland (Assistant Refuge Manager, U.S. Fish and Wildlife Service, Cabeza Prieta National Wildlife Refuge, 2003) and M. Brooks (Research Ecologist, U.S. Geological Survey, Reno Nevada, 2003).

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **B** *Doc'n Level:* **Obs.**

Identify type of impact or alteration: Changes in community composition and species abundance.

Rationale: *Brassica tournefortii* (Sahara mustard) and *Schismus arabicus/S. barbatus* (Arabian and Mediterranean grasses) are important exotic winter-spring annuals that compete with native annuals and grasses for rainfall, nutrients and microhabitats. The primary impacts are changes in community composition and species abundance (Van Devender et al. 1997). *Brassica tournefortii* has a strategy of early and quick growth therefore using resources before competition occurs on site. *Brassica tournefortii* appears to effectively capturing available soil moisture, building a canopy, reproducing, and maturing before the neighboring native species begin their reproductive phases (Minnich and Sanders 2000).

From Guertin and Halvorson (2003): Sue Rutman (personal communication) reports that at Cabeza Prieta National Wildlife Refuge in Arizona, Big Galleta grass-Creosotebush and dunal plant associations have been completely disrupted by *Brassica tournefortii*.

From Minnich and Sanders (2000): The density of Sahara mustard plants can vary with annual climate and fire history. For example, two years of drought during 1989–91 in Riverside County killed off existing red brome (*Bromus rubens*) cover on a dry southern exposure. Sahara mustard populations in this area subsequently increased by almost thirty-five times. During the wet winters of 1991–92 and 1992–93, while plant densities increased, overall biomass decreased, apparently reduced by intraspecific competition.

Sources of information: See cited literature; however, neither of the citations above are based on specifics, empirical studies, or documented evidence; therefore, the level of documentation is inference (observational). Observations are by S. Rutman (Plant Ecologist, Organ Pipe Cactus National Monument).

Question 1.3 Impact on higher trophic levels *Score:* **U** *Doc'n Level:* **No info.**

Identify type of impact or alteration: Unknown

Rationale: No information available. Sue Rutman (personal communication in Guertin and Halvorson 2003) suggests that lizards potentially will decline in numbers and kangaroo rats might also with increases in plant cover of this plant; kangaroo rats require open habitats to survive, and 'have trouble keeping it out of the mound sites' in their efforts to keep it clipped back.

Sources of information: None that support providing a score.

Question 1.4 Impact on genetic integrity *Score:* **U** *Doc'n Level:* **Other pub.**

Identify impacts: The genus *Brassica* is known to hybridize within the genera and across genera within the family *Brassica*ceae (see Warwick et al. 2000). Arizona has no native species in the *Brassica* genus but many native species in the family (Kearney and Peebles 1960).

Rationale: May hybridize with other mustards. On the basis of chromosome number and crossing ability, Harberd (1976) defined the *Brassica* coenospecies as "the group of wild species sufficiently related to the six cultivated species of *Brassica* to be potentially capable of experimental hybridization with them."

Sources of information: See cited literature.

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Moderate invasive potential. Establishes readily in dune ecosystems, desert washes, and disturbed areas near roadways.

Rationale: *Brassica tournefortii* establishes readily in disturbed areas (see below) and can establish in natural areas of *Larrea-Ambrosia* flats, primarily in areas with sandy soil (McCasland, pers. obser., 2003). Sahara mustard is most common in disturbed sites such as roadsides and abandoned fields (Minnich and Sanders 2000) and in sandy lowland habitats across the Sonoran Desert, including low dunes, interdune troughs, sandy flats, and sandy-gravelly washes (Van Devender et al. 1997). Sahara mustard plants are highly drought tolerant, and they are found in dry pastures, along roadsides, disturbed soils, and in fields and crops (Warwick et al. 2000). Border Patrol in southwestern AZ frequently drag roads with tires creating a an anthropogenic disturbance in a seeming natural area, thus providing the preferred germination conditions (burying seeds) for *Brassica* (Malusa et al. 2003).

Sources of information: See cited literature; also observations by C. McCasland (Assistant Refuge Manager, U.S. Fish and Wildlife Service, Cabeza Prieta National Wildlife Refuge, 2003).

Question 2.2 Local rate of spread with no management *Score:* **A** *Doc'n Level:* **Obs.**

Describe rate of spread: Increasing rapidly (doubling > 10years).

Rationale: In California, appeared to have a population explosion from 1977 to 1983, during successive years of above-normal precipitation (Minnich and Sanders 2000). *Brassica tournefortii* has spread almost explosively into lowland desert regions, especially in places with sandy soils (for example, Organ Pipe National Monument; Felger 1990).

Sources of information: See cited literature. Score based on Working Group discussion.

Question 2.3 Recent trend in total area infested within state *Score:* **B** *Doc'n Level:* **Obs.**

Describe trend: Increasing, but less rapidly. Species is spreading rapidly along roadsides, but in native undisturbed habitats the speed of infestation is lower.

Rationale: The earliest record in Arizona is 1957 (Mason 1960 in Van Devender et al. 1997) and by the 1970s it was widespread and will established in the lowland deserts of northern Baja California, southeastern California, southwestern Arizona and western Sonora (Van Devender et al. 1997). As noted from an early study (reported in Malusa et al. 2003), 180 miles during the wet spring of 2001, a variety of habitats between the southern Mohawk and Bryan Mountains and the Growler Mountains were hiked (much of the area is roadless and wilderness) and no *B. tournefortii* were noted.

Sources of information: See cited literature. Score based on Working Group discussion and personal observations by C. McCasland (Assistant Refuge Manager, U.S. Fish and Wildlife Service, Cabeza Prieta National Wildlife Refuge, 2003).

Question 2.4 Innate reproductive potential *Score:* A *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: An annual that produces between 750–9000 seeds/plant; self-compatible; produces seed for more than 3 months a year.

Rationale: See worksheet A.

Sources of information: See citations in worksheet A.

Question 2.5 Potential for human-caused dispersal *Score:* **B** *Doc'n Level:* **Other pub**.

Identify dispersal mechanisms: Potential for seeds to be present as a contaminant in bulk hay. Road construction and maintenance and transportation corridors also affect dispersal. Seeds are also carried along by vehicle tires.

Rationale: *Brassica* is found in disturbed areas including agricultural areas, construction/maintenance (including dragging of border roads) of roads moves seeds; seeds may adhere to vehicle tires travelling off-road. Border Patrol agents use a technique in which they drag tires along sandy roads where Brassica is present, further dispersing the seed (and burying it) both along these "roads" and off roads as well (Malusa et al. 2003).

Sources of information: See cited literature; also see Minnich and Sanders (2000) and West and Nabhan (2002).

Question 2.6 Potential for natural long-distance dispersal *Score:* **A** *Doc'n Level*: **Other pub.**

Identify dispersal mechanisms: Animals, water, and wind.

Rationale: Dead plants containing viable seeds will often break off at the base and act as a tumble weed. *Brassica* plants have been caught in dust-devils and transported large distances from their origin (Observational). Seeds are carried in washes during significant rain events. Sahara mustard is most common in wind-blown sand deposits (Minnich and Sanders 2000). During the rains, a sticky gel forms over the seed case that permits seeds to disperses long distances by adhering to animals (Minnich and Sanders 2000).

From Guertin and Halvorson 2003: After senescence and drying, the *Brassica tournefortii* plants can break off at the soil surface to tumble with the wind across the landscape dispersing its seeds. Although Felger (1990) notes this may occur in open, sandy places, it does not occur in other environments.

Sources of information: See cited literature.

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Obs.**

Identify other regions: No other ecological types invaded that aren't already invaded in AZ.

Rationale: Sahara mustard is native to the Mediterranean (Albania, Algeria, Egypt, Greece, Israel, Italy, Lebanon, Libya, Morocco, Syria, Tunisia, and Turkey) and the broad desert belt stretching from northwest Africa to the Saudi Arabian peninsula (Warwick et al. 2000). Sahara mustard is commonly found in Arizona, California, Louisiana, New Mexico, Nevada and Texas, as well as Europe, Africa, Asia, Australia, and Mexico (Warwick et al. 2000).

Brassica tournefortii was first collected in 1927 in California by J.B. Feudge (#1600, RSA); it was probably introduced in the early 1900's with date palms imported into Coachella, California from the Middle East (Minnich and Sanders 2000). In California, it is found up to 3300 feet (1000 m) elevation, but is more common below 1000 feet (305 m) in the deserts and the semi-arid south coastal area. Along with desert environments, it is invading annual grassland and coastal sage scrub (Minnich and Sanders 2000). *Brassica tournefortii* thrives in sandy locations (Felger 1990). In California, it can often form monospecific stands on abandoned sandy fields (Minnich and Sanders 2000). *Brassica tournefortii* appears to be highly susceptible to salinity; in greenhouse trials in India (Dhawan et al. 1987).

Sources of information: See cited literature. Score based on inference from California ecological types.

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Other pub.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Introduced to the United States in the 1930s, Sahara mustard has spread to many areas of the Southwest (Warwick et al. 2000). The earliest record for it in Arizona is 1957 (Mason 1960 in Van Devender et al. 1997) while Sonora, Mexico collections date from 1966 (Van Devender et al. 1997). Earliest record in Arizona herbaria is 1965 (SEINet 2004).

Preferred habitat: Found in semi-arid to arid coastal and riparian sands, dunes, and other sandy soils (though it is also found on non-sandy soils), Sahara mustard can be found from sea level up to 7,200 feet elevation (Warwick et al. 2000). It is especially common in sandy lowland habitats across the Sonoran Desert, including low dunes, interdune troughs, sandy flats, and sandy-gravelly washes (Van Devender et al. 1997). Sahara mustard plants are highly drought tolerant, and are found in dry pastures, along roadsides, disturbed soils, and in fields and crops (Warwick et al. 2000). Jim Malusa (personal communication, 2004) notes that roads that run perpendicular to the slope result in the partial damming of water (upslope); here there are often very large creosote or bursage, with *Brassica tournerfortii* beneath. The point is: they grow where the water is.

Seeds are adversely affected by light and have optimal emergence (germination) when seeda are buried at a depth of 0.5 cm (seed depth trials ranged up to 4 cm). Total inhibition of germination occurred for seeds on the soil surface (Thanos et al. 1991 in Guertin and Halvorson 2003).

In the Mohawk Dunes and Mountains of southwestern Arizona, in 2001 it was absent from stony slopes and alluvial fan pavements, rare in creosote flats, common in sandy flats, emphemeral water courses, and dunes; and most common on the north slopes of dunes (Malusa et al. 2003; spatial data layer for this region is available at: http://sdrsnet.srnr.arizona.edu/).

Rationale: Counties in Arizona: Maricopa, Pinal (Kearney and Peebles 1960), and Mohave (Kearney and Peebles 1960, McDougall 1973). Arizona herbaria records (www.seinet.asu.edu, accessed July 21, 2004) also have records from the additional counties of Yuma, Coconino, Pima, and Yavapai.

Preferred habitat: Found in semi-arid to arid coastal and riparian sands, dunes, and other sandy soils (though it is also found on non-sandy soils), Sahara mustard can be found from sea level up to 7,200 feet elevation (Warwick et al. 2000). It is especially common in sandy lowland habitats across the Sonoran Desert, including low dunes, interdune troughs, sandy flats, and sandy-gravelly washes (Van Devender et al. 1997). Sahara mustard plants are highly drought tolerant, and are found in dry pastures, along roadsides, disturbed soils, and in fields and crops (Warwick et al. 2000).

Sources of information: See cited literature; also considered personal communication from J. Malusa (U.S. Geological Survey, Sonoran Desert Research Station, Tucson, Arizona, 2004), personal observations by Working Group members, and information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed July 21, 2004).

Question 3.2 Distribution *Score:* **A** *Doc'n Level:* **Obs.**

Describe distribution: Present in all dunes in Arizona.

Rationale: An estimated 80 to 90% of the Mohawk Dunes are host to *B. tournefortii* (Malusa et al. 2003). Records from Arizona herbaria (SEINet 2004) describe some of the additional places where *B. tournefortii* is found in Arizona (most collections along roads, those records are not recorded here): Tonto National Forest-Canyon Lake Overlook, Superstition Wilderness Area, and along Apache Trail, Sedona (Cook's Hill); Cabeza Prieta Wildlife Refuge (west of Charlie Bell Pass); Mt Nutt (Bureau of Land Management Wildlife Study Area, Kingman); along trail in White Tank Mountains Park, sandy dry wash above Horse Tanks (Yuma County); dry wash of Harquahala Mountains.

Sources of information: See cited literature and information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed July 21, 2004).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ **Yes**] **No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	[✓ **Yes**] **No**	**2 pt.**
Populations of this species produce seeds every year.	[✓ **Yes**] **No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	[✓ **Yes**] **No**	**1 pt.**
Seeds remain viable in soil for three or more years	**Yes** **No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	[✓ **Yes**] **No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes** [✓ **No**]	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes** [✓ **No**]	**2 pt.**
Resprouts readily when cut, grazed, or burned	[✓ **Yes**] **No**	**1 pt.**
	Total pts: 7 Total unknowns: 1	
	Score : A	

Note any related traits: In Arizona *Brassica tournefortii* flowers from late winter to early spring (Epple 1995); generally from February to May (Felger 1990, Van Devender et al. 1997). In California it flowers as early as December into January, and it sets seed by February, fruiting or senesced by April (Minnich and Sanders 2000).

From Guertin and Halvorson (2003): *Brassica tournefortii*'s is a self-compatible species (autogamous; can self-pollinate) (Hinata et al. 1974, Minnich and Sanders 2000), with nearly 100% fruit set on most plants (Minnich and Sanders 2000).

Well developed plant produces between 750 and 9000 seeds (Minnich and Sanders 2000).

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	**A**
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	**C**
	Chihuahuan desertscrub	
	Sonoran desertscrub	**C**
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	**D**
	southwestern interior riparian	
	montane riparian	
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Bromus diandrus* Roth (USDA 2005)
Synonyms:	*Anisantha diandra* (Roth) Tutin ex Tzvelev, *Bromus gussonei* Parl., *Bromus rigidus* Roth var. *gussonei* (Parl.) Coss. & Durieu (USDA 2005)
Common names:	Ripgut brome
Evaluation date (mm/dd/yy)**:**	01/28/05
Evaluator #1 Name/Title:	Dr. Francis E. Northam
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List committee members:	D. Backer, J. Brock, J. Hall, B. Lake, C. Laws, L. Making, L. Moser F. Northam, P. Fenner, A. Salywon, S. Spiller
Committee review date:	01/28/05
List date:	01/28/05
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**B**	Other published material	**"Impact"** **Section 1 Score:** **B**	**"Plant Score"** **Overall Score:** **Medium** **Alert Status:** **Alert**
1.2	Impact on plant community	**B**	Other published material		
1.3	Impact on higher trophic levels	**C**	Other published material		
1.4	Impact on genetic integrity	**U**	No information		
2.1	Role of anthropogenic and natural disturbance	**B**	Other published material	**"Invasiveness"** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **11 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Observational		
2.3	Recent trend in total area infested within state	**C**	Observational		
2.4	Innate reproductive potential	**U**	Other published material		
2.5	Potential for human-caused dispersal	**B**	Observational		
2.6	Potential for natural long-distance dispersal	**B**	Observational		
2.7	Other regions invaded	**B**	Other published material		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**C**	Observational	**"Distribution"** **Section 3 Score:** **C**	
3.2	Distribution	**C**	Observational		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **B** *Doc'n Level:* **Other pub.**

Identify ecosystem processes impacted: Fire dynamics.

Rationale: Hitchcock (1950) described ripgut brome (*Bromus diandrus* Roth) as a common weed that forms dense stands in open ground, waste places and lowlands in southern California. Along Arizona stream banks under riparian woodland trees and shrubs, ripgut brome has been observed covering 50 to 90% of the soil surface (F. Northam, personal observation, 2000–2004). Colonies of ripgut brome with mature plant heights ranging up to 1.0 meter tall are documented in Arizona and surrounding states (McDougall 1973, Welch et al. 1987, Baldwin et al. 2002). As a result, this species is capable of producing sufficient litter to increase fire hazards. Moist wildland areas that have been subjected to intense disturbance in which soil surfaces were denuded of endemic herbaceous and shrub vegetation are especially vulnerable to *B. diandrus* colonization. This level of disturbance may be the results of previous cultivation, clearing construction sites, trampling by domestic livestock or humans, excavation projects, military activities, intensive grazing, fire abatement operations, wildfires, etc. Subsequent erosion typically enhances this degree of disturbance.

Sources of information: See cited literature. Also considered field observations of F. Northam (Noxious Weed Program Coordinator, Arizona Department of Agriculture, 2000–2003).

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **B** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Replaces native species.

Rationale: Branson (1985) described how perennial grasslands of elevations below 3500 feet in California were replaced by introduced winter annual grasses to such an extent that <0.1% of the former range supports original plant communities. Southern California Spanish ranching operations began in the 1760s. Introduced winter annual grasses (including two species of wild oats, soft brome [*Bromus hordeaceus*], and ripgut brome) are the predominant monocot forage producers in California's interior valley, zootic-altered, annual range vegetation type (Western North American Range Vegetation Descriptions 2005). Landscape level domination by these non-native Eurasian species in California is due to (1) a long time-frame of European ranching and agricultural plant introductions, (2) destructive grazing practices using introduced European livestock and (3) drought and associated severe wildfires. Because of urban expansion and cultivated agriculture, most of California's current annual grasslands are distributed as a herbaceous understory layer in oak woodlands.

Natural resource specialists managing grazing lands owned by California Polytechnical Institute in southern California attributed domination by Eurasian annuals to (1) quick germination after rains that enable these non-native plants to begin growing before native plants, (2) introduced, fall-germinating, winter annual species are the first plants to take moisture and nutrients at the start of each growing season (fall), and (3) these annuals, including ripgut brome, grow faster than perennials, which reduces light to later emerging native species (Plant Communities—Grassland 2005).

Dense populations of ripgut brome have been observed under tree and shrub canopies along southwest interior riparian corridors of central Arizona (F. Northam, personal observations, 2000–2003). In these sites ripgut brome can become the dominant herbaceous species in which percent cover by this species can range between 50 to 70%. Within ripgut brome patches, however, percent cover exceeds 90% and non-woody native species are absent.

Sources of information: See cited literature. Also considered field observations by F. Northam (Noxious Weed Program Coordinator, Arizona Department of Agriculture, 2000–2003) and information from Western North American Range Vegetation Descriptions (available online at: www.tarleton.edu/%7Erange/Home/home.htm; accessed January 26, 2005) and Plant Communities—

Grassland (available online at http://polyland.lib.calpoly.edu/overview/Archives/derome/grasslands.htm; accessed January 25, 2005).

Question 1.3 Impact on higher trophic levels *Score:* **C** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: *Bromus diandrus* causes physical injury to grazing animals, but it also produces good quality forage before inflorescences emerge.

Rationale: Ripgut brome florets are armed with stiff, barbed awns, plus a sharp callus at their base which can injure nose and eye tissues or lodge in ear cavities of grazing animals (Whitson et al. 2000). Proper timing of grazing will avoid animal injury from ripgut brome and allow livestock to harvest good quality forage produced by this grass (Western North American Range Vegetation Descriptions 2005).

Sources of information: See cited literature. Also considered information from Western North American Range Vegetation Descriptions (available online at www.tarleton.edu/%7Erange/Home/home.htm; accessed January 25, 2005).

Question 1.4 Impact on genetic integrity *Score:* **U** *Doc'n Level:* **No info.**

Identify impacts: Hybridization is unknown but potentially could occur.

Rationale: Several native *Bromus* species exist in Arizona (Kearney and Peebles 1960); however, no information was found indicating ripgut brome hybridizes with native bromes.

Sources of information: See cited literature. No sources were identified that address whether hybridization occurs.

Question 2.1 Role of anthropogenic & natural disturbance in establishment *Score:* **B** *Doc'n Level*: **Other pub.**

Describe role of disturbance: Surface disturbance of soil due to road/trail maintenance, cultivation, mined land reclamation, hazardous materials cleanup, timber harvest, mechanical brush control, wildfire abatement, human/livestock trampling and construction projects are necessary for widespread establishment of ripgut brome populations.

Rationale: Branson (1985) described how introduced winter annual grasses became dominate naturalized vegetation in California grasslands formerly occupied ed by perennial grasses. Human-induced disturbance opened the soil to colonization by Eurasian plants. Observations of established ripgut brome populations indicate this species will establish in sites where soil surfaces are disturbed by activities such as highway maintenance, mechanical weed control on vacant lots, abandoned cultivated ground, human/livestock trampling, bulldozed fire lines, all-terrain vehicle races, timber removal, wildfire, etc. (F. Northam, personal observations, 2000–2003).

Sources of information: See cited literature. Also considered field observations by F. Northam (Noxious Weed Program Coordinator, Arizona Department of Agriculture, 2000–2003).

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Obs.**

Describe rate of spread: Increasing but less rapidly than doubling in <10 years.

Rationale: Herbarium records (SEINet 2005) indicate currently infested wildland areas have had some level of infestation since the at least the 1970s. No recent increase, however, in herbarium records, published reports, or observations by scientists indicate ripgut brome infestations have had recent exponential colony growth.

Notwithstanding the preceding, natural and human-caused disturbances continue to occur in wildland riparian corridors and wetland environments. As a result, the Working Group inferred that these conditions have resulted in local ripgut brome populations continuing to expand into newly disturbed habitat.

Sources of information: SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed January 27, 2005). Score based on inference applied by Working Group members.

Question 2.3 Recent trend in total area infested within state *Score:* **C** *Doc'n Level:* **Other pub.**

Describe trend: Stable. Arizona herbarium collections of ripgut brome began in 1903, and 15 more collections from seven counties were added before 1950. Another 19 collections were added before 1980. Total collections are 61 from 11 counties. Collection trends do not indicate any recent range expansions.

Rationale: Herbarium specimens range from sites below 1500 feet to near 7000 feet elevation, but most occurred between 2500 and 6500 feet (SEINet 2005). Recent observations of thick ripgut brome stands in wildlands were along streams under riparian woodlands (F. Northam, personal observations, 2000–2003). These areas have been grazed since the 1880s. Grazing/trampling disturbance from decades of livestock harvesting, plus wild fires, and their impact on ripgut brome establishment agrees with the results of California grassland disturbance described above in questions 1.2 and 2.1 (Branson 1985). Furthermore, based on the early introductions into California of winter annual, Eurasian grasses previously described in questions 1.2 and 2.1, it is reasonable that ripgut brome populations probably have been associated with Arizona grazing industry for over 100 years. New population outbreaks in wildlands will require more disturbance in which surface layers of soil is broken by cultivation tools, construction equipment, additional livestock/ recreational trampling, excavation, etc.

Based on collection frequency from the early 1900s to present times, herbaria records do not: (1) indicate ripgut brome has recently colonized new ecological types or (2) suggest extensive increased colonization into non-infested areas of ecological types where this species has been historically recorded. Likewise, no published reports or observations by scientists indicate ripgut brome infestations have had significant range increases into non-infested areas of ecological types now infested. As a result, the Working Group inferred the total trend of infestation within the state is stable.

Sources of information: See cited literature. Also considered field observations by F. Northam (Noxious Weed Program Coordinator, Arizona Department of Agriculture, 2000–2003) and information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed January 27, 2005). Score based on inference applied by Working Group members.

Question 2.4 Innate reproductive potential *Score:* **U** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: Seeds (caryopses) are the only way this winter annual species reproduces (Baldwin et al. 2002). *Bromus diandrus* does not have vegetative reproduction or multi-season seed crops, and its flowering season is less than three months (Baldwin et al. 2002).

Rationale: Much of the seed dynamics of Arizona populations are unknown. See Worksheet A.

Sources of information: See cited literature.

Question 2.5 Potential for human-caused dispersal *Score:* **B** *Doc'n Level:* **Obs.**

Identify dispersal mechanisms: Transporting livestock and via contaminated equipment.

Rationale: Based on observations of current ripgut brome populations, dispersal of this species appears to be limited to human transport of caryopses from contaminated sites along road rights-of-way, construction sites or contaminated stream banks. Typical livestock operations on wildlands requires periodic movement of livestock from one site to another, and any weed seed contaminating hair or mud in hooves will also move. Furthermore, movement of restoration / reclamation ground seeding equipment, construction machines, fire abatement vehicles, off-road recreational vehicles, etc. through ripgut brome infestations are potential dispersal devices. Likewise, human foot traffic is a definite transporter of numerous annual grass seeds in shoes, boots and socks (F. Northam, personal observations, 2000–2003).

Sources of information: Field observations by F. Northam (Noxious Weed Program Coordinator, Arizona Department of Agriculture, 2000–2003).

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Obs.**

Identify dispersal mechanisms: Movement by runoff water following precipitation events and by attachment to fur or feet of native mammals.

Rationale: As noted above, locations of many ripgut brome infestations along stream corridors expose native wildlife to opportunities to entangle ripe brome florets in fur or in mud on hooves. In addition, flood-water movement could provide enough energy to move caryopses long distances (F. Northam, personal observations, 2000–2003).

Sources of information: Field observations by F. Northam (Noxious Weed Program Coordinator, Arizona Department of Agriculture, 2000–2003).

Question 2.7 Other regions invaded *Score:* **B** *Doc'n Level:* **Other pub.**

Identify other regions: In Utah disturbed sites in warm desert shrub, pinyon-juniper, and mountain brush communities are infested by *B. diandrus* (Welch et al. 1987). The last community is similar to southwestern interior chaparral scrub in Arizona. Grazing-disturbed canyon woodlands and bottomlands adjacent to riparian communities in southern California that are infested by *B. diandrus* (Plant Communities—Grasslands 2005) are similar to Great Basin conifer woodland in Arizona.

Rationale: Southwestern interior chaparral scrub and Great basin conifer woodland are two minor ecological types invaded elsewhere that are not yet invaded in Arizona.

Sources of information: See cited literature. Also considered information from Plant Communities—Grassland (available online at http://polyland.lib.calpoly.edu/overview/Archives/derome/grasslands.htm; accessed January 25, 2005).

Question 3.1 Ecological amplitude *Score:* **C** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: According to SEINet (2005) and observational data by F. Northam (personal observations, 2000–2003), Arizona's wildland populations of ripgut brome are concentrated in wetlands associated with Great Basin conifer, Petran mountain conifer, Great Basin desertscrub, southwestern interior chaparral, and semi-desert grassland plant communities, though not within these upland communities themselves. First herbarium record is from 1903 (SEINet 2005).

Rationale: Collections and observations of ripgut brome populations in wildland areas have been on sites where most native herbaceous vegetation has been eliminated by disturbances such as wildfires, livestock operations, recreational activities, or mining projects. No sites are known where this species has moved into mostly natural vegetation in which surface layers of the soil have not been broken open and mixed or scraped bare (F. Northam, personal observations, 2000–2003).

Sources of information: Field observations by F. Northam (Noxious Weed Program Coordinator, Arizona Department of Agriculture, 2000–2003) and information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed January 27, 2005).

Question 3.2 Distribution *Score:* **C** *Doc'n Level:* **Obs.**

Describe distribution: No more than 20% in the wetland communities that are infested.

Rationale: Distribution records in SEINet (2005) indicate ripgut brome can tolerate macro-environmental and soil conditions ranging from Sonoran desertscrub in Tempe and Tucson to montane conifer forest in Prescott and Flagstaff. *Bromus diandrus*, however, is restricted to sites with winter precipitation or abundant runoff moisture and where soil-surface disturbance has removed most native herbaceous plants. No sites are known where this species has moved into mostly undisturbed vegetation (F. Northam, personal observations, 2000–2003).

Sources of information: Field observations by F. Northam (Noxious Weed Program Coordinator, Arizona Department of Agriculture, 2000–2003) and information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed January 27, 2005).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ **Yes**]	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**Yes**	**No**	**2 pt.**
Populations of this species produce seeds every year.	[✓ **Yes**]	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**Yes**	[✓ **No**]	**1 pt.**
Seeds remain viable in soil for three or more years	**Yes**	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes**	**No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes**	[✓ **No**]	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	[✓ **No**]	**2 pt.**
Resprouts readily when cut, grazed, or burned	[✓ **Yes**]	**No**	**1 pt.**

Total pts: 3 Total unknowns: 3

Score : U

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	**D**
	southwestern interior wetlands	**C**
	montane wetlands	**D**
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	
	montane riparian	
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Bromus inermis* Leyss. (USDA 2005)
Synonyms:	None identified by USDA (2005).
Common names:	Smooth brome, awnless brome. Hungarian bromegrass
Evaluation date (mm/dd/yy)**:**	03/24/04
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List committee members:	W. Albrecht, D. Backer, S. Harger, L. Moser, B. Phillips, J. Schalau
Committee review date:	10/22/04
List date:	10/22/04
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**B**	Reviewed scientific publication	**“Impact”** **Section 1 Score:** **B**	**“Plant Score”** **Overall Score:** **Medium** **Alert Status:** **None**
1.2	Impact on plant community	**B**	Other published material		
1.3	Impact on higher trophic levels	**C**	Other published material		
1.4	Impact on genetic integrity	**C**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Observational	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **13 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Observational		
2.3	Recent trend in total area infested within state	**C**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**B**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Observational		
2.7	Other regions invaded	**C**	Other published material		RED FLAG **YES** Something you should know.
3.1	Ecological amplitude	**A**	Observational	**“Distribution”** **Section 3 Score:** **B**	
3.2	Distribution	**D**	Observational		

Red Flag Annotation

Bromus inermis should not be used for reclamation purposes in wildlands because of its persistence and invasive potential.

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Identify ecosystem processes impacted: Smooth brome populations modify or retard natural succession. Smooth brome is resistant to fire, which may disrupt natural fire regimes in some prairie and forest systems. It spreads extensively via rhizomes and binds soil altering geomorphological status and affecting surface water availability.

Rationale: A Canadian study (Grilz and Romo 1994) demonstrated that smooth brome is apparently resistant to fire effects in Fescue Prairie. Native species are suppressed by burning in the same system, which causes fire to possibly increase smooth brome populations. In ponderosa pine systems where fire is a natural process and the vegetation is adapted to fire, smooth brome populations may inhibit this process, or alter the frequency. Based on test plot observations at the Arboretum at Flagstaff, smooth brome did not carry fire effectively (W. Albrecht, personal observations, 2004).

Smooth brome is used for erosion control and streambank stabilization. Rhizomatous cultivars become sod-bound after several years unless litter is removed by grazing and/or fire. This sod forming mat of rhizomes could effect geomorphological changes by preventing the absorption of surface water that could potentially affect the water availability for nearby plants.

Due to cloning, smooth brome is a long-lived species. Plantings have been known to persist for at least 60 years, which may limit natural succession in some ecotypes. Individual rhizomes are reported to have longevity of one year. Old brome fields develop a "sod bound" condition in which shoot density is reduced and symptoms of nitrogen deficiency are exhibited (Meyers and Anderson 1942). This condition could be attributed to a carbon/nitrogen imbalance (perhaps because of the sheer mass of dead rhizomes) creating a potential for alteration of soil chemistry.

Sources of information: See cited literature; also observations by W. Albrecht (Natural Resources Educator and SFPWMA Coordinator, University of Arizona, Coconino County Cooperative Extension, Flagstaff, Arizona, 2004).

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **B** *Doc'n: Level:* **Other pub.**

Identify type of impact or alteration: Smooth brome has been widely planted as a forage and cover crop, and at reclamation/restoration sites and it is highly persistent. It forms a dense sod that often appears to exclude other species, thus contributing to the reduction of species diversity in natural areas. One study suggests smooth brome plants produce an allelopathic substance to inhibit its own root development.

Rationale: A restoration treatment at the Arboretum at Flagstaff, removed smooth brome from a meadow and results demonstrated that both abundance and diversity of natives are lower in the presence of smooth brome, supporting Elliot's (1949) assertion that smooth brome can out compete native species (Albrecht et al. In Press). In Rocky Mountain National Park, smooth brome is currently believed to be expanding from road shoulders. It is found in some areas disturbed within the last 11 to 50 years, and may be inhibiting natural succession processes. Smooth brome is highly competitive and may displace more desirable vegetation. In some cases, it appears to be invading native prairie areas in plains region from roadsides (USGS 2004).

Smooth brome is an invasive perennial in fescue prairies in North America. It is planted extensively for the stabilization of disturbed sites, it spreads aggressively by seeds and rhizomes and eventually gains dominance of the site and suppresses other plants. In Manitoba, Canada, smooth brome was the most competitive of several introduced species and excluded native species (Wilson 1989, Wilson and Belcher 1989).

Grant and Sallans (1964) suggest that the decomposing roots may actually produce an allelopathic substance inhibitory to further brome root development. It is not noted whether this substance has negative effects on native plants. A study in Sweden carried out from 1976 to 1985 examined establishment of plant cover on zinc mine wastes. Plant cover percentages were measured after 2 years and at 10 years from planting. Smooth brome constituted only a minor part of the mixed-grass stand, which included (*Poa pratensis, Dactylis glomerata, Festuca rubra,* and *Agrostis tenuis).* This study revealed that smooth brome does not possess invasive qualities, or could be outcompeted by the other exotics or adventive natives established on the site (Bergholm and Steen 1989).

Sources of information: See cited literature.

Question 1.3 Impact on higher trophic levels *Score:* **C** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Smooth brome is highly palatable and has fair to good nutritional as well as cover potential for birds and small mammals. Although some studies demonstrated that it was not the preferred food of some mammals, suggesting that it may be utilized because other more favorable species are not available.

Rationale: Grazing wildlife use smooth brome to varying degrees, depending upon wildlife species and smooth brome quality and time of year. A study by Hobbs et al. (1981) showed that elk use it as a winter food in Colorado. Mule deer in central Utah were found to graze smooth brome only lightly, but deer utilization of smooth brome is generally considered good. Geese and small rodents such as pocket gophers also graze smooth brome. The seeds may not be preferred by granivores. Everett and others (1978) found that when offered the seed of 18 herbaceous species, deer mouse selected smooth brome seed the least. Smooth brome provides cover for birds and small mammals. Ducks, gray partridge, American bittern, northern harrier, and short-eared owl use it as nesting cover.

Sources of information: See cited literature; also see Howard (1996) and Duebbert and Lokemoen (1977).

Question 1.4 Impact on genetic integrity *Score:* **C** *Doc'n Level:* **Other pub.**

Identify impacts: Smooth brome hybridizes readily with *Bromus pumpellianus*.

Rationale: Considerable hybridization and introgression have occurred between smooth brome and Pumpelly brome (*B. pumpellianus*), a native species which occurs in Michigan, eastern Utah, and the Rocky Mountains (Walsh 1994, USDA 2005). Elliot (1949) suggested that *B. pumpellianus has* been reduced to a subspecies of *B. inermis* due to the extensive introgression between the two. Welsh et al. (1987) could find no material belonging to the native strain. Smooth brome does not hybridize with other North American *Bromus* species.

Sources of information: See cited literature; also see Kearney and Peebles (1960), Armstrong (1981), and Sather (1987).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Obs.**

Describe role of disturbance: Smooth brome has been widely seeded along roads and in stabilization projects. It generally invades after disturbance and persists. Heavy grazing also increases smooth brome infestations, but it may spread into undisturbed areas.

Rationale: Smooth brome is a common invader of disturbed prairie throughout the Great Plains. Boggs and Weaver (1992) reported that along the Yellowstone River, moderate grazing increased the occurrence of shrubs in mature eastern cottonwood, and severe grazing converted the area to smooth brome, timothy (*Phleum pratense*), and Kentucky bluegrass (*Poa pratensis*). In Pipestone National Monument (Minnesota) it has been known to invade undisturbed habitat. Personal observations by L. Moser (2004) and W. Albrecht (2004) suggest that disturbance is necessary for establishment.

Sources of information: Boggs et al. (1992), Howard (1996), Southwest Exotic Plant Information Clearinghouse (SWEPIC; http://www.usgs.nau.edu/SWEPIC/): Pipestone National Monument Alien Plant Ranking System ranking. Also observations by L. Moser (Botanist, Coconino National Forest, USDA Forest Service, Flagstaff, Arizona, 2004) and W. Albrecht (Natural Resources Educator and SFPWMA Coordinator, University of Arizona, Coconino County Cooperative Extension, Flagstaff, Arizona, 2004).

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Obs.**
Describe rate of spread: Increases, but less rapidly.
Rationale: Persistent populations in and around ranch settlements in Oak Creek Canyon in northern Arizona, the Arboretum, and V-bar-V ranch; rate of spread is slow but is occurring.
Sources of information: Observations by J. Bradley (U.S. Forest Service).

Question 2.3 Recent trend in total area infested within state *Score:* **C** *Doc'n Level:* **Obs.**
Describe trend: Stable
Rationale: In the past, this plant was widely planted as a pasture grass but presently, the working group consensus is that this species seems to be stable within that state and is not expanding its range.
Sources of information: Working Group discussions.

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**
Describe key reproductive characteristics: Produces by seeds and rapid-forming rhizomatous root systems.
Rationale: Smooth brome is a rhizomatous, sod-forming species. The first adventitious roots develop within 5 days of germination. The number of seeds produced has a very wide range. Lowe and Murphy (1955) report 47 to 160 seed heads per plant, with 156 to 10,080 viable seeds per plant. Seed has remained viable for 22 months to over 14 years.
Sources of information: See cited literature; also see Sather (1987), SWEPIC (http://www.usgs.nau.edu/SWEPIC/): Grand Canyon National Park Alien Plant Ranking System ranking.

Question 2.5 Potential for human-caused dispersal *Score:* **B** *Doc'n Level:* **Other pub.**
Identify dispersal mechanisms: Smooth brome is planted extensively for erosion control, forage and revegetation throughout the Midwest and western U.S., and is spread throughout transportation corridors such as highways and railroads. Boggs and Weaver (1992) found that grazing activities increase smooth brome invasions on the Yellowstone River. Smooth brome has been used in post-fire revegetation.
Rationale: Human dispersal occurs, but not at a high level.
Sources of information: See cited literature; also see Sather (1987).

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Obs.**
Identify dispersal mechanisms: Seeds may be transported by ants, or short distances by wind and water, but generally rare dispersal occurs more than 1 km by animals and abiotic mechanisms. Regular flooding of watersheds/drainages can transport this species longer distances (>1km).
Rationale: Kramer (1975 in Sather 1987) suggests that seeds may be transported and sequestered by ants, resulting in creation of new brome patches on anthills.
Sources of information: See cited literature. Score based on Working Group observations and discussion.

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Other pub.**

Identify other regions: In North America smooth brome occurs from Alaska and all the Canadian provinces and territories south to southern California and New Mexico, northern Oklahoma, and North Carolina. Smooth brome is a Eurasian species ranging from France to Siberia, apparently introduced in the United States by the California Experiment Station in 1884 (Kennedy 1899, Archer and Branch 1953). Within the United States smooth brome has been introduced in the northeastern and northern Great Plains states as far south as Tennessee, New Mexico and California. It has become naturalized from the maritime provinces to the Pacific coast north to Alaska to California and through the plains states.

In Colorado from Rocky Mountain National Park records, smooth brome is found in openings in mountain brush, pinyon juniper, aspen, spruce fir, ponderosa pine, lodgepole pine, and meadow communities. In Utah, smooth brome is found along roads and waterways and in fallow fields from 1280 to 3240 m, and in openings in mountain brush, pinyon-juniper, aspen, spruce-fir, ponderosa pine, lodgepole pine and meadow communities and is known from every Utah county with the exception of Grand (Welsh et al. 1987). In New Mexico, smooth brome is in all counties excepting the eight easternmost that border Texas.

Rationale: Invades elsewhere but only in ecotypes that it has already invaded in the state.

Sources of information: See cited literature; also see the Atlas of the Vascular Plants of Utah (accessed online on February 10, 2004 at: http://www.gis.usu.edu/Geography-Department/utgeog/utvatlas/ut-vascatlas.html.), Grasses of New Mexico, New Mexico State University Range Science Herbarium, Texas A&M Bioinformatics. (Working Group accessed online at: http://www.csdl.tamu.edu/FLORA/cgi/newmex_taxa_page?all=yes.), and Baldwin et al. (2002).

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: First collection of smooth brome was from Schultz Creek in Coconino county in 1945. Smooth brome is widely adapted to a variety of sites. It is common in riparian zones, valley bottoms, and dryland sites. It is adapted to all soil textures, although it may not thrive on sand or heavy clay. Smooth brome tolerates acid and saline soils but it does not grow on soils that are more than moderately alkaline. Smooth brome grows best on moist, well-drained soils, but tolerates poorly drained soils. Based on observations of Working Group members, smooth brome tolerates moderate shade to full sun.

Rationale: Smooth brome distribution is widespread, invading six major and nine minor ecotypes. In Arizona smooth brome is widespread in the northern half of the state.

Sources of information: SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed February 2004), USGS (2004), SWEMP-Cain Crisis map (available online at: http://cain.nbii.gov/cgibin/mapserv?map=../html/cain/crisis/crisismaps/crisis.map&mode=browse&layer=state&layer=county; accessed February 2004), and personal observations.

Question 3.2 Distribution *Score:* **D** *Doc'n Level:* **Obs.**

Describe distribution: Limited

Rationale: Although smooth brome is in lots of ecological types it occurs at a low frequency.

Sources of information: Based on Working Group observations and discussion. Also see sources in Question 3.1.

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**[✓ Yes] No 1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**[✓ Yes] No 2 pt.**
Populations of this species produce seeds every year.	**[✓ Yes] No 1 pt.**
Seed production sustained for 3 or more months within a population annually	**[✓ Yes] No 1 pt.**
Seeds remain viable in soil for three or more years	**[✓ Yes] No 2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes [✓ No] 1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**[✓ Yes] No 1 pt.**
Fragments easily and fragments can become established elsewhere	**[✓ Yes] No 2 pt.**
Resprouts readily when cut, grazed, or burned	**[✓ Yes] No 1 pt.**
	Total pts: 11 Total unknowns: 0
	Score : A

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	**D**
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	**D**
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	**U**
	montane wetlands	**D**
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	**D**
	montane riparian	**D**
Woodlands	Great Basin conifer woodland	**D**
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	**D**
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A. means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Bromus rubens* L. (USDA 2005)
Synonyms:	*Anisantha rubens* (L.) Nevski, *Bromus madritensis* L. ssp. *rubens* (L.) Husnot (USDA 2005)
Common names:	Red brome, foxtail chess, foxtail brome
Evaluation date (mm/dd/yy)**:**	08/06/04
Evaluator #1 Name/Title:	John Brock
Affiliation:	Arizona State University East
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List committee members:	W. Albrecht, W. Austin, D. Backer, J. Hall, L. Moser, F. Northam, B. Phillips, J. Schalau, K. Watters
Committee review date:	08/06/04
List date:	08/06/04
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**A**	Reviewed scientific publication	**“Impact”** **Section 1 Score:** **A**	**“Plant Score”** **Overall Score:** **High** **Alert Status:** **None**
1.2	Impact on plant community	**A**	Reviewed scientific publication		
1.3	Impact on higher trophic levels	**B**	Other published material		
1.4	Impact on genetic integrity	**U**	No information		
2.1	Role of anthropogenic and natural disturbance	**A**	Reviewed scientific publication	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **15 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Other published material		
2.3	Recent trend in total area infested within state	**C**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**A**	Observational		
2.6	Potential for natural long-distance dispersal	**B**	Observational		
2.7	Other regions invaded	**C**	Observational		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**A**	Observational	**“Distribution”** **Section 3 Score:** **A**	
3.2	Distribution	**A**	Observational		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Identify ecosystem processes impacted: Fire regimes, soil moisture and nutrient depletion (Alford 2002, D'Antonio and Vitousek 2002).

Rationale: Provides fine fuel to change fire frequency, intensity and rate of spread (Hunter 1991, Brooks 1999, Alford 2002) in the Sonoran, Mojave and Lower Colorado Desert (In Salo 2002). Fire impacts native desert communities especially in reducing various species of cactus and stem photosynthetic species (Alford and Brock 2002).

From Simonin (2001): Red brome generally shortens fire return intervals (McClaran and Brady 1994, McPherson and Muller 1969, Zedler et al. 1983). Increased presence of red brome has promoted fires in areas where fire was previously infrequent due to insufficient fuels (Phillips 1992). Once established red brome may increase fire frequency by enhancing potential for start and spread (Beatley 1966). In general, red brome produces an abundant and continuous cover of persistent fine fuels, promoting fast, "hot" fires (Brooks 1999). Red brome produces high amounts of persistent flammable fuels in perennial plant interspaces, promoting ignition and spread (Brown and Smith 2000). Within the Sonoran Desert, dead and dry brome is easily ignited, supporting fast-moving surface fires (Phillips 1992).

In Salo (2002): *Bromus rubens* has higher nitrogen uptake rates, relative to native western USA species (Hunter 1991, Brooks 1998, Padgett and Allen 1999).

Sources of information: See cited literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Identify type of impact or alteration: Competition with native species for soil moisture and soil nutrients. Can displace native plants especially in areas with repeated disturbance or as a result of fire in a fire-intolerant system (clear links between invasion by red brome and damage to fire-intolerant perennials Brook 1999).

Rationale: In the Sonoran Desert, fire return intervals are shortened, changing the vegetational composition through increase of non-native components and loss of native plant species (Rogers and Steele 1980 in Simonin 2001).

From Simonin (2001): Since 1976, increased winter ppt has promoted the spread of red brome. In relatively dry areas of the Southwest, red brome may displace native species during wetter years (Banner 1992, Biswell 1974, Hunter 1991).

Species will out-compete other grass/shrub species for available surface soil moisture and nutrients, especially nitrogen (Allen et al 2001). Dense stands utilize winter moisture (Wu and Jain 1979) and uptake soil nutrients (D'Antonio and Vitousek 2002). In stands of *B. rubens* competition for water, nutrients, and light, decreases the survivability of a plant (Hufstader 1976 in Newman 1992, Wu and Jain 1979). Density and biomass of native annual species (Mojave Desert) were significantly greater when red brome density was reduced, indicating that this grass may reduce the growth of native annuals (Brooks 2000 in Salo 2002). However, Salo (2002) found red brome did not exclude native Sonoran Desert winter annuals from emergence nor survival; however, there was clear evidence of reduced growth of Sonoran Desert winter annuals occurring with red brome.

Red brome is an example of species with a positive fire grass cycle (D'Antonio and Vitousek 2002) which can alter the physiognomy of southwestern communities, killing fire intolerant native succulents and woody species (Salo 2002). Other authors note that the shallow root system of red brome limits its ability to search for nutrients (Newman 1992). Impact of the shallow fibrous root system more prevalent in a wet year versus a dry year. Years of above-average winter precipitation red brome can dominate annual communities in the Sonoran (P. Anning, personal communication, 1998 in Salo 2002) and Mojave Deserts (Brooks 1998). Cohorts of red brome emerge in episodes related to late summer, autumn and early winter precipitation events (M. Acton and J. Brock, personal observations, 2004).

Sources of information: See cited literature and personal observations by J. Brock (Professor, Applied Biological Science, Arizona State University, Tempe, 2004) and M. Acton (Graduate Researcher, Arizona State University, Tempe, 2004).

Question 1.3 Impact on higher trophic levels *Score:* **B** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Reduces diversity of food types and tends to convert desert shrub/perennial grass communities to annual grasslands especially with fire (Beatley 1966, Turkowski 1975 in Simonin 2001). Dominance of red brome grass essentially creates a monoculture on more of a micro-scale than landscape scale (Alford and Brock 2002). Seed awns of many *Bromus* species are harmful to large mammals (Humphrey 1950 in Simonin 2000).

Rationale: Changes in community that can occur following fire, from desert shrub/perennial grass communities to annual exotic grasslands also influences the density (positively and negatively) of wildlife and insects (Newman 1992). Less variety of forage for animals, especially affects small mammals due to seed production and shoot/seedling herbivory of native plants (Turkowski 1975 in Simonin 2001). Small mammal populations may decrease through loss of food items. Little forage value to livestock and big game (Simonin 2001). Krausman and others observed light use by desert mule deer (Krausman et al. 1997). Desert cottontails prefer red brome, especially during the winter (Turkowski 1975 in Simonin 2001).

Sources of information: See cited literature.

Question 1.4 Impact on genetic integrity *Score:* **U** *Doc'n Level:* **No info.**

Identify impacts: Unknown

Rationale: Hybridization is not known (K. Steele, personal communication, 2004). There are studies of hybridization among perennial *Bromus* species (Ferdinandez and Coulman 2001). However, *Bromus arizonicus*, a native annual *Bromus,* overlaps in range with red brome (USDA 2005 and B. Phillips, personal communication, 2004).

Sources of information: See cited literature and personal communications by B. Phillips (Zone Botanist, U.S. Department of Agriculture, Forest Service, Coconino, Kaibab, and Prescott National Forests, 2004) and K. Steele (Associate Professor, Arizona State University East, Applied Biological Science, Mesa, 2004).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Describe role of disturbance: Can established with or without disturbance.

Rationale: Disturbance of natural vegetation and bare surface soils are prime candidates for red brome invasion (Beatley 1966, Hunter 1991). "Invades even relatively undisturbed areas of the Sonoran (Burgess et al. 1991), Mojave (Beatley 1966, Hunter 1991), and Great Basin Deserts (Tausch et al. 1994)" (Salo 2002). These disturbances are often initially human caused, but red brome can also establish without human disturbance from natural perturbations like droughts and floods (K. Watters, personal communication, 2004). Invades denuded lands (Mojave Desert) (Piemeisel 1932 in Burgess et al 1991), disturbed sites (Hitchcock et al. 1969) and undisturbed landscapes (Beatley 1966). Tends to colonize waste sites, roadsides, disturbed areas, heavily grazed areas, perimeters of nuclear test sites (Hunter 1991). Humans tend to bare soil surfaces, opening niches for invasive plant establishment. Red brome also appears in areas of very low disturbance (Hunter 1991).

In Simonin (2001): Red brome establishes from on- and off- site seed sources following fire (O'Leary and Westman 1988). In the Sonoran Desert, red brome showed dramatic increases following a prescribed burn in a desert scrub of paloverde, bursage and cholla (Loftin 1987).

Within the Mojave Desert of AZ, red brome prefers disturbed sites, especially areas where shrubs have been removed by fire; readily invaded blackbush communities susceptible to fire (Beatley 1966).

Sources of information: See cited literature and personal communication by K. Watters (Research Technician, Southern Colorado Plateau Network, National Park Service, Flagstaff, Arizona 2004).

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Other Pub**.

Describe rate of spread: Increasing, but less rapidly.

Rationale: All habitats in the hot desert, shrublands and desert grasslands of Arizona (below Mogollan Rim) contain this species (J. Brock, personal observation, 2004). Rate of spread is cyclical, dependent upon the wet-dry cycles of the Sonoran Desert ecosystem. Ruyle and Young (1997 in Guertin and Halvorson 2003) report that this grass is still spreading within Arizona's borders.

From Simonin (2001): Betancout (1996) attributes red brome expansion in the upper Sonoran Desert of central and southern Arizona to climate change. Since 1976 increased winter ppt has promoted the spread of red brome. In relatively dry areas of the Southwest, red brome may displace native species during wetter years (Banner 1992, Biswell 1974, Hunter 1991).

Sources of information: Score based on personal observations by J. Brock (Professor, Applied Biological Science, Arizona State University, Tempe, 2004) and Working Group discussion; also see cited literature.

Question 2.3 Recent trend in total area infested within state *Score:* **C** *Doc'n Level:* **Obs.**

Describe trend: Stable

Rationale: Appears to have established in all niches within the state (J. Brock, personal observation, 2004 and Working Group consensus). Comments from Salo (2002) "although the rate spread has slowed since 1942, it appears to have moved into new regions during this time, including northern and south-central Utah, northeastern Arizona, southwestern New Mexico and northwestern Sonora, Mexico. May have reached its ecological limits (Wu and Jain 1979).

Sources of information: Score based on personal observations by J. Brock (Professor, Applied Biological Science, Arizona State University, Tempe, 2004) and Working Group discussion; also see cited literature.

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other Pub.**

Describe key reproductive characteristics: Flowers in winter, begins seed dispersal in late spring. Reproduces by seed only.

Rationale: Annual seed production high in wet winters, and especially high in years following 2 wet winters (Wu and Jain 1979).

In Guertin and Halvorson (2003): Red brome produces an average of 76 seeds per plant, measured in natural populations and calculated 83,699 seeds/m^2 are produced in a plot of densely spaced plants (Wu and Jain 1979). Can germinate in fall, winter, and spring (Newman 1992).

Can survive long periods of drought (Beatley 1966). No reproductive info in the Fire Effects Information System (Simonin 2001).

Sources of information: See cited literature.

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Obs**.

Identify dispersal mechanisms: Penetrates human clothing, vehicle tire treads and parts of off road vehicles. Can be contaminant of hay and cereal crops.

Rationale: Barbed awns readily attach to susceptible surfaces (Hitchcock 1971). Harvested native grasses could contain seeds of red brome.

Sources of information: Score based on Working Group consensus; also see cited literature.

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Obs.**

Identify dispersal mechanisms: Occurs at an infrequent rate. Attaches to hairs and fur of animals. Potential for seedheads/seeds to be transported by wind, water, and animal movement (Guertin and Halvorson 2003).

Rationale: Barbed awns readily attach to susceptible surfaces (Hitchcock 1971). Slightly winged nature of caryopsis allows for some buoyancy in wind. Wind helps red bromes' short distance dispersal, along with man aiding in its long-distance dispersal (Brooks 2000).

Sources of information: Score based on Working Group consensus; also see cited literature.

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Obs.**

Identify other regions: Hot deserts and chaparral of California, hot deserts of Nevada and Mexico and chaparral in Mexico. Occurs in deserts of Oregon and Washington and, based on Gould (1975), the Trans-Pecos region of west Texas.

Rationale: Inference based on literature and personal observations.

Sources of information: See cited literature; also see Kearney and Peebles (1960) and (Hitchcock 1971). Also considered personal observations by J. Brock (Professor, Applied Biological Science, Arizona State University, Tempe, 2004)

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Assumed to have been introduced to AZ by Spanish colonizers sometime after 1530 (Tellman 1997), and continual reintroduction from California, Nevada (Hunter 1991, Beatley 1966) and Mexico by human commerce.

From Guertin and Halvorson (2003): Germination occurs in cooler, moister seasons, usually after heavy rains through the winter and into spring (Beatley 1966). Hammouda and Bakr (1969) report that optimum conditions for germination of *Bromus rubens*' seeds are temperatures between 68 to 77°F (20 to 25°C) during the deliverance of rainfall greater than 0.4 in. (1.0 cm). *Bromus rubens* grows well on shallow soils (Sampson et al. 1951 in Winkler 1987, Thornburg 1982 in Winkler 1987) with optimum soil depth 0-10 in. (0 to 25 cm). It grows in sandy, sandy loam, and loam soils with some tolerance for saline soils (Dittberner and Olson 1983 in Winkler 1987), although it prefers and grows optimally in silty to mid-clay soils (Thornburg 1982 in Winkler 1987). It prefers gentle to moderate slopes, and grows poorly on steep slopes (Dittberger and Olson 1983 in Winkler 1987). It prefers soils with a minimum pH of 6.0 and a maximum pH of 8.2 (USDA 2005). The species' success in desert areas may also be attributed to its high tolerance to salt and to high pH in soils (Newman 1992).

Earliest record in SEINet as of 11/10/04 was 1926, collected along the Verde River. Lots of records began showing up in the 1930s.

Rationale: Over 300 records in Arizona herbariums. See also Worksheet B of this document.

Sources of information: See cited literature. Also considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed 2004) individual Working Group member observations.

Question 3.2 Distribution *Score:* **A** *Doc'n Level:* **Obs.**

Describe distribution: Continuous distribution within hot deserts and areas with Mediterranean climates of the southwest. Most commonly found within canopy zone of woody perennials like mesquite during less favorable years of rainfall (J. Brock, personal observation, 2004).

Rationale: Over 300 records in Arizona herbariums (SEINet 2004). See also Worksheet B of this document.

Sources of information: SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed 2004). Also considered personal observations by J. Brock (Professor, Applied Biological Science, Arizona State University, Tempe, 2004).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**[✓ Yes]**	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**[✓ Yes]**	**No**	**2 pt.**
Populations of this species produce seeds every year.	**[✓ Yes]**	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**[✓ Yes]**	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	**Yes**	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes**	**[✓ No]**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes**	**[✓ No]**	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	**[✓ No]**	**2 pt.**
Resprouts readily when cut, grazed, or burned	**[✓ Yes]**	**No**	**1 pt.**

Total pts: 6 Total unknowns: 1

Score : A

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	**C**
	southwestern interior chaparral scrub	**C**
Desertlands	Great Basin desertscrub	**A**
	Mohave desertscrub	**A**
	Chihuahuan desertscrub	**B**
	Sonoran desertscrub	**A**
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	**B**
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	**A**
	southwestern interior riparian	**A**
	montane riparian	
Woodlands	Great Basin conifer woodland	**D**
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands"
by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association
(Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Bromus tectorum* L. (USDA 2005)
Synonyms:	*Anisantha tectorum* (L.) Nevski, *Bromus tectorum* L. var. *glabratus* Spenner, *Bromus tectorum* L. var. *hirsutus* Regel, *Bromus tectorum* L. var. *nudus* Klett & Richter (USDA 2005)
Common names:	Cheatgrass, downy brome
Evaluation date (mm/dd/yy)**:**	02/08/03
Evaluator #1 Name/Title:	Joe DiTomaso
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Evaluator #2 Name/Title:	Kate Watters, Graduate Student
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List committee members:	W. Albrecht, W. Austin, D. Backer, J. Crawford, L. Moser, F. Northam, T. Olson, B. Phillips, K. Watters
Committee review date:	02/17/04
List date:	02/17/04
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**A**	Reviewed scientific publication	**"Impact"** **Section 1 Score:** **A**	**"Plant Score"** **Overall Score:** **High** **Alert Status:** **None**
1.2	Impact on plant community	**A**	Reviewed scientific publication		
1.3	Impact on higher trophic levels	**A**	Reviewed scientific publication		
1.4	Impact on genetic integrity	**D**	Reviewed scientific publication		
2.1	Role of anthropogenic and natural disturbance	**A**	Other published material	**"Invasiveness"** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **18 pts** **Section 2 Score:** **A**	
2.2	Local rate of spread with no management	**A**	Other published material		
2.3	Recent trend in total area infested within state	**B**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**A**	Other published material		
2.6	Potential for natural long-distance dispersal	**A**	Other published material		
2.7	Other regions invaded	**C**	Other published material		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**A**	Other published material	**"Distribution"** **Section 3 Score:** **A**	
3.2	Distribution	**A**	Other published material		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Identify ecosystem processes impacted: Cheatgrass changes the frequency, extent, and timing of wildfires. In many areas that have been invaded by cheatgrass the natural fire cycle has shortened from every 60 to 100 years to every 3 to 5 years.

Rationale: Early fine fuel of cheatgrass forms a continuum between shrubs and bunchgrasses allowing fires to carry farther. The shorter fire frequency has eliminated many shrubs in these communities. As fires become even more frequent, the area will be dominated by annual grasses alone, with the loss of surface soil, nutrients, and near permanent deterioration of the site.

Sources of information: See West (1979), Whisenant (1990), Mosley et al. (1999; for review and other citations), and Young (2000).

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Identify type of impact or alteration: Cheatgrass disrupts ecosystems that are not adapted to increased rates of fire frequency. It is also known to displace native vegetation by outcompeting them for soil moisture.

Rationale: Cheatgrass is well adapted to fire and often dominates plant communities after fire (Melgoza et al. 1990). Changes in fire frequency can completely alter vegetation and lead to monotypic stands of cheatgrass. The change induced by cheatgrass in the fire cycle frequency is probably the species' greatest competitive advantage. Although fire is a natural part of the sagebrush grassland ecosystem, those fires usually occurred at intervals between 60 to 100 years. Cheatgrass infested areas burn at a much greater frequency, every 3 to 5 years. At this frequency, native shrubs and perennial grasses cannot recover and after a few wildfire cycles a cheatgrass monoculture develops. This monoculture further increases the frequency of fires and increases the dominance by cheatgrass in the area. Put simply, fire begets cheatgrass and cheatgrass begets fire. Vast numbers of cheatgrass seedlings usually germinate after the first fall rain in infested areas. The root system continues to develop throughout most of the winter and the plant has an extensive root system by spring. This allows it to extract higher levels of soil moisture and nutrients. Cheatgrass reproduces only from seeds and rapidly exploits the available water and nutrients in early spring. In sensitive ecological regions such as Northern Arizona, cheatgrass competes with native plants and can change the soil chemistry of an area, thereby reducing the populations of native plants. One study demonstrated cheatgrass' ability to reduce soil moisture to the permanent wilting point to the depth of 28 in (70 cm), reducing competition from other species.

Sources of information: See West (1979), Melgoza et al. (1990), Whisenant (1990), Skipper (1996), Devine (1998), Mosley et al. (1999; for review and other citations), Young (2000), and Carpenter and Murray (Undated); see also the Northern Arizona Integrated Weed Management Reference CD\Resources: *Bromus tectorum* infosheet.

Question 1.3 Impact on higher trophic levels *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Identify type of impact or alteration: Cheatgrass has had a negative effect on wildlife, particularly due to change in fire frequency which alters habitat structure. The implications of loss of shrubland refugia may be severe for ground squirrels and their predators. Does have a positive impact of forage for wildland in spring. Dried awns can damage the mouths of native wildlife species. Reduces biodiversity in ecosystems by replacing native vegetation.

Rationale: Slow-moving fauna such as desert tortoises are sometimes killed in the rapidly moving fires. Although cheatgrass provides good quality forage when used by livestock in the early spring, it can have negative effects when consumed in late spring and summer. Mature seeds contain long, stiff awns that often puncture the mouth and throat tissue of livestock, reducing feed intake and subsequent weight gain. Effects on native game species are largely unknown, but expected to be similar to livestock. The process in which a pristine shrub-steppe ecosystem deteriorates into one dominated by cheatgrass takes several years and has several distinct cycles. First, some sort of disturbance, typically heavy grazing, allows cheatgrass and other annuals to invade and proliferate. The dry beds of cheatgrass in the summer increase the occurrence of frequent fires. Initially, this creates an environment dominated by annual grasses, matchweed (*Gutierrezia sarothrae*), and rabbitbrush (*Chrysothamnus* spp.). As fires become even more frequent, the area will be dominated by annual grasses alone, with the loss of surface soil, nutrients, and near permanent deterioration of the site. This complete replacement of native flora, esp shrubs that are an important component of community structure, alters the structure of animal communities. Animal species that have co-evolved with a vegetation community for forage, cover and shelter, cannot adapt quickly enough to the rapid changes in the plant community. Sagebrush provides a principal source of browse on winter ranges for both wild and domestic ungulates, it is undoubtedly central to the habitat requirements of a host of other wildlife species.

A study by Van Horne et al (1997), found that the replacement of native shrub species by exotic annual forbs and grasses appears to be a unidirectional and permanent change in the study area in Idaho. Their findings suggest that further loss of shrubland in the Birds of Prey Area could greatly reduce ground squirrel densities that occur during such "ecological crunches," enhancing the risk of localized or area-wide extinction of populations. Moreover, given the apparent dependence of ground squirrels on native bunchgrasses for food and water, it is likely that replacement of these grasses by cheatgrass, with its much shorter succulent phase, would have a strong negative impact on ground squirrel populations, especially where there are few alternative forages, such as on grassland sites.

Sources of information: See West (1979), Currie et al. (1987), Van Horne et al (1997), Mosley et al. (1999; for review and other citations), Young (2000), Carpenter and Murray (Undated), and Meyer (Undated); score also based on inference.

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Rev. sci. pub.**

Identify impacts: Hybridization with other species rarely occurs under natural conditions.

Rationale: Unlikely to hydridize with native *Bromus* species. No evidence that this has occurred.

Sources of information: See Upadhaya et al. (1986) and Rice and Mack (1991b).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **A** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Cultivation and subsequent land abandonment, excessive livestock grazing and repeated fires can all interact to proliferate cheatgrass. However, it can also thrive in areas that have never been cultivated or grazed by domestic livestock.

Rationale: Movement into grasslands and scrublands appear to be initially in disturbed areas, but it is then capable of moving into undisturbed sites. In undisturbed sites, cheatgrass will most commonly spread along soil cracks and work its way outward into the natural community. Study plots from the Ecological Restoration Institute from Powell Plateau on the North Rim of Grand Canyon National Park show an occurrence of cheatgrass at a frequency of 1 to 14%, which demonstrates the plant's ability to invade undisturbed sites.

Sources of information: See Douglas et al. (1990), Rice and Mack (1991a), and Mosley et al. (1999; for review and other citations); also considered Ecological Restoration Institute, unpublished data.

Question 2.2 Local rate of spread with no management *Score:* **A** *Doc'n Level:* **Other pub.**

Describe rate of spread: Can double in area in less than 10 years.

Rationale: Because cheatgrass now occupies 100 million acres in the US and was only introduced a bit over 100 years ago, it is clear that it is capable of doubling its infestation level within 10 years.

Observations from the North Rim areas (Powell Plateau and the Walhalla Plateau) demonstrate cheatgrass infestations have the ability to double within 10 years.

Sources of information: See Mosley et al. (1999); also considered personal observations by K. Watters (Research Technician, Grand Canyon National Park, Flagstaff, Arizona, 2002 to 2003).

Question 2.3 Recent trend in total area infested within state *Score:* **B** *Doc'n Level:* **Obs.**

Describe trend: Increasing, but less rapidly.

Rationale: According to many local botanists, cheatgrass has not occupied its total potential range in Arizona. In ponderosa pine and pinyon juniper habitat, the invasion has gone from existing in small pockets to expanding.

Sources of information: Observational information from B. Phillips (Zone Botanist, U.S. Department of Agriculture, Forest Service, Coconino, Kaibab and Prescott National Forests).

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: High seed production every year. Seeds can survive for about 3 years in the soil, but most seed survives only one year.

Rationale: Reproductive strategy similar to most other invasive winter annual grasses. The density of cheatgrass plants in degraded grassland communities is about 10,000 to 13,000 plants/m^2. At this population level 10,000 to 15,000 viable but dormant seeds/m^2 are present in the litter and surface soil. Even with the elimination of the current year's seed production, the seed bank is capable of renewing cheatgrass populations for two or possibly three years without noticeable reductions in plant density. Cheatgrass is a highly self-pollinating species.

Sources of information: See Young and Evans (1985), Upadhaya et al. (1986), Mosley et al. (1999), Young (2000), and Zouhar (2003).

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Other pub**.

Identify dispersal mechanisms: Spread by attachment to human clothing or by clinging to hair and fur of livestock. Contaminated grain seed probably was the early method of dispersal. Seeds can also be dispersed as a contaminant in hay and straw or by mud clinging to machinery. According to botanists with the USFS, there is an element of cheatgrass seed in certified weed-free seed used for reseeding areas that have been burned as it is impossible to separate. Both fire suppression and prescribed fire activities can aid in the dispersal of cheatgrass.

Rationale: There are numerous opportunities for dispersal to new areas. Fire suppression equipment and firefighters track the seeds to new areas where plants can readily establish. Whereas prescribed fire seeks to restore natural processes in Ponderosa pine ecosystems, species diversity is not immediately altered by fire. However, within the first 3 years of a prescribed fire program, high-fire intensity patches are also the most susceptible to invasion by non-native plant species. The lower elevation ponderosa pine forests are potentially most susceptible to new invasions. Particularly troublesome is the apparently recent expansion of non-native cheatgrass in these forests in Kings Canyon National Park. As is the case with species diversity in general, the expansion of cheatgrass is strongly correlated with localized patch-level fire intensity.

Sources of information: See Mosley et al. (1999), Keeley (2000), and Young (2000); also considered personal communication with B. Phillips (Zone Botanist, U.S. Department of Agriculture, Forest Service, Coconino, Kaibab and Prescott National Forests).

Question 2.6 Potential for natural long-distance dispersal *Score:* **A** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Cheatgrass is spread by wind, water, attachment to animal fur and hooves, or by small rodents and ants.

Rationale: Long distance dispersal of cheatgrass by natural mechanisms is frequent. Cheatgrass is subject to animal dispersal as well-established base populations are common and barbed seeds easily cling to fur and hooves and are transported to new areas to form new populations. The eroded nature of annual grassland sites dominated by cheatgrass may promote water flow and therefore dispersal through this mechanism.

Sources of information: See and Young (2000) and Zouhar (2003); also considered: An Assessment of Exotic Plant Species of Rocky Mountain National Park. *Bromus tectorum* L. (available online at: http://www.npwrc.usgs.gov/resource/othrdata/explant/bromtect.htm; accessed January 8, 2004.

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Other pub**.

Identify other regions: Has invaded other areas of Europe, southern Russia, west central Asia, most of North America, Japan, South Africa, Australia, New Zealand, Iceland, and Greenland. In Utah, cheatgrass is invasive in sagebrush (*Artemisia* spp.) steppe and bunchgrass regions Great Basin desert scrub. Cheatgrass invades elsewhere in habitat types that have already been invaded in the state.

Rationale: Native to southern Europe, northern Africa, and southwestern Asia. One of the most widely invasive species around the world. In Utah 297,000 acres is considered cheatgrass monoculture (>60%), and cheatgrass is considered a major understory component (10 to 59%) in 1,082,880 acres. According to S. Cassidy (personal communication, 2003) and L. Walker (personal communication, 2003), both of whom have worked extensively with cheatgrass on the Arizona Strip, cheatgrass covers every square foot of the Great Basin desert scrub and grassland ecological types.

Sources of information: See Upadhaya (1986), Mosley at al. (1999), and Young (2000). Also considered personal communications with S. Cassidy (Natural Resources Conservation Service, 2003) and L. Walker (Weed Specialist, Bureau of Land Management, Arizona Strip, St. George, Utah, 2003)

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Other pub.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Downy brome was first found in the United States near Denver, Colorado, in the late 1800s (Whitson et al. 1991). It is most abundant in the Great Basin and Columbia Basin of the western United States.

Rationale: Most common in sagebrush/bunchgrass communities, although its distribution extends to higher-elevation juniper, pinyon-juniper, and pine woodlands.

Sources of information: See Mosley at al. (1999) and Young (2000).

Question 3.2 Distribution *Score:* **A** *Doc'n Level:* **Other pub.**

Describe distribution: Widespread throughout Arizona. Dominant annual grass on sagebrush rangelands on the Colorado Plateau and in rapidly colonizing Pinyon Juniper and Ponderosa pine woodlands in National Forest lands.

Rationale: Most common introduced annual grass in the United States. Today, cheatgrass is the dominant species on more than 100 million acres of the Intermountain west. Although cheatgrass can be found in both disturbed and undisturbed shrub-steppe and intermountain grasslands, the largest infestations are usually found in disturbed shrub-steppe areas, overgrazed rangeland, abandoned fields, eroded areas, road verges, and waste places.

Sources of information: See Whisenant (1990), Mosley at al. (1999), Young (2000), and Carpenter and Murray (Undated); distribution scores also based on Working Group observations.

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ **Yes**]	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	[✓ **Yes**]	**No**	**2 pt.**
Populations of this species produce seeds every year.	[✓ **Yes**]	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	[✓ **Yes**]	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	[✓ **Yes**]	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	[✓ **Yes**]	**No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes**	[✓ **No**]	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	[✓ **No**]	**2 pt.**
Resprouts readily when cut, grazed, or burned	[✓ **Yes**]	**No**	**1 pt.**

Total pts: 9 Total unknowns: 0

Score : A

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	**A**
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	**A**
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	**A**
	semi-desert grassland	**D**
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	
	montane riparian	**D**
Woodlands	Great Basin conifer woodland	**D**
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Cardaria chalapensis* (L.) Hand.-Maz.; *Cardaria draba* (L.) Desv.; *Cardaria pubescens* (C.A. Mey.) Jarmolenko (USDA 2005)
Synonyms:	*Cardaria chalapensis: Cardaria draba* (L.) Desv. ssp. *chalapensis* (L.) O.E. Schulz, *Cardaria draba* (L.) Desv. var. *repens* (Schrenk) O.E. Schulz, *Cardaria repens* (Schrenk) Jarmolenko, *Lepidium repens* (Schrenk) Boiss.; *Cardaria draba: Lepidium draba* L.; *Cardaria pubescens*: *Cardaria pubescens* (C.A. Mey.) Jarmolenko var. *elongata* Rollins and *Hymenophysa pubescens* C.A. Mey. (USDA 2005)
Common names:	*Cardaria pubescens*: lenspod whitetop, lens podded hoary cress *Cardaria draba:* whitetop, globe-podded hoary cress *Cardaria pubescens*: hairy whitetop
Evaluation date (mm/dd/yy)**:**	08/11/03
Evaluator #1 Name/Title:	Kate Watters Biotech (Plants)
Affiliation:	CPCESU/GRCA
Phone numbers:	(928) 523–8518
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Evaluator #2 Name/Title:	
Affiliation:	
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Address:	

List committee members:	10/23/03: W. Albrecht, W. Austin, D. Backer, J. Crawford, K. Thomas, T. Olson, B. Phillips, T. Robb, K. Watters 12/17/03: W. Albrecht, W. Austin, D. Backer, J. Crawford, K. Darrow, B. Phillips, K. Watters 02/17/04: W. Albrecht, W. Austin, D. Backer, J. Crawford, L. Moser, F. Northam. T. Olson, B. Phillips, K. Watters
Committee review date:	10/23/03, 12/17/03, and 02/17/04
List date:	12/17/03; revised 02/17/04
Re-evaluation date(s):	

Taxonomic Comment

A 1933 study by Bellue showed that *Cardaria draba*, known to North America, consisted of three European and Asian species: *C. chalapensis*, *C. draba, and C. pubescens* (Lyons, 1998). Although at times one or more of the preceding have been treated as subspecies, we follow the treatment of USDA (2005) that treats each taxon as a separate species. Based on herbarium records and personal communications with A. Salywon (Research Geneticist, U.S. Department of Agriculture, Agricultural Research Service, Water Conservation Laboratory, Phoenix, Arizona, 2005) all three taxa were determined to occur within Arizona wildlands. *Cardaria chalapensis, C. draba, and C. pubescens* are evaluated together here as they are genetically and morphologically similar, as well as have comparable ranges and habitat affinities (Bossard and Chipping 2000, Baldwin et al. 2002). In addition, because of the similar appearance of these three species they are easily misidentified in the field, as they require fruit to be properly identified (taxonomic differentiation between *C. draba and C. chalapensis* is in the shape of fruit; *C. pubescens* is differentiated by hairy fruit).

Recent unpublished work by A. Salywon (Research Geneticist, U.S. Department of Agriculture, Agricultural Research Service, Water Conservation Laboratory, Phoenix, Arizona, personal communication, 2005) suggests that the above taxa should be placed in the genus *Lepidium*, in which *Cardaria chalapensis* equals *Lepidium draba* ssp. *chalapense*, *Cardaria draba* equals *Lepidium draba* ssp. *draba*, and *Cardaria pubescens* equals *Lepidium appelianum* Al-Shehbaz. Until this work has been appropriately reviewed and published we have chosen to stay with the taxonomic treatment of USDA (2005).

Table 2. Scores, Designations, and Documentation Levels

Question		**Score**	**Documentation Level**	**Section Scores**	**Overall Score & Designations**
1.1	Impact on abiotic ecosystem processes	**B**	Other published material	**"Impact"** **Section 1 Score:** **B**	**"Plant Score"** **Overall Score:** **Medium** **Alert Status:** **Alert**
1.2	Impact on plant community	**A**	Other published material		
1.3	Impact on higher trophic levels	**B**	Other published material		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Other published material	**"Invasiveness"** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **14 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Observational		
2.3	Recent trend in total area infested within state	**C**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**A**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Reviewed scientific publication		
2.7	Other regions invaded	**C**	Other published material		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**B**	Observational	**"Distribution"** **Section 3 Score:** **C**	
3.2	Distribution	**D**	Observational		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **B** *Doc'n Level:* **Other pub.**
Identify ecosystem processes impacted: Reduction of soil water table, and light availability diminish ability of native species to reproduce.
Rationale: All species of *Cardaria* have extensive systems of persistent, deep, vertical and horizontal roots that penetrate the soil to depths of 2 m or more (CDFA 2003). All three *Cardaria* species are strong competitors for moisture, which puts native communities at a disadvantage (Bossard and Chipping 2000).
Sources of information: See cited literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **A** *Doc'n Level:* **Other pub.**
Identify type of impact or alteration: *Cardaria draba* forms dense patches and reduces native species populations.
Rationale: *Cardaria draba* establishes monospecific mats that exclude most vegetation. *Cardaria chalapensis* forms dense infestations in meadows and fields that outcompete forage plants for wildlife in California (Bossard and Chipping 2000). At Nature Conservancy preserves in Northern Idaho and at the Yampa River in Colorado, *C. draba* is reported as a moderate threat to biodiversity and infestations are currently 1% of all vulnerable habitat infested (Hill 1995, Williams 1995). Mycorrhizal associations do not develop with any of the three species of *Cardaria*, which may alter the trophic relationships in the soil (Lyons 1998) Patches in Yavapai County create a monoculture where occlusion of native species is likely (J. Schalau, personal communication, 2003). On Audubon Appleton-Whittell Research Ranch (ARR), *C. draba* was found in the spring of 2000, in a disturbed area at the intersection of a road and wash through a sacaton grassland. L. Kennedy reports from monitoring the population, that there is no indication that the *C. draba* displaced any native vegetation, but it seems likely that it could, over time. Of similar habitat on ARR, *C. draba* currently covers less than 1% (L. Kennedy, personal communication, 2003).
Sources of information: See cited literature; also considered personal communications with J. Schalau (Assistant Agent, Agriculture and Natural Resources, University of Arizona Cooperative Extension, Yavapai County, 2003) and L. Kennedy (Assistant Director, Audubon Appleton-Whittell Research Ranch, Elgin, Arizona, 2003). In addition, see Sheley and Stivers (2000).

Question 1.3 Impact on higher trophic levels *Score:* **B** *Doc'n Level:* **Other pub.**
Identify type of impact or alteration: Moderate reduction in foraging sites for native animals. *Cardaria chalapensis* is toxic to stock-unknown if toxic to foraging ungulates. Positive impact-plants provide nectar for honeybees (Sheley and Stivers 2000).
Rationale: *Cardaria draba* displaces valuable rangeland forage species (Lyons 1998), and *C.chalapensis* forms dense infestations that crowd out forage plants in meadows and fields. By displacing native vegetation utilized by wildlife, both species demonstrate the ability to impact native fauna negatively (Bossard and Chipping 2000). *Cardaria chalapensis* contains glucosnolates, which are toxic to stock and could have the same reaction to native ungulates (Sheley and Stivers 2000).
Sources of information: See cited literature.

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub.**
Identify impacts: No known hybridization between native plants of same genus.
Rationale: No known native species of *Cardaria* exists in the state. (Kearney and Peebles 1960). Plants identified as *C. draba* var. *repens* are apparent hybrids with *C. chalapensis* (Baldwin et al. 2002). According to A. Salywon (personal communication, 2003), species of *Cardaria* have been shown using molecular data to belong in *Lepidium* (most *Cardaria* were originally described as species of *Lepidium*).

Apparently, however, no hybridization occurs between them and the native species of *Lepidium*, though hybridization between the native species of *Lepidium* is common.

Sources of information: See cited literature; also considered personal communication with A. Salywon, (Research Geneticist, U.S. Department of Agriculture, Agricultural Research Service, Water Conservation Laboratory, Phoenix, Arizona, 2003).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Both species readily establish in disturbed areas in range and wildland areas.

Rationale: Cultivation in agricultural fields aids in dispersal as farm machinery can spread plants by dispersing root fragments. Invasion potential is greater under heavily grazed conditions or other disturbances. Irrigation causes increases in population (CDFA 2003). These species grow in a variety of habitats, but they thrive in disturbed or irrigated areas. They are less of a problem in undisturbed settings (Lyons 1998). The Nature Conservancy reports types of disturbance that promote colonization and spread on preserves in Colorado, Idaho and Montana including grazing (Carr 1995), irrigation, and cultivation (O'Brien and O'Brien 1994). In Las Vegas Wash in Nevada, natural disturbance creates new populations (T. Olson, personal communication, 2003)

Sources of information: See cited literature; also considered observations by T. Olson (Wildlife Biologist, Bureau of Reclamation, Boulder City, Nevada, 2003).

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Obs.**

Describe rate of spread: Increases, but less rapidly.

Rationale: In Saskatchewan, Canada in one year, a single plant on open ground without competition can spread vegetatively to cover an area to 3.7 m in diameter and can produce up to 455 shoots (CDFA 2003). Also, infestations of both species contracted when in competition with other species (particularly perennials) and when not irrigated. In Grand Canyon National Park, two populations totaling 280 m^2 have increased slightly, even with management (Rodeo herbicide application) (L. Johnson, personal communication, 2003). Prescott populations are small and isolated monocultures. In Camp Verde the populations are on agricultural land and cultural practices may be increasing their spread (J. Schalau, personal communication, 2003). At Audubon Appleton-Whittell Research Ranch plants were treated early in the spring (2001). The next year, 2002, the infestation had spread at least 1/4 mile downstream in the wash and in the open spaces between the sacaton near the wash, apparently from seed (L. Kennedy, personal communication, 2003).

Sources of information: See cited literature; also considered personal communications with L. Johnson (Ecologist, U.S. Department of Agriculture, Forest Service, Kaibab National Forest, 2003), L. Kennedy (Assistant Director, Audubon Appleton-Whittell Research Ranch, Elgin, Arizona, 2003), and J. Schalau (Assistant Agent, Agriculture and Natural Resources, University of Arizona Cooperative Extension, Yavapai County, 2003) and Southwest Exotic Plant Management Program (SWEMP) records for Grand Canyon National Park 2001 to 2003 (available online at: http://www.usgs.nau.edu/swepic/swemp/maps.html).

Question 2.3 Recent trend in total area infested within state *Score:* **C** *Doc'n Level:* **Obs.**

Describe trend: Stable.

Rationale: CAIN/CRISIS Map records three occurrences of *C. draba*: one in Yavapai, one in Coconino, and one in Mohave County. Parker (1972) reported *C. draba* on ranches in the Springerville-Eager area in Apache County to Peeples Valley in Yavapai County and northward to Fredonia in Coconino County. Populations at Grand Canyon National Park remained relatively stable with Rodeo herbicide treatment. Cultural practices may be increasing populations somewhat in Yavapai County (J. Schalau, personal

communication, 2003). In 1972 *C. pubescens* was unknown in Arizona (Parker 1972). Its current distribution in the state seems quite limited (A. Salywon, personal communication, 2003). *Cardaria chalapensis* is distributed in southern and central counties of UT, but similar to *C. pubescens* seems to have limited distribution in Arizona (A. Salywon, personal communication, 2003).

Sources of information: See cited literature; also considered CAIN/CRISIS Map (available online at: http://cain.nbii.gov/cgibin/mapserv?map=../html/cain/crisis/crisismaps/crisis.map&mode=browse&layer=state&layer=county), Southwest Exotic Plant Management Program (SWEMP) records for Grand Canyon National Park 2001 to 2003 (available online at: http://www.usgs.nau.edu/swepic/swemp/maps.html), and personal communications from A. Salywon (Research Geneticist, U.S. Department of Agriculture, Agricultural Research Service, Water Conservation Laboratory, Phoenix, Arizona, 2005) and J. Schalau (Assistant Agent, Agriculture and Natural Resources, University of Arizona Cooperative Extension, Yavapai County, 2003).

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: Plants reproduce from seeds and underground rhizome/root fragments.

Rationale: *Cardaria draba* plants can produce 1,500 to 4,800 seeds in a year with 85% viability and can produce 455 shoots. *Cardaria pubescens* plants produce 30 to 560 (average 300) pods per plant.

Sources of information: See CDFA (2003).

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Seeds are dispersed by water, vehicles, farm machinery, and contaminated hay and crop seeds. Grazing activities can cause *C. draba* populations to invade an area.

Rationale: *Cardaria* spp. are agricultural weeds that can be transported via humans, as root fragments transported by farm machinery can potentially reestablish in new areas (CDFA 2003). *Cardaria draba* population germination rates were greatest in areas of soil disturbance (Larson et al. 2000)

Sources of information: See cited literature.

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Identify dispersal mechanisms: Dispersal of root fragments through flooding events.

Rationale: *Cardaria* spp. reproduce vegetatively from rhizomatous systems and less importantly by seed (Lyons 1998). Severed root segments only 1.3 cm long can regenerate into new plants if they are left within approximately 7 to 10 cm or the soil surface (Scurfield 1962). All three species are found to be a problem in moist environments, including drainage ditches like Las Vegas Wash, where the potential for long-distance dispersal via flooding events is possible (T. Olson, personal communication, 2003). In Camp Verde, populations are on agricultural lands and cultural practices may be increasing their spread. These lands are also adjacent to the Verde River adding to the potential for increased spread (J. Schalau, personal communication, 2003). On Audubon Appleton-Whittell Research Ranch, *C. draba* was found in the spring of 2000, in a disturbed area at the intersection of a road and wash through a sacaton grassland. Total area of coverage was approximately 20 m x 40 m. It's likely that seed or rhizomes were introduced via gravel used to surface the road. The entire spread of *C. draba* is downstream of this point (L. Kennedy, personal communication, 2003). The dispersal that L. Kennedy reports at the Audubon Appleton-Whittell Research Ranch is due to seeds in addition to root fragments, but this is based on the observation that the spread is within the arroyo (wash) where root fragments are likely to be created and carried, but also on the floodplain terrace where overland flow is less dramatic and root fragmentation is less likely. This dispersal mechanism could potentially be a severe problem if there were two wet winters in a row. The first to produce a good crop of seed and the second to allow the seed to germinate and establish (L. Kennedy, personal communication, 2003).

Sources of information: See cited literature; also considered observations by L. Kennedy (Assistant Director, Audubon Appleton-Whittell Research Ranch, Elgin, Arizona, 2003), T. Olson (Wildlife

Biologist, Bureau of Reclamation, Boulder City, Nevada, 2003), and J. Schalau (Assistant Agent, Agriculture and Natural Resources, University of Arizona Cooperative Extension, Yavapai County, 2003).

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Other pub.**

Identify other regions: Invades elsewhere but only in ecological types that it has already invaded in the state.

Rationale: In California *C. draba* is frequent in Sacramento Valley, San Francisco Bay, and South Coast regions to 3850 feet. *Cardaria pubescens* is frequent in the Sacramento Valley, South Coast region, and Great Basin to 6560 feet. In Wyoming *C. draba* invades riparian meadows (Studenmund 1995). In Colorado at the Yampa River Preserve, *C. draba* invades open grasslands of non-native species (Williams 1995). In Idaho it is reported from willow/rose riparian edge. In Utah *C. draba* has a distribution throughout the central northwestern part of the state with an elevation range from 1,330 to 2,670 meters.

Sources of information: See cited literature; also see O'Brien and O'Brien (1994), Hill (1995), CDFA (2003), and the Vascular Plant Atlas of Utah (available online at: http://www.gis.usu.edu/Geography-Department/utgeog/utvatlas, September 2003).

Question 3.1 Ecological amplitude *Score:* **B** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Introduced from central Europe and western Asia, specifically Georgia, Syria, Iraq, Iran, and Armenia. Introduction date to Arizona is unknown. Present in three Arizona ecological types.

Rationale: *Cardaria draba* is found in the west from Colorado to Wyoming to California and also on the east coast. First collected in 1876. *Cardaria pubescens* probably arrived from infested alfalfa seed from Turkestan and was first collected in North America in 1919. This species is more common in the northwestern USA with few occurrences in the mid-west. Ecological types invaded may indicate distribution is limited by excessive temperatures and adequate moisture.

Sources of information: See Lyons (1998) and Bossard and Chipping (2000); also applied inference.

Question 3.2 Distribution *Score:* **D** *Doc'n Level:* **Obs.**

Describe distribution: Present in three Arizona ecological types but less than or equal to 5% occurrence in each.

Rationale: Observations of *C. draba* collectively reported by Working Group members in grasslands, montane forest, and southwestern interior riparian based on observations in Grand Canyon ponderosa pine, Las Vegas Wash, and Petrified National Forest communities.

Sources of information: Observations by T. Olson (Wildlife Biologist. Bureau of Reclamation. Boulder City, Nevada, 2003), L. Makarick (Below the Rim Vegetation Program Manager, Grand Canyon National Park Science Center, Flagstaff, Arizona, 2003), and K. Thomas (Vegetation Ecologist, U.S. Geological Survey, Southwest Biological Science Center, Flagstaff, Arizona, 2003).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**[✓ Yes]**	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**[✓ Yes]**	**No**	**2 pt.**
Populations of this species produce seeds every year.	**Yes**	**[✓ No]**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**Yes**	**[✓ No]**	**1 pt.**
Seeds remain viable in soil for three or more years	**[✓ Yes]**	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**[✓ Yes]**	**No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**[✓ Yes]**	**No**	**1 pt.**
Fragments easily and fragments can become established elsewhere	**[✓ Yes]**	**No**	**2 pt.**
Resprouts readily when cut, grazed, or burned	**Yes**	**[✓ No]**	**1 pt.**
	Total pts: 9	**Total unknowns: 0**	
	Score : A		

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	**D**
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	**D**
	montane riparian	
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Cardaria chalapensis* (L.) Hand.-Maz.; *Cardaria draba* (L.) Desv.; *Cardaria pubescens* (C.A. Mey.) Jarmolenko (USDA 2005)
Synonyms:	*Cardaria chalapensis: Cardaria draba* (L.) Desv. ssp. *chalapensis* (L.) O.E. Schulz, *Cardaria draba* (L.) Desv. var. *repens* (Schrenk) O.E. Schulz, *Cardaria repens* (Schrenk) Jarmolenko, *Lepidium repens* (Schrenk) Boiss.; *Cardaria draba: Lepidium draba* L.; *Cardaria pubescens*: *Cardaria pubescens* (C.A. Mey.) Jarmolenko var. *elongata* Rollins and *Hymenophysa pubescens* C.A. Mey. (USDA 2005)
Common names:	*Cardaria pubescens*: lenspod whitetop, lens podded hoary cress *Cardaria draba:* whitetop, globe-podded hoary cress *Cardaria pubescens*: hairy whitetop
Evaluation date (mm/dd/yy)**:**	08/11/03
Evaluator #1 Name/Title:	Kate Watters Biotech (Plants)
Affiliation:	CPCESU/GRCA
Phone numbers:	(928) 523–8518
Email address:	kw6@dana.ucc.nau.edu
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Evaluator #2 Name/Title:	
Affiliation:	
Phone numbers:	
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Address:	

List committee members:	10/23/03: W. Albrecht, W. Austin, D. Backer, J. Crawford, K. Thomas, T. Olson, B. Phillips, T. Robb, K. Watters 12/17/03: W. Albrecht, W. Austin, D. Backer, J. Crawford, K. Darrow, B. Phillips, K. Watters 02/17/04: W. Albrecht, W. Austin, D. Backer, J. Crawford, L. Moser, F. Northam. T. Olson, B. Phillips, K. Watters
Committee review date:	10/23/03, 12/17/03, and 02/17/04
List date:	12/17/03; revised 02/17/04
Re-evaluation date(s):	

Taxonomic Comment

A 1933 study by Bellue showed that *Cardaria draba*, known to North America, consisted of three European and Asian species: *C. chalapensis*, *C. draba, and C. pubescens* (Lyons, 1998). Although at times one or more of the preceding have been treated as subspecies, we follow the treatment of USDA (2005) that treats each taxon as a separate species. Based on herbarium records and personal communications with A. Salywon (Research Geneticist, U.S. Department of Agriculture, Agricultural Research Service, Water Conservation Laboratory, Phoenix, Arizona, 2005) all three taxa were determined to occur within Arizona wildlands. *Cardaria chalapensis, C. draba, and C. pubescens* are evaluated together here as they are genetically and morphologically similar, as well as have comparable ranges and habitat affinities (Bossard and Chipping 2000, Baldwin et al. 2002). In addition, because of the similar appearance of these three species they are easily misidentified in the field, as they require fruit to be properly identified (taxonomic differentiation between *C. draba and C. chalapensis* is in the shape of fruit; *C. pubescens* is differentiated by hairy fruit).

Recent unpublished work by A. Salywon (Research Geneticist, U.S. Department of Agriculture, Agricultural Research Service, Water Conservation Laboratory, Phoenix, Arizona, personal communication, 2005) suggests that the above taxa should be placed in the genus *Lepidium*, in which *Cardaria chalapensis* equals *Lepidium draba* ssp. *chalapense*, *Cardaria draba* equals *Lepidium draba* ssp. *draba*, and *Cardaria pubescens* equals *Lepidium appelianum* Al-Shehbaz. Until this work has been appropriately reviewed and published we have chosen to stay with the taxonomic treatment of USDA (2005).

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**B**	Other published material	**“Impact”** **Section 1 Score:** **B**	**“Plant Score”** **Overall Score:** **Medium** **Alert Status:** **Alert**
1.2	Impact on plant community	**A**	Other published material		
1.3	Impact on higher trophic levels	**B**	Other published material		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Other published material	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **14 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Observational		
2.3	Recent trend in total area infested within state	**C**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**A**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Reviewed scientific publication		
2.7	Other regions invaded	**C**	Other published material		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**B**	Observational	**“Distribution”** **Section 3 Score:** **C**	
3.2	Distribution	**D**	Observational		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **B** *Doc'n Level:* **Other pub.**

Identify ecosystem processes impacted: Reduction of soil water table, and light availability diminish ability of native species to reproduce.

Rationale: All species of *Cardaria* have extensive systems of persistent, deep, vertical and horizontal roots that penetrate the soil to depths of 2 m or more (CDFA 2003). All three *Cardaria* species are strong competitors for moisture, which puts native communities at a disadvantage (Bossard and Chipping 2000).

Sources of information: See cited literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **A** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: *Cardaria draba* forms dense patches and reduces native species populations.

Rationale: *Cardaria draba* establishes monospecific mats that exclude most vegetation. *Cardaria chalapensis* forms dense infestations in meadows and fields that outcompete forage plants for wildlife in California (Bossard and Chipping 2000). At Nature Conservancy preserves in Northern Idaho and at the Yampa River in Colorado, *C. draba* is reported as a moderate threat to biodiversity and infestations are currently 1% of all vulnerable habitat infested (Hill 1995, Williams 1995). Mycorrhizal associations do not develop with any of the three species of *Cardaria*, which may alter the trophic relationships in the soil (Lyons 1998) Patches in Yavapai County create a monoculture where occlusion of native species is likely (J. Schalau, personal communication, 2003). On Audubon Appleton-Whittell Research Ranch (ARR), *C. draba* was found in the spring of 2000, in a disturbed area at the intersection of a road and wash through a sacaton grassland. L. Kennedy reports from monitoring the population, that there is no indication that the *C. draba* displaced any native vegetation, but it seems likely that it could, over time. Of similar habitat on ARR, *C. draba* currently covers less than 1% (L. Kennedy, personal communication, 2003).

Sources of information: See cited literature; also considered personal communications with J. Schalau (Assistant Agent, Agriculture and Natural Resources, University of Arizona Cooperative Extension, Yavapai County, 2003) and L. Kennedy (Assistant Director, Audubon Appleton-Whittell Research Ranch, Elgin, Arizona, 2003). In addition, see Sheley and Stivers (2000).

Question 1.3 Impact on higher trophic levels *Score:* **B** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Moderate reduction in foraging sites for native animals. *Cardaria chalapensis* is toxic to stock-unknown if toxic to foraging ungulates. Positive impact-plants provide nectar for honeybees (Sheley and Stivers 2000).

Rationale: *Cardaria draba* displaces valuable rangeland forage species (Lyons 1998), and *C.chalapensis* forms dense infestations that crowd out forage plants in meadows and fields. By displacing native vegetation utilized by wildlife, both species demonstrate the ability to impact native fauna negatively (Bossard and Chipping 2000). *Cardaria chalapensis* contains glucosnolates, which are toxic to stock and could have the same reaction to native ungulates (Sheley and Stivers 2000).

Sources of information: See cited literature.

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub.**

Identify impacts: No known hybridization between native plants of same genus.

Rationale: No known native species of *Cardaria* exists in the state. (Kearney and Peebles 1960). Plants identified as *C. draba* var. *repens* are apparent hybrids with *C. chalapensis* (Baldwin et al. 2002). According to A. Salywon (personal communication, 2003), species of *Cardaria* have been shown using molecular data to belong in *Lepidium* (most *Cardaria* were originally described as species of *Lepidium*).

Apparently, however, no hybridization occurs between them and the native species of *Lepidium*, though hybridization between the native species of *Lepidium* is common.

Sources of information: See cited literature; also considered personal communication with A. Salywon, (Research Geneticist, U.S. Department of Agriculture, Agricultural Research Service, Water Conservation Laboratory, Phoenix, Arizona, 2003).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Both species readily establish in disturbed areas in range and wildland areas.

Rationale: Cultivation in agricultural fields aids in dispersal as farm machinery can spread plants by dispersing root fragments. Invasion potential is greater under heavily grazed conditions or other disturbances. Irrigation causes increases in population (CDFA 2003). These species grow in a variety of habitats, but they thrive in disturbed or irrigated areas. They are less of a problem in undisturbed settings (Lyons 1998). The Nature Conservancy reports types of disturbance that promote colonization and spread on preserves in Colorado, Idaho and Montana including grazing (Carr 1995), irrigation, and cultivation (O'Brien and O'Brien 1994). In Las Vegas Wash in Nevada, natural disturbance creates new populations (T. Olson, personal communication, 2003)

Sources of information: See cited literature; also considered observations by T. Olson (Wildlife Biologist, Bureau of Reclamation, Boulder City, Nevada, 2003).

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Obs.**

Describe rate of spread: Increases, but less rapidly.

Rationale: In Saskatchewan, Canada in one year, a single plant on open ground without competition can spread vegetatively to cover an area to 3.7 m in diameter and can produce up to 455 shoots (CDFA 2003). Also, infestations of both species contracted when in competition with other species (particularly perennials) and when not irrigated. In Grand Canyon National Park, two populations totaling 280 m^2 have increased slightly, even with management (Rodeo herbicide application) (L. Johnson, personal communication, 2003). Prescott populations are small and isolated monocultures. In Camp Verde the populations are on agricultural land and cultural practices may be increasing their spread (J. Schalau, personal communication, 2003). At Audubon Appleton-Whittell Research Ranch plants were treated early in the spring (2001). The next year, 2002, the infestation had spread at least 1/4 mile downstream in the wash and in the open spaces between the sacaton near the wash, apparently from seed (L. Kennedy, personal communication, 2003).

Sources of information: See cited literature; also considered personal communications with L. Johnson (Ecologist, U.S. Department of Agriculture, Forest Service, Kaibab National Forest, 2003), L. Kennedy (Assistant Director, Audubon Appleton-Whittell Research Ranch, Elgin, Arizona, 2003), and J. Schalau (Assistant Agent, Agriculture and Natural Resources, University of Arizona Cooperative Extension, Yavapai County, 2003) and Southwest Exotic Plant Management Program (SWEMP) records for Grand Canyon National Park 2001 to 2003 (available online at: http://www.usgs.nau.edu/swepic/swemp/maps.html).

Question 2.3 Recent trend in total area infested within state *Score:* **C** *Doc'n Level:* **Obs.**

Describe trend: Stable.

Rationale: CAIN/CRISIS Map records three occurrences of *C. draba*: one in Yavapai, one in Coconino, and one in Mohave County. Parker (1972) reported *C. draba* on ranches in the Springerville-Eager area in Apache County to Peeples Valley in Yavapai County and northward to Fredonia in Coconino County. Populations at Grand Canyon National Park remained relatively stable with Rodeo herbicide treatment. Cultural practices may be increasing populations somewhat in Yavapai County (J. Schalau, personal

communication, 2003). In 1972 *C. pubescens* was unknown in Arizona (Parker 1972). Its current distribution in the state seems quite limited (A. Salywon, personal communication, 2003). *Cardaria chalapensis* is distributed in southern and central counties of UT, but similar to *C. pubescens* seems to have limited distribution in Arizona (A. Salywon, personal communication, 2003).

Sources of information: See cited literature; also considered CAIN/CRISIS Map (available online at: http://cain.nbii.gov/cgibin/mapserv?map=../html/cain/crisis/crisismaps/crisis.map&mode=browse&layer=state&layer=county), Southwest Exotic Plant Management Program (SWEMP) records for Grand Canyon National Park 2001 to 2003 (available online at: http://www.usgs.nau.edu/swepic/swemp/maps.html), and personal communications from A. Salywon (Research Geneticist, U.S. Department of Agriculture, Agricultural Research Service, Water Conservation Laboratory, Phoenix, Arizona, 2005) and J. Schalau (Assistant Agent, Agriculture and Natural Resources, University of Arizona Cooperative Extension, Yavapai County, 2003).

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: Plants reproduce from seeds and underground rhizome/root fragments.

Rationale: *Cardaria draba* plants can produce 1,500 to 4,800 seeds in a year with 85% viability and can produce 455 shoots. *Cardaria pubescens* plants produce 30 to 560 (average 300) pods per plant.

Sources of information: See CDFA (2003).

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Seeds are dispersed by water, vehicles, farm machinery, and contaminated hay and crop seeds. Grazing activities can cause *C. draba* populations to invade an area.

Rationale: *Cardaria* spp. are agricultural weeds that can be transported via humans, as root fragments transported by farm machinery can potentially reestablish in new areas (CDFA 2003). *Cardaria draba* population germination rates were greatest in areas of soil disturbance (Larson et al. 2000)

Sources of information: See cited literature.

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Identify dispersal mechanisms: Dispersal of root fragments through flooding events.

Rationale: *Cardaria* spp. reproduce vegetatively from rhizomatous systems and less importantly by seed (Lyons 1998). Severed root segments only 1.3 cm long can regenerate into new plants if they are left within approximately 7 to 10 cm or the soil surface (Scurfield 1962). All three species are found to be a problem in moist environments, including drainage ditches like Las Vegas Wash, where the potential for long-distance dispersal via flooding events is possible (T. Olson, personal communication, 2003). In Camp Verde, populations are on agricultural lands and cultural practices may be increasing their spread. These lands are also adjacent to the Verde River adding to the potential for increased spread (J. Schalau, personal communication, 2003). On Audubon Appleton-Whittell Research Ranch, *C. draba* was found in the spring of 2000, in a disturbed area at the intersection of a road and wash through a sacaton grassland. Total area of coverage was approximately 20 m x 40 m. It's likely that seed or rhizomes were introduced via gravel used to surface the road. The entire spread of *C. draba* is downstream of this point (L. Kennedy, personal communication, 2003). The dispersal that L. Kennedy reports at the Audubon Appleton-Whittell Research Ranch is due to seeds in addition to root fragments, but this is based on the observation that the spread is within the arroyo (wash) where root fragments are likely to be created and carried, but also on the floodplain terrace where overland flow is less dramatic and root fragmentation is less likely. This dispersal mechanism could potentially be a severe problem if there were two wet winters in a row. The first to produce a good crop of seed and the second to allow the seed to germinate and establish (L. Kennedy, personal communication, 2003).

Sources of information: See cited literature; also considered observations by L. Kennedy (Assistant Director, Audubon Appleton-Whittell Research Ranch, Elgin, Arizona, 2003), T. Olson (Wildlife

Biologist, Bureau of Reclamation, Boulder City, Nevada, 2003), and J. Schalau (Assistant Agent, Agriculture and Natural Resources, University of Arizona Cooperative Extension, Yavapai County, 2003).

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Other pub.**

Identify other regions: Invades elsewhere but only in ecological types that it has already invaded in the state.

Rationale: In California *C. draba* is frequent in Sacramento Valley, San Francisco Bay, and South Coast regions to 3850 feet. *Cardaria pubescens* is frequent in the Sacramento Valley, South Coast region, and Great Basin to 6560 feet. In Wyoming *C. draba* invades riparian meadows (Studenmund 1995). In Colorado at the Yampa River Preserve, *C. draba* invades open grasslands of non-native species (Williams 1995). In Idaho it is reported from willow/rose riparian edge. In Utah *C. draba* has a distribution throughout the central northwestern part of the state with an elevation range from 1,330 to 2,670 meters.

Sources of information: See cited literature; also see O'Brien and O'Brien (1994), Hill (1995), CDFA (2003), and the Vascular Plant Atlas of Utah (available online at: http://www.gis.usu.edu/Geography-Department/utgeog/utvatlas, September 2003).

Question 3.1 Ecological amplitude *Score:* **B** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Introduced from central Europe and western Asia, specifically Georgia, Syria, Iraq, Iran, and Armenia. Introduction date to Arizona is unknown. Present in three Arizona ecological types.

Rationale: *Cardaria draba* is found in the west from Colorado to Wyoming to California and also on the east coast. First collected in 1876. *Cardaria pubescens* probably arrived from infested alfalfa seed from Turkestan and was first collected in North America in 1919. This species is more common in the northwestern USA with few occurrences in the mid-west. Ecological types invaded may indicate distribution is limited by excessive temperatures and adequate moisture.

Sources of information: See Lyons (1998) and Bossard and Chipping (2000); also applied inference.

Question 3.2 Distribution *Score:* **D** *Doc'n Level:* **Obs.**

Describe distribution: Present in three Arizona ecological types but less than or equal to 5% occurrence in each.

Rationale: Observations of *C. draba* collectively reported by Working Group members in grasslands, montane forest, and southwestern interior riparian based on observations in Grand Canyon ponderosa pine, Las Vegas Wash, and Petrified National Forest communities.

Sources of information: Observations by T. Olson (Wildlife Biologist. Bureau of Reclamation. Boulder City, Nevada, 2003), L. Makarick (Below the Rim Vegetation Program Manager, Grand Canyon National Park Science Center, Flagstaff, Arizona, 2003), and K. Thomas (Vegetation Ecologist, U.S. Geological Survey, Southwest Biological Science Center, Flagstaff, Arizona, 2003).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ **Yes**]	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	[✓ **Yes**]	**No**	**2 pt.**
Populations of this species produce seeds every year.	**Yes**	[✓ **No**]	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**Yes**	[✓ **No**]	**1 pt.**
Seeds remain viable in soil for three or more years	[✓ **Yes**]	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	[✓ **Yes**]	**No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	[✓ **Yes**]	**No**	**1 pt.**
Fragments easily and fragments can become established elsewhere	[✓ **Yes**]	**No**	**2 pt.**
Resprouts readily when cut, grazed, or burned	**Yes**	[✓ **No**]	**1 pt.**

Total pts: 9 Total unknowns: 0

Score : A

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	**D**
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	**D**
	montane riparian	
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Cardaria chalapensis* (L.) Hand.-Maz.; *Cardaria draba* (L.) Desv.; *Cardaria pubescens* (C.A. Mey.) Jarmolenko (USDA 2005)
Synonyms:	*Cardaria chalapensis: Cardaria draba* (L.) Desv. ssp. *chalapensis* (L.) O.E. Schulz, *Cardaria draba* (L.) Desv. var. *repens* (Schrenk) O.E. Schulz, *Cardaria repens* (Schrenk) Jarmolenko, *Lepidium repens* (Schrenk) Boiss.; *Cardaria draba: Lepidium draba* L.; *Cardaria pubescens*: *Cardaria pubescens* (C.A. Mey.) Jarmolenko var. *elongata* Rollins and *Hymenophysa pubescens* C.A. Mey. (USDA 2005)
Common names:	*Cardaria pubescens*: lenspod whitetop, lens podded hoary cress *Cardaria draba:* whitetop, globe-podded hoary cress *Cardaria pubescens*: hairy whitetop
Evaluation date (mm/dd/yy)**:**	08/11/03
Evaluator #1 Name/Title:	Kate Watters Biotech (Plants)
Affiliation:	CPCESU/GRCA
Phone numbers:	(928) 523–8518
Email address:	kw6@dana.ucc.nau.edu
Address:	P.O. Box 5765, Flagstaff, Arizona 86011–5765
Evaluator #2 Name/Title:	
Affiliation:	
Phone numbers:	
Email address:	
Address:	

List committee members:	10/23/03: W. Albrecht, W. Austin, D. Backer, J. Crawford, K. Thomas, T. Olson, B. Phillips, T. Robb, K. Watters 12/17/03: W. Albrecht, W. Austin, D. Backer, J. Crawford, K. Darrow, B. Phillips, K. Watters 02/17/04: W. Albrecht, W. Austin, D. Backer, J. Crawford, L. Moser, F. Northam. T. Olson, B. Phillips, K. Watters
Committee review date:	10/23/03, 12/17/03, and 02/17/04
List date:	12/17/03; revised 02/17/04
Re-evaluation date(s):	

Taxonomic Comment

A 1933 study by Bellue showed that *Cardaria draba*, known to North America, consisted of three European and Asian species: *C. chalapensis*, *C. draba, and C. pubescens* (Lyons, 1998). Although at times one or more of the preceding have been treated as subspecies, we follow the treatment of USDA (2005) that treats each taxon as a separate species. Based on herbarium records and personal communications with A. Salywon (Research Geneticist, U.S. Department of Agriculture, Agricultural Research Service, Water Conservation Laboratory, Phoenix, Arizona, 2005) all three taxa were determined to occur within Arizona wildlands. *Cardaria chalapensis, C. draba, and C. pubescens* are evaluated together here as they are genetically and morphologically similar, as well as have comparable ranges and habitat affinities (Bossard and Chipping 2000, Baldwin et al. 2002). In addition, because of the similar appearance of these three species they are easily misidentified in the field, as they require fruit to be properly identified (taxonomic differentiation between *C. draba and C. chalapensis* is in the shape of fruit; *C. pubescens* is differentiated by hairy fruit).

Recent unpublished work by A. Salywon (Research Geneticist, U.S. Department of Agriculture, Agricultural Research Service, Water Conservation Laboratory, Phoenix, Arizona, personal communication, 2005) suggests that the above taxa should be placed in the genus *Lepidium*, in which *Cardaria chalapensis* equals *Lepidium draba* ssp. *chalapense*, *Cardaria draba* equals *Lepidium draba* ssp. *draba*, and *Cardaria pubescens* equals *Lepidium appelianum* Al-Shehbaz. Until this work has been appropriately reviewed and published we have chosen to stay with the taxonomic treatment of USDA (2005).

Table 2. Scores, Designations, and Documentation Levels

Question		**Score**	**Documentation Level**	**Section Scores**	**Overall Score & Designations**
1.1	Impact on abiotic ecosystem processes	**B**	Other published material	**“Impact”** **Section 1 Score:** **B**	**“Plant Score”** **Overall Score:** **Medium** **Alert Status:** **Alert**
1.2	Impact on plant community	**A**	Other published material		
1.3	Impact on higher trophic levels	**B**	Other published material		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Other published material	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **14 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Observational		
2.3	Recent trend in total area infested within state	**C**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**A**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Reviewed scientific publication		
2.7	Other regions invaded	**C**	Other published material		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**B**	Observational	**“Distribution”** **Section 3 Score:** **C**	
3.2	Distribution	**D**	Observational		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **B** *Doc'n Level:* **Other pub.**
Identify ecosystem processes impacted: Reduction of soil water table, and light availability diminish ability of native species to reproduce.
Rationale: All species of *Cardaria* have extensive systems of persistent, deep, vertical and horizontal roots that penetrate the soil to depths of 2 m or more (CDFA 2003). All three *Cardaria* species are strong competitors for moisture, which puts native communities at a disadvantage (Bossard and Chipping 2000).
Sources of information: See cited literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **A** *Doc'n Level:* **Other pub.**
Identify type of impact or alteration: *Cardaria draba* forms dense patches and reduces native species populations.
Rationale: *Cardaria draba* establishes monospecific mats that exclude most vegetation. *Cardaria chalapensis* forms dense infestations in meadows and fields that outcompete forage plants for wildlife in California (Bossard and Chipping 2000). At Nature Conservancy preserves in Northern Idaho and at the Yampa River in Colorado, *C. draba* is reported as a moderate threat to biodiversity and infestations are currently 1% of all vulnerable habitat infested (Hill 1995, Williams 1995). Mycorrhizal associations do not develop with any of the three species of *Cardaria*, which may alter the trophic relationships in the soil (Lyons 1998) Patches in Yavapai County create a monoculture where occlusion of native species is likely (J. Schalau, personal communication, 2003). On Audubon Appleton-Whittell Research Ranch (ARR), *C. draba* was found in the spring of 2000, in a disturbed area at the intersection of a road and wash through a sacaton grassland. L. Kennedy reports from monitoring the population, that there is no indication that the *C. draba* displaced any native vegetation, but it seems likely that it could, over time. Of similar habitat on ARR, *C. draba* currently covers less than 1% (L. Kennedy, personal communication, 2003).
Sources of information: See cited literature; also considered personal communications with J. Schalau (Assistant Agent, Agriculture and Natural Resources, University of Arizona Cooperative Extension, Yavapai County, 2003) and L. Kennedy (Assistant Director, Audubon Appleton-Whittell Research Ranch, Elgin, Arizona, 2003). In addition, see Sheley and Stivers (2000).

Question 1.3 Impact on higher trophic levels *Score:* **B** *Doc'n Level:* **Other pub.**
Identify type of impact or alteration: Moderate reduction in foraging sites for native animals. *Cardaria chalapensis* is toxic to stock-unknown if toxic to foraging ungulates. Positive impact-plants provide nectar for honeybees (Sheley and Stivers 2000).
Rationale: *Cardaria draba* displaces valuable rangeland forage species (Lyons 1998), and *C.chalapensis* forms dense infestations that crowd out forage plants in meadows and fields. By displacing native vegetation utilized by wildlife, both species demonstrate the ability to impact native fauna negatively (Bossard and Chipping 2000). *Cardaria chalapensis* contains glucosnolates, which are toxic to stock and could have the same reaction to native ungulates (Sheley and Stivers 2000).
Sources of information: See cited literature.

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub.**
Identify impacts: No known hybridization between native plants of same genus.
Rationale: No known native species of *Cardaria* exists in the state. (Kearney and Peebles 1960). Plants identified as *C. draba* var. *repens* are apparent hybrids with *C. chalapensis* (Baldwin et al. 2002). According to A. Salywon (personal communication, 2003), species of *Cardaria* have been shown using molecular data to belong in *Lepidium* (most *Cardaria* were originally described as species of *Lepidium*).

Apparently, however, no hybridization occurs between them and the native species of *Lepidium*, though hybridization between the native species of *Lepidium* is common.

Sources of information: See cited literature; also considered personal communication with A. Salywon, (Research Geneticist, U.S. Department of Agriculture, Agricultural Research Service, Water Conservation Laboratory, Phoenix, Arizona, 2003).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Both species readily establish in disturbed areas in range and wildland areas.

Rationale: Cultivation in agricultural fields aids in dispersal as farm machinery can spread plants by dispersing root fragments. Invasion potential is greater under heavily grazed conditions or other disturbances. Irrigation causes increases in population (CDFA 2003). These species grow in a variety of habitats, but they thrive in disturbed or irrigated areas. They are less of a problem in undisturbed settings (Lyons 1998). The Nature Conservancy reports types of disturbance that promote colonization and spread on preserves in Colorado, Idaho and Montana including grazing (Carr 1995), irrigation, and cultivation (O'Brien and O'Brien 1994). In Las Vegas Wash in Nevada, natural disturbance creates new populations (T. Olson, personal communication, 2003)

Sources of information: See cited literature; also considered observations by T. Olson (Wildlife Biologist, Bureau of Reclamation, Boulder City, Nevada, 2003).

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Obs.**

Describe rate of spread: Increases, but less rapidly.

Rationale: In Saskatchewan, Canada in one year, a single plant on open ground without competition can spread vegetatively to cover an area to 3.7 m in diameter and can produce up to 455 shoots (CDFA 2003). Also, infestations of both species contracted when in competition with other species (particularly perennials) and when not irrigated. In Grand Canyon National Park, two populations totaling 280 m^2 have increased slightly, even with management (Rodeo herbicide application) (L. Johnson, personal communication, 2003). Prescott populations are small and isolated monocultures. In Camp Verde the populations are on agricultural land and cultural practices may be increasing their spread (J. Schalau, personal communication, 2003). At Audubon Appleton-Whittell Research Ranch plants were treated early in the spring (2001). The next year, 2002, the infestation had spread at least 1/4 mile downstream in the wash and in the open spaces between the sacaton near the wash, apparently from seed (L. Kennedy, personal communication, 2003).

Sources of information: See cited literature; also considered personal communications with L. Johnson (Ecologist, U.S. Department of Agriculture, Forest Service, Kaibab National Forest, 2003), L. Kennedy (Assistant Director, Audubon Appleton-Whittell Research Ranch, Elgin, Arizona, 2003), and J. Schalau (Assistant Agent, Agriculture and Natural Resources, University of Arizona Cooperative Extension, Yavapai County, 2003) and Southwest Exotic Plant Management Program (SWEMP) records for Grand Canyon National Park 2001 to 2003 (available online at: http://www.usgs.nau.edu/swepic/swemp/maps.html).

Question 2.3 Recent trend in total area infested within state *Score:* **C** *Doc'n Level:* **Obs.**

Describe trend: Stable.

Rationale: CAIN/CRISIS Map records three occurrences of *C. draba*: one in Yavapai, one in Coconino, and one in Mohave County. Parker (1972) reported *C. draba* on ranches in the Springerville-Eager area in Apache County to Peeples Valley in Yavapai County and northward to Fredonia in Coconino County. Populations at Grand Canyon National Park remained relatively stable with Rodeo herbicide treatment. Cultural practices may be increasing populations somewhat in Yavapai County (J. Schalau, personal

communication, 2003). In 1972 *C. pubescens* was unknown in Arizona (Parker 1972). Its current distribution in the state seems quite limited (A. Salywon, personal communication, 2003). *Cardaria chalapensis* is distributed in southern and central counties of UT, but similar to *C. pubescens* seems to have limited distribution in Arizona (A. Salywon, personal communication, 2003).

Sources of information: See cited literature; also considered CAIN/CRISIS Map (available online at: http://cain.nbii.gov/cgibin/mapserv?map=../html/cain/crisis/crisismaps/crisis.map&mode=browse&layer=state&layer=county), Southwest Exotic Plant Management Program (SWEMP) records for Grand Canyon National Park 2001 to 2003 (available online at: http://www.usgs.nau.edu/swepic/swemp/maps.html), and personal communications from A. Salywon (Research Geneticist, U.S. Department of Agriculture, Agricultural Research Service, Water Conservation Laboratory, Phoenix, Arizona, 2005) and J. Schalau (Assistant Agent, Agriculture and Natural Resources, University of Arizona Cooperative Extension, Yavapai County, 2003).

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: Plants reproduce from seeds and underground rhizome/root fragments.

Rationale: *Cardaria draba* plants can produce 1,500 to 4,800 seeds in a year with 85% viability and can produce 455 shoots. *Cardaria pubescens* plants produce 30 to 560 (average 300) pods per plant.

Sources of information: See CDFA (2003).

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Seeds are dispersed by water, vehicles, farm machinery, and contaminated hay and crop seeds. Grazing activities can cause *C. draba* populations to invade an area.

Rationale: *Cardaria* spp. are agricultural weeds that can be transported via humans, as root fragments transported by farm machinery can potentially reestablish in new areas (CDFA 2003). *Cardaria draba* population germination rates were greatest in areas of soil disturbance (Larson et al. 2000)

Sources of information: See cited literature.

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Identify dispersal mechanisms: Dispersal of root fragments through flooding events.

Rationale: *Cardaria* spp. reproduce vegetatively from rhizomatous systems and less importantly by seed (Lyons 1998). Severed root segments only 1.3 cm long can regenerate into new plants if they are left within approximately 7 to 10 cm or the soil surface (Scurfield 1962). All three species are found to be a problem in moist environments, including drainage ditches like Las Vegas Wash, where the potential for long-distance dispersal via flooding events is possible (T. Olson, personal communication, 2003). In Camp Verde, populations are on agricultural lands and cultural practices may be increasing their spread. These lands are also adjacent to the Verde River adding to the potential for increased spread (J. Schalau, personal communication, 2003). On Audubon Appleton-Whittell Research Ranch, *C. draba* was found in the spring of 2000, in a disturbed area at the intersection of a road and wash through a sacaton grassland. Total area of coverage was approximately 20 m x 40 m. It's likely that seed or rhizomes were introduced via gravel used to surface the road. The entire spread of *C. draba* is downstream of this point (L. Kennedy, personal communication, 2003). The dispersal that L. Kennedy reports at the Audubon Appleton-Whittell Research Ranch is due to seeds in addition to root fragments, but this is based on the observation that the spread is within the arroyo (wash) where root fragments are likely to be created and carried, but also on the floodplain terrace where overland flow is less dramatic and root fragmentation is less likely. This dispersal mechanism could potentially be a severe problem if there were two wet winters in a row. The first to produce a good crop of seed and the second to allow the seed to germinate and establish (L. Kennedy, personal communication, 2003).

Sources of information: See cited literature; also considered observations by L. Kennedy (Assistant Director, Audubon Appleton-Whittell Research Ranch, Elgin, Arizona, 2003), T. Olson (Wildlife

Biologist, Bureau of Reclamation, Boulder City, Nevada, 2003), and J. Schalau (Assistant Agent, Agriculture and Natural Resources, University of Arizona Cooperative Extension, Yavapai County, 2003).

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Other pub.**

Identify other regions: Invades elsewhere but only in ecological types that it has already invaded in the state.

Rationale: In California *C. draba* is frequent in Sacramento Valley, San Francisco Bay, and South Coast regions to 3850 feet. *Cardaria pubescens* is frequent in the Sacramento Valley, South Coast region, and Great Basin to 6560 feet. In Wyoming *C. draba* invades riparian meadows (Studenmund 1995). In Colorado at the Yampa River Preserve, *C. draba* invades open grasslands of non-native species (Williams 1995). In Idaho it is reported from willow/rose riparian edge. In Utah *C. draba* has a distribution throughout the central northwestern part of the state with an elevation range from 1,330 to 2,670 meters.

Sources of information: See cited literature; also see O'Brien and O'Brien (1994), Hill (1995), CDFA (2003), and the Vascular Plant Atlas of Utah (available online at: http://www.gis.usu.edu/Geography-Department/utgeog/utvatlas, September 2003).

Question 3.1 Ecological amplitude *Score:* **B** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Introduced from central Europe and western Asia, specifically Georgia, Syria, Iraq, Iran, and Armenia. Introduction date to Arizona is unknown. Present in three Arizona ecological types.

Rationale: *Cardaria draba* is found in the west from Colorado to Wyoming to California and also on the east coast. First collected in 1876. *Cardaria pubescens* probably arrived from infested alfalfa seed from Turkestan and was first collected in North America in 1919. This species is more common in the northwestern USA with few occurrences in the mid-west. Ecological types invaded may indicate distribution is limited by excessive temperatures and adequate moisture.

Sources of information: See Lyons (1998) and Bossard and Chipping (2000); also applied inference.

Question 3.2 Distribution *Score:* **D** *Doc'n Level:* **Obs.**

Describe distribution: Present in three Arizona ecological types but less than or equal to 5% occurrence in each.

Rationale: Observations of *C. draba* collectively reported by Working Group members in grasslands, montane forest, and southwestern interior riparian based on observations in Grand Canyon ponderosa pine, Las Vegas Wash, and Petrified National Forest communities.

Sources of information: Observations by T. Olson (Wildlife Biologist. Bureau of Reclamation. Boulder City, Nevada, 2003), L. Makarick (Below the Rim Vegetation Program Manager, Grand Canyon National Park Science Center, Flagstaff, Arizona, 2003), and K. Thomas (Vegetation Ecologist, U.S. Geological Survey, Southwest Biological Science Center, Flagstaff, Arizona, 2003).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**[✓ Yes]**	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**[✓ Yes]**	**No**	**2 pt.**
Populations of this species produce seeds every year.	**Yes**	**[✓ No]**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**Yes**	**[✓ No]**	**1 pt.**
Seeds remain viable in soil for three or more years	**[✓ Yes]**	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**[✓ Yes]**	**No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**[✓ Yes]**	**No**	**1 pt.**
Fragments easily and fragments can become established elsewhere	**[✓ Yes]**	**No**	**2 pt.**
Resprouts readily when cut, grazed, or burned	**Yes**	**[✓ No]**	**1 pt.**

Total pts: 9 Total unknowns: 0

Score : A

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	**D**
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	**D**
	montane riparian	
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

Literature Cited

Baldwin, B.G., S. Boyd, B.J. Ertter, R.W. Patterson, T.J. Rosatti, and D.H. Wilken (eds.). 2002. The Jepson Desert Manual: Vascular Plants of Southeastern California. University of California Press, Berkeley.

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Carduus nutans* L. (USDA 2005)
Synonyms:	None listed in USDA (2005).
Common names:	Musk thistle, nodding thistle, nodding plumeless thistle, plumeless thistle, chardon penche
Evaluation date (mm/dd/yy)**:**	10/12/03
Evaluator #1 Name/Title:	Dana Backer, Conservation Ecologist
Affiliation:	The Nature Conservancy
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Evaluator #2 Name/Title:	
Affiliation:	
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Address:	

List committee members:	12/17/03: W. Albrecht, W. Austin, D. Backer, J. Crawford, K. Darrow, B. Phillips, K. Watters 02/17/04: W. Albrecht, W. Austin, D. Backer, J. Crawford, L. Moser, F. Northam, T. Olson, B. Phillips, K. Watters
Committee review date:	12/17/03 and 02/17/04
List date:	02/17/04
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**C**	Other published material	**“Impact”** **Section 1 Score:** **B**	**“Plant Score”** **Overall Score:** **Medium** **Alert Status:** **None**
1.2	Impact on plant community	**B**	Other published material		
1.3	Impact on higher trophic levels	**C**	Other published material		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Other published material	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **16 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**A**	Observational		
2.3	Recent trend in total area infested within state	**A**	Observational		
2.4	Innate reproductive potential	**A**	Reviewed scientific publication		
2.5	Potential for human-caused dispersal	**B**	Other published material		
2.6	Potential for natural long-distance dispersal	**C**	Other published material		
2.7	Other regions invaded	**B**	Other published material		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**A**	Observational	**“Distribution”** **Section 3 Score:** **B**	
3.2	Distribution	**D**	Observational		

Table 3. Documentation

Note: Carduus *nutans and C. acanthoides* are often sympathric and readily hybridize (Desrochers et al. 1988, Warwick et al. 1989, Warwick and Thompson 1989, Thompson and Black 1992). Although it is not a regulated plant in Arizona, *Carduus nutans* is listed as a noxious, restricted, or prohibited weed in 24 states including all of the states surrounding Arizona (USDA 2005). *Carduus acanthoides* is listed as a noxious weed in Arizona but is not known to occur in the state (USDA 2005). Most of the studies involving *C. nutans* are in relation to effects on pasture species.

Question 1.1 Impact on abiotic ecosystem processes *Score:* **C** *Doc'n Level:* **Other pub.**

Identify ecosystem processes impacted: Minor alteration. Inhibits nitrogen fixation.

Rationale: Although invasive species are often assumed to be associated with soil nitrogen build-up, Wardle et al. (1993 in Zouhar 2002) suggested that some invasive species, such as *C. nutans,* have the potential to induce long-term decline of soil nitrogen input.

Sources of information: See cited literature. Because primary/original literature was not reviewed, the category of other published material is used.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **B** *Doc'n Level:* **Other pub**.

Identify type of impact or alteration: Plant composition and interactions.

Rationale: Capable of forming dense stands (noted in Canada [150,000/ha], Nebraska, and Australia), especially in highly disturbed sites where competition is low or in overgrazed or disturbed pasturelands (Beck 1999, Zouhar 2002) and rangelands (Desrochers et al. 1988, Zouhar 2002). Medd and Lovett (1978 in Zouhar 2002) suggested *C. nutans* may be sensitive to competition with neighboring plants for light. *Carduus nutans* does not tolerate interspecific competition (Nebraska: McCarty and Scifres 1969 and Australia: Austin et al. 1985; both in Zouhar 2002). In Nebraska, McCarty and Scifres (1969 in Zouhar 2002) observed that *C. nutans* plants growing with competition suffered more mortality than those with no competition. One study suggested *C. nutans* litter may encourage germination of *C. nutans* seeds (Wardle et al. 1993 in Zouhar 2002).

"It is proposed that nodding [musk] thistle is allelopathic at two phases of its development, i.e. at the early bolting stage when the larger rosette leaves are decomposing and releasing soluble inhibitors, and at the stage when bolting plants are drying and releasing insoluble inhibitors. Nodding [musk] thistle seedlings appear to be stimulated by addition of thistle tissues to soil, indicating that thistle plants may weaken pasture and simultaneously encourage recruitment of its own species "(Wardle et al 1993 in Zouhar 2002).

Abundant soil nitrogen may favor *C. nutans* (Medd and Lovett 1978 in Beck 1999), as will adequate moisture and sunlight (Feldman et al. 1968 and Doing et al. 1969 in Beck 1999). The *Rhinocyllus conicus* (seed head weevil) introduced in Utah as a biocontrol for *C. nutans* is known to host on native thistles (R. Lee, personal communication, 2004). The presence of *R. concicus* and the level of predation on native Arizona thistles is not known. Other biocontrol agents have been released in other states and their impact on native Arizona thistles is also not known.

Sources of information: See cited literature. Because primary/original literature was not reviewed, the category of other published material is used. Also considered a personal communication with R. Lee (Weed Specialist, Bureau of Land Management, Denver, Colorado, 2004).

Question 1.3 Impact on higher trophic levels *Score:* **C** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Negligible. Impacts cited in primary literature are on livestock.

Rationale: Foliage is unpalatable to wildlife and livestock, selective grazing leads to severe degradation of native meadows and grasslands as wildlife focus their foraging on native plants (from Tennessee:

Remaley 2003). *Carduus nutans* is a problem on range and pastures because it competes with desirable forage, and its sharp spines can hinder movement and deter livestock, and ***presumably wildlife***, from grazing (several authors in Zouhar 2002, Beck 1999). Domestic livestock have been observed consuming flowers and seed heads but do not know the resultant seed viability (Zouhar 2002). R. Lee suggests that the buds are eaten when they are immature and the seeds are not viable. Seeds of *C. nutans* that have passed through a cow's digestive system are still viable. In most cases, the reproductive structure (bud) of the thistle is eaten by livestock and wildlife when the seeds are not mature enough to be viable (R. Lee, personal communication, 2004).

A number of species of birds graze on mature *C. nutans* seed in Australia (positive effect: Popay and Medd 1990 in Zouhar 2002). Insect and bird foraging occurs on *C. nutans* in Colorado. R. Lee (personal communication, 2004) suggests that *C. nutans* seed that passes through a bird may be viable. As a result, birds may be a potential vector for long distance dispersal of *C. nutans* seed. Holm and others (1997 in Beck 1999) stated *C. nutans* seeds have been found in the crops of birds and in their nests. In dense stands of *C. nutans*, hunting of rodents by goshawks or other raptors would be impaired (anecdotal).

Sources of information: See cited literature; also considered personal communication with R. Lee (Weed Specialist, Bureau of Land Management, Denver, Colorado, 2004).

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub.**

Identify impacts: None.

Rationale: Hybridizes with other *Carduus* species but none of these are native to Arizona. Pollinators may favor non-native thistles over native thistles but no published information documents this.

Sources of information: Kearney and Peebles (1960) and Desrochers et al. (1988) and Warwick and Thompson (1989) (both in Zouchar 2002).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Can invade sites disturbed either naturally or anthropogenically. The disturbance of fire usually requires a seed source to be present in the soil for it to establish post fire.

Rationale: Spreads rapidly in areas subjected to frequent natural disturbance events (landslides, flooding [Southeast EPPC]). *Carduus nutans* is most often described as occurring on disturbed sites and waste areas and along roads (Zouhar 2002). Yet populations have occurred elsewhere, outside of heavily disturbed areas (personal observations by Working Group members and R. Lee and L. Walker).

Role of fire: if *C. nutans* seeds are present and competition is minimal, fire creates conditions that are favorable (i.e., open canopy, reduced competition, areas of bare soil) to the establishment of *C. nutans* (Zouhar 2002). Where there is competition either via post fire seeding or pre-existing native seeds in the seed bank, plant invasion by *C. nutans* has been limited (Floyd-Hanna et al. 1999 and Goodrich 1999 in Zouhar 2002).

Sources of information: See cited literature and information from the Southeast Exotic Pest Plant Council (EPPC; available on line at: http://www.se-eppc.org); also considered Working Group member observations and personal communications with R. Lee (Weed Specialist, Bureau of Land Management, Denver, Colorado, 2004) and L. Walker (Weed Specialist, Bureau of Land Management, Arizona Strip, St. George, Utah, 2004).

Question 2.2 Local rate of spread with no management *Score:* **A** *Doc'n Level:* **Obs**.

Describe rate of spread: Doubling in less than 10 years.

Rationale: Because *C. nutans* is listed in 24 states as a noxious, prohibited or restricted weed (USDA 2005) and thus has some level of enforcement/management to control it, it is unclear what the local rate of spread is with no management. Where it is most invasive (populations in Springerville, Eagar, and areas near St. Johns), it is spreading at a rate, which itself may be increasing, greater than 100% in less than 10 years (F. Northam, personal observations, 2003). Considered by land managers in northern Arizona as “can’t keep ahead of it” (Working Group discussions, December 2003).

Sources of information: Working Group discussions and personal observations by (F. Northam (Arizona Department of Agriculture Noxious Weed Coordinator, 2003).

Question 2.3 Recent trend in total area infested within state *Score:* **A** *Doc’n Level:* **Obs.**

Describe trend: Increasing rapidly, doubling in range in less than 10 years.

Rationale: *Carduus nutans* is relatively new to Arizona and has yet to realize its potential. Several suitable habitats in the Flagstaff, Prescott, and Payson areas have not yet been invaded. As a result, *C. nutans* is expected to expand the number of ecological types that it has invaded in Arizona.

A variety of mechanical, chemical and biological (several different types of weevils, fly, and rust) control mechanisms have been successful. Although biocontrols *Trichosirocalus horridus* and *Rhinocyllus concius* (weevils) have not been released in Arizona, it is possible that these biocontrol agents have spread into Arizona on their own from neighboring states where they have been released (Zouhar 2002; R. Lee and F. Northam, personal communications, 2003). Several researchers have assessed the effects of *R. conicus* on *C. nutans* seed production in different areas of the US and found decreases from 10 to 78% (Surles and Kok 1978 and McCarty and Lamp 1982 both in Beck 1999).

Sources of information: Based on Working Group discussions and personal communications with R. Lee (Weed Specialist, Bureau of Land Management, Denver, Colorado, 2004) and F. Northam (Arizona Department of Agriculture Noxious Weed Coordinator, 2003); also see cited literature.

Question 2.4 Innate reproductive potential *Score:* **A** *Doc’n Level:* **Rev. sci. pub.**

Describe key reproductive characteristics: High reproductive potential.

Rationale: Based on seed number, production, and viability; ability to self- and cross-fertilize. See Worksheet A.

Sources of information: See Worksheet A notes and cited literature therein.

Question 2.5 Potential for human-caused dispersal *Score:* **B** *Doc’n Level:* **Other pub.**

Identify dispersal mechanisms: Roadways; agricultural/livestock products; logging road and timber related vehicles; horse trails; irrigation ditches.

Rationale: Along roadsides; livestock and human activities; contaminated in crop seed and hay (Beck 1999, Rees et al. 1996 in Zouhar 2002).

Sources of information: See cited literature; also considered Working Group member observations.

Question 2.6 Potential for natural long-distance dispersal *Score:* **C** *Doc’n Level:* **Other pub.**

Identify dispersal mechanisms: Wind, water, and wildlife.

Rationale: Wind, water, wildlife, (livestock, and human) activities disperse *C. nutans* seed (Beck 1999). *Carduus nutans* seeds are attached to a pappus, but less than 5% of the seed remains attached to the pappus when it breaks off the flower head and floats away on wind currents (Beck 2003). Under controlled, windy conditions (up to 18.5 feet per second [5.6 m/s]), fewer than 1% of *C. nutans* seeds moved more than 330 feet (100 m), and most seeds were deposited within 160 feet (50 m) of the point of release (Smith and Kok 1984 in Zouhar 2002). Most seeds (99%) are dispersed within 50 m of the parent plant. Few seeds are deposited farther than 100 m (CDFA 2003) along travel and water corridors (Zouhar 2002). It is highly likely that seeds (sources of forage for birds and small rodents) are viable after consumed, based on viability after passing through other animal digestive systems (R. Lee, personal communication, 2003), and therefore have the potential for long distance dispersal. Holm and others (1997 in Beck 1999) stated *C. nutans* seeds have been found in the crops of birds and in their nests.

Sources of information: See cited literature; also considered personal communication with R. Lee (Weed Specialist, Bureau of Land Management, Denver, Colorado, 2004).

Question 2.7 Other regions invaded *Score:* **B** *Doc'n Level:* **Other pub.**

Identify other regions: Two other regions (Colorado and Utah) invaded that include ecological types not invaded in Arizona.

Rationale: Subalpine community invaded in the Rocky Mountains (Beck 1999). Mountain brush communities also invaded (Welsh et al. 1987) that are equivalent to Great Basin montane scrub.

Sources of information: See cited literature.

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Earliest record in Arizona's herbaria is 1952 Apache County, Ganado Dam (SEINet 2003). Introduced to North America during the period of 1853 to 1866 in Pennsylvania (Stuckey and Forsythe 1971 in Heidel 1987). Native to western and central Europe; restricted to temperate zones (Zouhar 2002).

Rationale: Grows from sea level to about 2400 m (~8000 feet) in elevation and can survive with annual rainfall of 25 cm (Hull and Evans 1973 in Desrochers et al. 1988, Beck 1999). Beck (1999) states *C. nutans* has been found at elevations between 2743 to 3048 m (9000 and 10,000 feet). Its wide geographic range suggests there is not a specific climatic requirement (Desrochers et al. 1988). Invades open natural areas, such as meadows, grasslands (Moore and Frankton 1974 and Harris 1984 both in Desrochers et al. 1988). In the intermountain region of western North America, it occupies habitats ranging from saline soils to low altitude valleys to acidic soils at 8000 feet (Beck 1999). Most often associated with soils derived from limestone (Stuckey and Forsythe 1971, Batra 1978 in Heidel 1987); however, in the Great Basin and West this relationship does not necessarily hold true (Batra 1978 in Heidel 1987).

Although plants are hardier where there is little competition, *C. nutans* also can grow in native and seeded ranges, irrigated pastures, and wet meadows with dense stands of graminoids (Hull and Evans 1973 in Zouhar 2002). Distribution of *C. nutans* is restricted mainly by extremes in soil water content, nutrient deficient or acid soils, and competition from other plant species (Australia: Doing and others 1969 in Desrochers et al. 1988). Several authors (see citations in Desrochers et al. 1988) report a minimal vernalization requirement for *C. nutans* of at least 40 days below 10 degrees C (50 F), which perhaps excludes it from dunes and the Mohave Desert.

Sources of information: See cited literature. Also considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed 2003).

Question 3.2 Distribution *Score:* **D** *Doc'n Level:* **Obs.**

Describe distribution: Morman Lake, Lake Mary (western Arizona extent); Coconino National Forest (in ponderosa pine); Springerville (concentrated there in mainly irrigated pastures); Eagar, St. Johns, Little Colorado River (in prairie remnants/meadows); Navajo Reservation, near Ganado (in pinyon-juniper); and coming in through drainages and valleys from New Mexico; Chinile (D. Evans, personal communication, 2003). Montane riparian along the Little Colorado River (ottonwood, willow, herbaceous), shortgrass prairie, ponderosa pine, montane grasslands; populations on the Apache Sitgreaves are all associated with roads (M. White, personal communication, 2004). On the Arizona strip, occurs on Forest Service but not Bureau of Land Management land (L. Walker, personal communication, 2004).

Rationale: By 1999 *C. nutans* was reported to occur in 45 states in the U.S. and all southern Canadian provinces (Kartesz 1999). Previous infestations in Mojave Desert (southeastern San Bernardino County) have been eradicated (CDFA 2003). Despite a fairly broad ecological amplitude, *C. nutans* does not exceed 5% frequency of occurrence within any ecological type that it invades (see Worksheet B).

Sources of information: See cited literature; also considered personal communications with D. Evans (Range Specialist, U.S. Department of Agriculture, Forest Service, Prescott National Forest, 2003), L. Walker (Weed Specialist, Bureau of Land Management. Arizona Strip, St. George, Utah, 2004), and M. White (Rangeland Ecologist, U.S. Department of Agriculture, Forest Service, Apache Site-Greaves National Forest, Springerville, Arizona, 2004), and Working Group member discussions. In addition, considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed 2003) and Southwest Exotic Plant Mapping Program (SWEMP) records (http://www.usgs.nau.edu/SWEPIC/) to assist in distribution assessment.

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ Yes]	No	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	[✓ Yes]	No	**2 pt.**
Populations of this species produce seeds every year.	[✓ Yes]	No	**1 pt.**
Seed production sustained for 3 or more months within a population annually	[✓ Yes]	No	**1 pt.**
Seeds remain viable in soil for three or more years	[✓ Yes]	No	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	[✓ Yes]	No	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	Yes	[✓ No]	**1 pt.**
Fragments easily and fragments can become established elsewhere	Yes	[✓ No]	**2 pt.**
Resprouts readily when cut, grazed, or burned	Yes	[✓ No]	**1 pt.**

Total pts: 8 Total unknowns: 0

Score : A

Note any related traits: *Carduus nutans* is an herbaceous biennial or occasionally winter annual or annual (Feldman et al. 1968 in Beck 1999). An average plant produces approximately 10,000 to 11,000 seeds/plant (McCarty and Scrifres 1969 [cited in many different sources], McCarty 1982); however, only 1/3 of the seeds are viable (McCarty 1982). Holm and others (1997 in Beck 1999) report seed production per plant to range from a few thousand to more than 100,000. Sindel 1991 (in Zouhar 2002) reported *C. nutans* can produce flowers and seeds throughout the growing season if soil moisture levels are adequate. Noted elsewhere, the growing season for *C. nutans* is May to September depending on location, habitat, and environmental conditions (various authors), but in New Mexico flowering occurs July to August (Martin and Hutchins 1981 in Zouhar 2002). Flowers over a 7 to 9 week period (Beck 2003). Seed can remain viable for over 10 years (Burnside et al. 1981 in Heidel 1987, Beck 1999, Desrochers et al. 1988).

Root crown needs to have high severity fire to kill *C. nutans*; if only scared, they can bolt and bloom (observed in Nebraska; reviewed by Heidel 1987). Fire has been used as a control mechanism (see Zouhar 2002). Seed production and seedling establishment are enhanced under distrubed conditions (Beck 1999). Can out-cross and self pollinate (McCarty 1982, Popay and Medd 1990, and Beck 1999 all in Zouhar 2002). Seeds germinate at high rates in soil cracks or rough microtopographies with reduced evaporation (Zouhar 2002).

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	**D**
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	**D**
	plains and Great Basin shrub-grassland	**D**
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	**D**
	montane riparian	**D**
Woodlands	Great Basin conifer woodland	**D**
	Madrean evergreen woodland	**D**
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

Elevation ranges below provided in the Fire Effects Information System (available online at: http:///fs.fed.us/database/feis/plants). Arizona and specific plant communities are not listed.

Location	Elevation Range	Reference
California	330 to 3,960 feet (100 to 1,200 m)	Hickman (1993)
Colorado	9,000 to 10,000 feet (2,700 to 3,000 m)	Holm et al. (1997) in Beck (1999)
New Mexico	4,500 to 8,500 feet (1,400 to 2,600 m)	Martin and Hutchins (1981)
Utah	4,400 to 8,100 feet (1,340 to 2,440 m)	Welsh et al. (1999)

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Centaurea biebersteinii* DC. (USDA 2005)
Synonyms:	*Acosta maculosa* auct. non Holub, *Centaurea maculosa* auct. non Lam. (USDA 2005)
Common names:	Spotted knapweed
Evaluation date (mm/dd/yy)**:**	04/23/04
Evaluator #1 Name/Title:	Kate Watters, Graduate student
Affiliation:	Northern Arizona University
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List committee members:	W. Albrecht, W. Austin, D. Backer, J. Hall, L. Moser, F. Northam, B. Phillips, J. Schalau, K. Watters
Committee review date:	08/06/04
List date:	08/06/04
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**B**	Other published material	**“Impact”** **Section 1 Score:** **B**	**“Plant Score”** **Overall Score:** **Medium** **Alert Status:** **None**
1.2	Impact on plant community	**A**	Other published material		
1.3	Impact on higher trophic levels	**B**	Reviewed scientific publication		
1.4	Impact on genetic integrity	**C**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**A**	Other published material	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **16 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Observational		
2.3	Recent trend in total area infested within state	**B**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**B**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Reviewed scientific publication		
2.7	Other regions invaded	**B**	Other published material		RED FLAG **YES** Something you should know.
3.1	Ecological amplitude	**A**	Observational	**“Distribution”** **Section 3 Score:** **B**	
3.2	Distribution	**D**	Observational		

Red Flag Annotation

Centaurea biebersteinii likely has not yet reached its full invasive potential in Arizona. Its ecological impacts and reproductive capacity are well documented in other states, especially in Montana. *Centaurea biebersteinii* has great potential to increase its abundance and areal extent in Arizona on sites that are subjected to fire suppression, mechanical fuel treatment (that is, thinning), or timber harvest activities on public lands.

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **B** *Doc'n Level:* **Other pub.**

Identify ecosystem processes impacted: Spotted knapweed can alter fire regimes where populations are dense in ponderosa pine forest community types. Spotted knapweed infestations have been associated with increases in bare ground, surface water runoff, and stream sedimentation rates.

Rationale: Spotted knapweed occurs primarily in bunchgrass and open ponderosa pine forest community types in the Intermountain West, especially Montana. The historical fire regimes of these communities were relatively frequent, low-severity surface fires. Spotted knapweed did not occur in these communities at the time in which these fire regimes were functioning, but has established since fire exclusion began. It is unclear how this type of fire regime might affect spotted knapweed populations. It is also unclear how the presence of spotted knapweed might affect these fire regimes, though it has been observed that spotted knapweed does not carry ground fire as readily as grasses. Therefore, dense knapweed infestations can alter the fire regime by changing the fuel characteristics and thus reducing the fire return interval at a given site (Xanthopoulous 1988, J. McGowan-Stinski, personal communication in Zouhar 2001). Dense populations of spotted knapweed have influenced increased bare ground, surface water runoff and stream sedimentation rates. In a Montana study runoff and sediment yield in plots dominated by spotted knapweed were 56% and 192% higher respectively as compared to bunchgrass vegetation types (Lacey et al. 1989).

Sources of information: See cited literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **A** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Spotted knapweed infestations reduce plant species richness and diversity, as well as pose serious impacts on foothill grasslands and a rare plant species in Montana. Spotted knapweed has developed many ways to outcompete native plants including production of chemical allelopathy, and root colonization by mycorrhizal fungi allowing greater resource uptake.

Rationale: Spotted knapweed is considered a serious threat to rangelands in Montana, Washington, Idaho, Oregon, Wyoming, and British Columbia. In Montana, the primary habitat for spotted knapweed are the foothill grasslands in western Montana and Bedunah (1992) speculated that because of spotted knapweed invasions, this grassland is becoming an endangered vegetation type. In studies by Tyser and associates that measured spotted knapweed populations in roadside areas and adjoining grasslands in Glacier National Park, spotted knapweed infestations were found to reduce plant species richness and diversity (Tyser 1990, Tyser and Key 1988) and cryptogam cover (Tyser 1992) and increase the amount of bare ground (Tyser and Key 1988). Lesica and Shelly (1996) also found that spotted knapweed reduced seed germination and seedling establishment of a rare Montana endemic forb, Mt. Sapphire rockcress (*Arabis fecunda*).

Chemical allelopathy of spotted and diffuse knapweeds has been charged with negatively impacting other herbaceous species. However, cnicin concentrations in soil tests are lower than those found to be toxic in in-vitro experiments. So in determining the ecological success of spotted knapweed allelopathy is not considered as important as resource competition. Allelopathic activity of cnicin may be enhanced, however, when large quantities of stem and leaf tissue from live or dead spotted knapweed plants come in direct contact with the soil surface, as when plants are trampled or mowed and the effects of grazed lands infested with knapweed and cnicin levels has not been explored. More recent experimental evidence suggests that knapweed's advantage over its North American neighbors could be attributed to differences in the effects of its root exudates and how they, in turn, affect competition for resources, thus linking allelopathy and resource competition (Locken and Kelsey 1987).

Experimental evidence suggests that spotted knapweed gains dominance in part by its ability to out-compete native grasses for nutrients such as nitrogen and phosphorus (Harvey and Nowierski 1989).

Other evidence suggests that the competitive advantage shifts from spotted knapweed to native plants such as bluebunch wheatgrass as succession proceeds and nutrients become less available (Krueger *et al* 2001). Spotted knapweed has the ability to rapidly develop a fine and deep penetrating root system that is colonized by arbuscular mycorrhizal fungi, which may contribute to its competitive dominance over native grasses by allowing for greater resource acquisition (Marler et al. 1999a, b).

Fertilization in spotted knapweed requires cross-pollination between flowers on different plants (obligately xenogamous). This can limit the reproductive success of isolated individuals, but it also promotes genetic diversity, and may thereby improve competitive ability (Harrod and Taylor 1995).

Sources of information: See cited literature.

Question 1.3 Impact on higher trophic levels *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Identify type of impact or alteration: Spotted knapweed infestations have been associated with reductions in forage production and wildlife habitat; however, there have been some examples where spotted knapweed is important forage, seed and nectar source for some species.

Rationale: Large reductions in available forage and wildlife in Montana use have been reported on knapweed-infested range (Bedunah and Carpenter 1989). Large-scale infestations of spotted knapweed can impede access to more desirable forage for livestock and wildlife, especially when the presence of old, dried knapweed stems creates a dense and spiny overstory (Watson and Renney 1974). Reports of forage losses for elk vary, and probably do not consider the possibility of elk using spotted knapweed as forage. Reports on wildlife use of spotted knapweed are also varied. Bedunah (1992) cites several studies suggesting large potential losses of elk range to spotted knapweed, though he indicates that quantifying the effects of infestation on elk populations is complicated by their mobility. A spotted knapweed infestation is considered more detrimental to elk than to deer because spotted knapweed replaces grasses that are preferred by elk, while deer have a diet of predominantly shrubs and conifers that spotted knapweed does not replace (Lavelle 1986). Elk use increased following removal of spotted knapweed with herbicides on sites in Montana (Rice 2000).

The importance of spotted knapweed to livestock and wildlife depends upon the size and density of the infestation, the availability of other forage plants, and the season. Spotted knapweed was preferred by deer and elk over other plant species on sites with dense knapweed cover. It was suggested that deer and elk did not frequently use the spotted knapweed sites in this study because cervid densities were relatively low and other forage was available. The authors suggest that when estimating carrying capacity of a cervid range, spotted knapweed can be considered a potential food source, because when animal densities are high and food choices are limited, elk and deer will consume spotted knapweed (Wright and Kelsey 1997).

Flowers are pollinated by insects, and spotted knapweed is heavily visited by several species of bees. Rodent utilization of spotted knapweed seed has been suggested (Watson and Renney 1974). Spotted knapweed is a nectar source for the endangered Karner blue butterfly in Wisconsin (Haack 1993).

Sources of information: See cited literature; also see Zouhar (2001).

Question 1.4 Impact on genetic integrity *Score:* **C** *Doc'n Level:* **Other pub.**

Identify impacts: It is unknown whether hybridization occurs.

Rationale: Hybridization readily occurs between *Centaurea* species. However, it is unknown whether hybridization could occur between non-native and native species in Arizona. *Centaurea rothrockii* occurs in the Chirichauas and Huachuca Mountains and it is unknown at this time whether *C. biebersteinii* even exists in the same area, and if present, would hybridize with our native species.

Sources of information: See Kearney and Peebles (1960); also considered personal communication with R. Scott (Professor, Northern Arizona University, Biological Sciences, Flagstaff, Arizona).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **A** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Spotted knapweed infestations are associated and increase with disturbance, especially logging, yet it also is capable of invading undisturbed wilderness sites.

Rationale: Spotted knapweed not only readily occupies disturbed sites, but it also invades relatively undisturbed perennial native plant communities in the northern Intermountain region (Lacey et al. 1989, Tyser and Worley 1992, DiTomaso 2000), and it invades wilderness areas all over Montana (Kummerow 1992). In Glacier National Park, spotted knapweed colonized undisturbed rough fescue grasslands adjacent to roadside spotted knapweed infestations. Spotted knapweed establishes and dominates on dry, disturbed sites, especially along roads (Tyser and Worley 1992). In western Montana, the success of spotted knapweed increases with site disturbance and soil moisture stress. Disturbance intensity has the greatest influence in habitat types moister than the Douglas-fir group, with coarse soil texture and steep slopes adding to success. In grass and shrub habitat types, south aspect and disturbance intensity are important variables for spotted knapweed success (Willard et al. 1988). Spotted knapweed is well adapted to open forested areas, especially after logging or other disturbances (Zouhar 2001).

Sources of information: See cited literature.

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Obs.**

Describe rate of spread: Spotted knapweed occurs at roadsides on the Arizona Strip and in Sedona, which are increasing, but less rapidly (with treatment).

Rationale: The density of spotted knapweed infestations are related to the level of soil moisture, and disturbance, the higher level of moisture and disturbance in the soil, the greater the stem density. Once a population has been established, it is able to form solid stands because of the ability to occupy different soil rooting zones and niches.

Working group members observed that the major limiting factor to establishment of spotted knapweed in Arizona is lack of moisture.

Sources of information: Sheley et al. (1999) and Working Group member observations and discussion.

Question 2.3 Recent trend in total area infested within state *Score:* **B** *Doc'n Level:* **Obs.**

Describe trend: In 1997 spotted knapweed populations were reported from Coconino, Yavapai and Navajo counties. Current Southwest Exotic Plant Mapping Program (SWEMP)-Cain Crisis map records (2004) show that Arizona infestations are still within the boundaries of those counties. There are high concentrations of spotted knapweed observations in the southern region of Coconino county. Estimates of acreage infested with spotted knapweed in 2000 by Duncan (2001) for Arizona was 1800 acres. Current federal and state efforts are being made by Forest Service and county extension agents to control populations.

Rationale: Populations are expanding, but less rapidly.

Sources of information: See cited literature; also considered personal communications with L. Moser (Botanist, U.S. Department of Agriculture, Forest Service, Coconino National Forest, Flagstaff, Arizona) and J. Schalau (Assistant Agent, Agriculture and Natural Resources, University of Arizona Cooperative Extension, Yavapai County) and SWEMP-Cain Crisis map records (available at: http://cain.nbii.gov/cgibin/mapserv?map=../html/cain/crisis/crisismaps/crisis.map&mode=browse&layer=state&layer=county; accessed online on February 10, 2004).

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: Spotted knapweed is a biennial/perennial plant that can live up to nine years and reproduces primarily by seed.

Rationale: A population of plants may produce about 5,000 to 40,000 seeds/m^2/year. Spotted knapweed plants may remain in the rosette stage for 1 to 4 years, producing flowering stems the 2nd year or later (Tyser and Key 1988). Flowering during the year of seedling emergence is rare Spotted knapweed reproduces almost entirely from seed. Plants are also able to extend lateral shoots below the soil surface that form rosettes adjacent to the parent plant, and multiple rosettes on a single spotted knapweed root crown are common (Watson and Renney 1974).

Sources of information: See cited literature; also see Zouhar (2001) and Sheley et al. (1999).

Question 2.5 Potential for human-caused dispersal *Score:* **B** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Seeds are transported by human recreation, vehicles, bikes and equipment. Spotted knapweed seeds are contaminants in crop seed and hay, and may readily establish through fuel reduction activities.

Rationale: Seeds mixed with soil and mud may be carried by vehicles or other equipment that, in turn, create an ideal seedbed for spotted knapweed establishment (Watson and Renney 1974). Spread of seeds on logging trucks, off-road vehicles, and trail bikes has contributed greatly to the spread of knapweed into new areas in British Columbia. Working Group members observed that seeds are spread by hikers into new areas and that fuel reduction/forest thinning equipment and activities have the potential to introduce spotted knapweed into new areas. Spotted knapweed seeds are transported in crop seed and hay (Strang et al. 1979).

Sources of information: See cited literature; also see Sheley et al. (1999) and Zouhar (2001). Also considered Working Group member observations.

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* ***Rev. sci. pub.***

Identify dispersal mechanisms: Seeds are dispersed by wind, and by passing animals or rodents and birds. Seeds remain viable in domestic sheep and mule deer feces.

Rationale: As soon as bracts open, any movement of the stem (e.g. by wind or passing animals) expels the loosely held seeds from the head with a flicking action. The seeds usually land within 3 to 4 feet (0.9-1.2 m) of the parent plant. In this way, spotted knapweed populations spread outward and downwind from the perimeter of existing stands (Watson and Renney 1974). Dispersal of achenes over long distances is facilitated by animals and birds. Wallander et al. (1995) show that both domestic sheep and mule deer excrete viable seeds of spotted knapweed in their feces for 7 to 10 days after consumption, respectively. Spotted knapweed seeds can also be transported in rivers and other watercourses. Most seeds are shed upon maturity; very few overwinter in seedheads.

Sources of information: See cited literature.

Question 2.7 Other regions invaded *Score:* **B** *Doc'n Level:* **Other pub.**

Identify other regions: Spotted knapweed is native to eastern Europe, though it now occurs in western and central Europe. It was introduced to North America, probably as a contaminant in alfalfa (*Medicago sativa*) seed and/or ship's ballast, in the late 1800s. In 1920 the distribution of spotted knapweed in North America was limited to the San Juan Islands, Washington. By 1980 it had spread to 48 counties in the Pacific Northwest. Between 1980 and 1998, the known range of spotted knapweed included 326 counties in the western United States, including every county in Washington, Idaho, Montana, and Wyoming.

In the Southwest it occurs in Sedona, Arizona and in Ponderosa pine ecological types in Coconino National Forest. In Utah it is known from the counties of Piute, Duchesne, Tooele, Washington, Utah, Millard, Kane, San Juan, Salt Lake, Juab, Grand, Uintah, Wasatch, Beaver and Cache (Welsh et al 1987).

Rationale: Spotted knapweed invades alpine and subalpine grassland ecological types in Montana, and has not yet invaded those types in Arizona.

Sources of information: See cited literature; also see Zouhar (2001). In addition, consideration was given to the observations of Working Group members and data from the Atlas of the Vascular Plants of Utah (available online at: http://www.gis.usu.edu/Geography-Department/utgeog/utvatlas/ut-vascatlas.html; accessed on February 10, 2004) and the SEInet (Southwest Environmental Information Network), Arizona collections search (available online at: http://seinet.asu.edu/collections/selection.jsp; accessed on February 10, 2004).

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Spotted knapweed is native to central Europe and east to central Caucasia, and western Siberia. Spotted knapweed is primarily a problem in Montana, and habitat types that are susceptible to invasion include: Great Basin Desert Scrub, alpine and subalpine grassland, plains and Great Basin shrub-grassland, pinyon-juniper, spruce-fir, ponderosa pine, wet meadows and montane riparian areas. It has been observed at elevations ranging from 1,900 to more than 10,000 feet and in areas receiving from 8 to 79 inches in precipitation annually. It does especially well in coarse-textured soils that are well-drained with low water holding capacity.

Rationale: Spotted knapweed invades five major ecological types in Arizona.

Sources of information: See Zouhar (2001) and Sheley et al. (1999). In addition, consideration also was given to the observations of Working Group members and information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed February 10, 2004).

Question 3.2 *Score:* **D** *Doc'n Level:* **Obs.**

Describe distribution: In 2000 Arizona had 1,800 acres infested with spotted knapweed mainly in montane habitats.

Rationale: Spotted knapweed occurs in Coconino National Forest, and Yavapai county near Sedona in Arizona. More research needs to be completed on distribution of spotted knapweed in Arizona.

Sources of information: See Zouhar (2001) and Duncan (2001). In addition, consideration also was given to the observations of Working Group members and data from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed February 10, 2004).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**[✓ Yes]**	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**[✓ Yes]**	**No**	**2 pt.**
Populations of this species produce seeds every year.	**Yes**	**[✓ No]**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**[✓ Yes]**	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	**[✓ Yes]**	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes**	**[✓ No]**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes**	**[✓ No]**	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	**[✓ No]**	**2 pt.**
Resprouts readily when cut, grazed, or burned	**[✓ Yes]**	**No**	**1 pt.**

Total pts: 7 Total unknowns: 0

Score : A

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	**U**
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	**D**
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	**D**
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	
	montane riparian	**D**
Woodlands	Great Basin conifer woodland	**D**
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Centaurea diffusa* Lam. (USDA 2005)
Synonyms:	*Acosta diffusa* (Lam.) Soják (USDA 2005)
Common names:	Diffuse knapweed, white knapweed, tumble knapweed
Evaluation date (mm/dd/yy)**:**	02/10/04
Evaluator #1 Name/Title:	Kate Watters
Affiliation:	Northern Arizona University
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List committee members:	W. Albrecht, D. Backer, J. Crawford, H. Folger, J. Hall, R. Hiebert, F. Northam, T. Olson, K. Watters
Committee review date:	04/16/04
List date:	04/16/04
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**B**	Other published material	**"Impact"** **Section 1 Score:** **B**	**"Plant Score"** **Overall Score:** **Medium** **Alert Status:** **None**
1.2	Impact on plant community	**A**	Other published material		
1.3	Impact on higher trophic levels	**B**	Other published material		
1.4	Impact on genetic integrity	**U**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Other published material	**"Invasiveness"** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **17 pts** **Section 2 Score:** **A**	
2.2	Local rate of spread with no management	**A**	Observational		
2.3	Recent trend in total area infested within state	**A**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**A**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Other published material		
2.7	Other regions invaded	**C**	Other published material		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**A**	Observational	**"Distribution"** **Section 3 Score:** **B**	
3.2	Distribution	**C**	Observational		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **B** *Doc'n Level:* **Other pub.**

Identify ecosystem processes impacted: Diffuse knapweed infestations increase soil erosion and increased surface runoff. Plants produce allelopathic substances that alter the nutrient and mineral dynamics of the soil.

Rationale: Results of diffuse knapweed infestations on disturbed sites increase soil erosion and create a sustained decline of biological productivity in semi-arid and arid lands. Often the declines are associated with manmade stresses or in conjunction with a natural extreme event like fire or a hailstorm, or prolonged drought (Sheley et al. 1998). A study by Kelsey and Locken (1987) showed that cnicin did not inhibit germination, but effectively retarded the root growth of other plants. The data suggests that within their Montana study site, cnicin was not functioning as an allelopathic compound. It is unclear from the research whether the presence of cnicin in the soils has the ability to alter the mineral or mycorrhizal associations that benefit plant nutrient uptake.

Sources of information: See cited literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **A** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Plants produce allelopathic substances that inhibit productivity of native plants which are not adapted to compete with this chemical in the soil, thus are more readily invaded. Diffuse knapweed can dominate a site over time and persist in monotypic stands, thus occluding native canopy and reducing native species diversity. Diffuse knapweed suppresses other vegetation presumably by intense competition for limited soil water.

Rationale: Diffuse knapweed leaves contain an allelopathic chemical, cnicin that prevents other species from establishing allowing formation of pure diffuse knapweed stands (Fletcher and Renney 1963). Invading exotic plants are thought to succeed primarily because they have escaped their natural enemies, not because of novel interactions with their new neighbors. A study by Calloway and Aschehoug (2000), however, demonstrated that *Centaurea diffusa*, has much stronger negative effects on grass species from North America than on closely related grass species from communities to which *Centaurea* is native. *Centaurea*'s advantage against North American species appears to be due to differences in the effects of its root exudates and how these root exudates affect competition for resources. Cnicin inhibits root growth of other plants, and destroys their ability to compete for limited soil moisture and nutrients. The highest concentrations of cnicin are found in the leaves of diffuse knapweed and the compound may makes its way into the soil by way of leaching or decomposition of leaves or both. The extent to which the cnicin and plant materials are toxic to their own seeds was not determined as difficulties were encountered in attempting to germinate knapweed seeds (Fletcher and Renney 1963). However, field observations indicate diffuse knapweed seedlings readily develop in close proximity to mature plants (Zouhar 2001).

Associated grasses that remove moisture and nutrients from the rooting zone of diffuse knapweed can retard its spread through vegetated areas. Other non-native species, such as crested wheatgrass (*Agropyron cristatum*) have been shown to stress, and inhibit, diffuse knapweed invasion by limiting available soil moisture during the critical seedling growth stage (Carpenter and Murray 2000).

Kelsey and Bedunah (1989) provided evidence that, although cnicin could be isolated from knapweed tissues at varying concentrations and reduce seedling development of some species. They found that concentrations of cnicin are too low to affect other vegetation and allelopathy does not appear to be a large factor in competitive ability of diffuse knapweed. Also, when the foliage, which contains the chemical, was applied at three times the normal litter production, no reduction of grass growth was attributed. This study chalked knapweed invasions up to poor range management (Roché and Roché 1999).

Sources of information: See cited literature; also see Kelsey and Locken (1987).

Question 1.3 Impact on higher trophic levels *Score:* **B** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Reduces biodiversity and replaces wildlife forage on rangeland.

Rationale: Diffuse knapweed contains the allelopathic chemical cnicin, which can suppress the growth of other species and allow diffuse knapweed to grow in single-species stands. The densities of these stands can range from 1−500 plants/m^2. These stands can produce up to 40,000 seeds/m^2, which enables the infestation to proliferate rapidly, and reduces biodiversity of native plants that provide forage and cover to native fauna (Carpenter and Murray 2000). Diffuse knapweed causes reductions in wildlife populations due to the decrease in native forage production (Roche and Roche 1988). One study done by Miller (1990) in British Colombia demonstrated that mule deer, white-tailed deer and California bighorn sheep diets were comprised of 80% diffuse knapweed rosettes and 18% grass as snow receded in January and February, and only through the bolting stage of the plant's development. Plants form low rosettes and may remain in this form for one to several years depending on environmental conditions (Carpenter and Murray 2000). However, prior to snowfall, when other forage is available the diets of the same animals were 80% grass, 18% forbs and 2% shrubs, demonstrating that animals are utilizing knapweed when other plants are not available. Diffuse knapweed is also a source of pollen and nectar for honeybees (Roché and Roché 1999). Effects on native pollinators is not known.

Knapweeds are often considered poor forage for grazing animals; on rangeland, mature diffuse knapweed is generally unpalatable to livestock, as the spines may cause injury to the mouth and digestive tract of grazing animals (Carpenter and Murray 2000). Infestations can greatly reduce dryland forage production with estimated losses of up to 88% in some areas (Harris and Cranston 1979). In a Montana economic study, utilizing surveys by weed boards and an input-output model, the impacts of spotted, diffuse and Russian knapweed were assessed for grazing capacity and wildlife habitat and watershed capacity on wildlands. The study found that total direct and secondary economic impacts exceeded $42 million, which could support an estimated 518 jobs for the state (Roché and Roché 1999).

Sources of information: See cited literature.

Question 1.4 Impact on genetic *Score:* **U** *Doc'n Level:* **Other pub.**

Identify impacts: It is unknown whether hybridization occurs.

Rationale: Hybridization readily occurs between *Centaurea* species. However, it is unknown whether hybridization could occur between non-native and native species in Arizona. *Centaurea rothrockii* occurs in the Chirichauas and Huachuca Mountains and it is unknown at this time whether *C. diffusa* even exists in the same area, and if present, would hybridize with our native species.

Sources of information: See Kearney and Peebles (1960); also considered personal communication with R. Scott (Professor, Northern Arizona University, Biological Sciences, Flagstaff, Arizona).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Grazing practices, roads and trails, construction, landslides, native animal browsing and burrowing-any type of activity that creates disturbance.

Rationale: Diffuse knapweed is an early success ional species that establishes best on disturbed ground. The density of a diffuse knapweed stand is often correlated with the level of soil disturbance. Grazing at high levels, which reduces native plant competition, encourages diffuse knapweed on rangelands (Roché and Roché 1999). It has the capability of invading undisturbed habitats, but often infestations are less dense. However, Lacey et al. (1990) reports that disturbances need not be recent and a disturbance can be as insignificant as rodent activity or one hailstorm to allow a diffuse knapweed invasion to take hold.

Sources of information: See cited literature; also see Carpenter and Murray (2000).

Question 2.2 Local rate of spread with no management *Score:* **A** *Doc'n Level:* **Obs.**

Describe rate of spread: Increases rapidly (doubling in <10 years).

Rationale: Lacey (1989) reported approx 3.1 million acres in the western U.S. infested with diffuse knapweed. Since the 1989 summary, it has been expanding rapidly. In addition, Lacey (1989) reports 30,000 acres infested in Colorado in 1989; in 1997 it occupied a reported 100,000 acres (however, see Duncan 2001 in Zouhar 2001 for a different estimate. Carpenter and Murray (2000) report that the area infested by diffuse knapweed is increasing an estimated 18 percent per year. Many reports vary widely as Sheley (2001) reports that estimates of infestation size are extremely subjective because of survey groundrules. Observations from local botanists from the Coconino National Forest report populations increasing at 15 to 20% per year, even with treatment.

Sources of information: See cited literature; also see Roché and Roché (1999). In addition, consideration was given to personal observations of L. Moser (Botanist, U.S. Department of Agriculture, Forest Service, Coconino National Forest, Flagstaff, Arizona) and B. Phillips (Zone Botanist, U.S. Department of Agriculture, Forest Service, Coconino National Forest, Flagstaff, Arizona).

Question 2.3 Recent trend in total area infested within state *Score:* **A** *Doc'n Level:* **Obs.**

Describe trend: Increasing rapidly (doubling in total range statewide in <10 years).

Rationale: States surveyed in 1988 and then again in 2001 showed that diffuse knapweed infestations were doubling in <10 years. Utah in 1988 had 25 acres and in 2001, 1,300 acres were reported. Colorado had 30,000 acres of diffuse knapweed in 1988 and 83,000 acres in 2001. Arizona was not reported in 1988 but had 1,800 acres in 2001, but because of the trends in both Utah and Colorado the Working Group agreed that these trends are likely similar in Arizona.

Sources of information: Duncan (2001) in Zouhar (2001). In addition, consideration was given to observations of Working Group members.

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: Diffuse knapweed is a biennial or short-lived perennial that reproduces primarily by seed.

Rationale: Fertilization in diffuse knapweed requires cross-pollination between flowers on different plants. This can limit the reproductive success of isolated individuals, but it also promotes genetic diversity and may thereby improve competitive ability. Watson and Renney (1974) reported that diffuse knapweed is self-compatible, but the results of Harrod and Taylor (1995) refute this assertion. Diffuse knapweed has a large, perennial taproot that may survive fire if the root crown is not killed, and/or establish from seed after fire (Zouhar 2001). Seed can remain viable in soil for up to 12 years (Roché and Roché 1999). A single diffuse knapweed plant can produce up to 18,000 seeds and a stand of diffuse knapweed can produce up to 40,000 seeds per square meter (Carpenter and Murray 2000).

Sources of information: See cited literature.

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Seeds spread along transportation corridors, such as highways, railroads, and trails; seed are transported by humans on foot and in vehicles, grazed or lands with disturbance are more susceptible to invasion. Diffuse knapweed is a seed contaminant in hay, and present in seed harvested from wild populations for restoration and erosion control projects.

Rationale: Seeds of diffuse knapweed have a plume of bristle-like hairs, resembling scales that easily cling to objects, shoes and clothing, and on vehicle chassis. Diffuse knapweed is not common on cultivated lands or irrigated pasture because it cannot tolerate cultivation or excessive moisture, but is common on fence lines.

Sources of information: Watson and Renney (1974), Carpenter and Murray (2000), and Working Group member observations.

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Seeds dispersed by wind, and tumbling.

Rationale: Wind dispersal of individual seeds does not carry them far from actual parent plant, however, most of the heads remain closed until the plant dries up and during the second year of growth, diffuse knapweed often detaches from root crown and the entire plant is carried by winds as a tumble-weed, allowing seeds to be individually dispersed over long distances.

Sources of information: See Carpenter and Murray (2000).

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Other pub.**

Identify other regions: Diffuse knapweed is currently found from Yukon in the north, throughout most of western Canada, east to Ontario. In the United States, the primary range of diffuse knapweed is the western states, from Washington, Idaho and Montana south to New Mexico and Arizona. Maddox (1979) notes that diffuse knapweed is more common on the western side of the Great Basin, and spotted knapweed is more common on the eastern side (in Zouhar 2001).

Rationale: In Utah the antelope bitterbrush/bunchgrass shrub steppe is highly susceptible to invasion by diffuse knapweed, as well as the La Sal Mountain range, and Welsh et al. (1987*)*, report it is probably throughout middle elevations of the state. In Colorado diffuse knapweed invades more than 145,000 acres in the shortgrass steppe along the Front Range, including the foothills. Adjacent montane zones and the lower elevation pinyon-juniper-oak (*Pinus-Juniperus-Quercus* spp.) brush zones are also susceptible. Diffuse knapweed is also found on upland sites in pinyon and juniper woodlands in the interior west. Presently, diffuse knapweed invades in the above listed ecotypes elsewhere, but only in those types it has already invaded in Arizona.

Sources of information: See cited literature; also see Zouhar (2001). In addition, consideration was given to observational information from Working Group members and data from the Atlas of the Vascular Plants of Utah (available online at: http://www.gis.usu.edu/Geography-Department/utgeog/utvatlas/ut-vascatlas.html; accessed on February 11, 2004).

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: The earliest record of diffuse knapweed in North America is from an alfalfa field in Washington state in 1907 (Zouhar 2001). In Utah it is known from Iron, San Juan, Utah, Sanpete, and Juab counties from 1360 m to 1970 m in elevation. In Colorado diffuse knapweed is reported from Delta, Montrose, San Miguel, Dolores, Montezuma, La Plata and Archuleta counties (Roché and Roché 1999). The first collection of this plant in Arizona was made August 5, 1979 along Highway 89, seven miles north of Flagstaff near Black Mountain Homes (Coconino National Forest Weed Information records).

Rationale: Diffuse knapweed is reported to be invasive in the following communities: douglas-fir, ponderosa pine, fir-spruce, sagebrush, pinyon-juniper, mountain grasslands, plains grasslands, desert grasslands (Zouhar 2001).

Sources of information: See cited literature; also considered data from the Atlas of the Vascular Plants of Utah (available online at: http://www.gis.usu.edu/Geography-Department/utgeog/utvatlas/ut-vascatlas.html; accessed on February 11, 2004) and Coconino National Forest Weed Information records.

Question 3.2 Distribution *Score:* **C** *Doc'n Level:* **Obs.**

Describe distribution: In Arizona, it is found in Navajo Nation botanical records from Apache County. Southwest Exotic Plant Mapping Program (SWEMP)-Cain Crisis map records (2004) report infestations densest in Coconino county, but also occurring in Navajo and Apache counties.

Rationale: Reported from National Park Service species databases in ROMO, YUHO, GRCA, FOBU and MEVE.

Sources of information: Kearney and Peebles (1960), Navajo Nation botanical records, SWEMP-Cain Crisis map records (available at: http://cain.nbii.gov/cgibin/mapserv?map=../html/cain/crisis/crisismaps/crisis.map&mode=browse&layer=state&layer=county; accessed online on February 11, 2004, and observations from Working Group members.

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ **Yes**]	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	[✓ **Yes**]	**No**	**2 pt.**
Populations of this species produce seeds every year.	[✓ **Yes**]	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	[✓ **Yes**]	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	[✓ **Yes**]	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes**	[✓ **No**]	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes**	[✓ **No**]	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	[✓ **No**]	**2 pt.**
Resprouts readily when cut, grazed, or burned	[✓ **Yes**]	**No**	**1 pt.**
	Total pts: 8 Total unknowns: 0		
	Score : A		

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	**D**
	southwestern interior chaparral scrub	**D**
Desertlands	Great Basin desertscrub	**D**
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	**D**
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	**D**
	semi-desert grassland	**D**
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	
	montane riparian	
Woodlands	Great Basin conifer woodland	**D**
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**C**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Centaurea melitensis* L. (USDA 2005)
Synonyms:	None identified in USDA (2005).
Common names:	Malta starthistle, Maltese star thistle, Napa star thistle, tocolote[1]
Evaluation date (mm/dd/yy)**:**	03/26/04
Evaluator #1 Name/Title:	Judy Ward, Biological Science Technician
Affiliation:	Jornada Experimental Range
Phone numbers:	(505) 644–8363
Email address:	jward@nmsu.edu
Address:	Wooton Hall, 2995 Knox Street, Las Cruces, New Mexico 88003–8003
Evaluator #2 Name/Title:	
Affiliation:	
Phone numbers:	
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Address:	

List committee members:	03/26/04: D. Backer, K. Brown, P. Guertin, J. Hall, B. Munda, F. Northam, M. Quinn, J. Ward 05/21/04: D. Backer, K. Brown, D. Casper, G. Ferguson, D. Foster, P. Guertin, J. Hall, C. Laws, D. Madison, F. Northam, J. Ward 04/15/05: J. Hall, H. Messing, B. Munda, F. Northam
Committee review date:	03/26/04, 05/21/04, and 04/15/05
List date:	05/21/04; revised 04/15/05
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**C**	Other published material	**“Impact”** **Section 1 Score:** **B**	**“Plant Score”** **Overall Score:** **Medium** **Alert Status:** **None**
1.2	Impact on plant community	**B**	Reviewed scientific publication		
1.3	Impact on higher trophic levels	**D**	Other published material		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Observational	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **16 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**A**	Observational		
2.3	Recent trend in total area infested within state	**B**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**A**	Observational		
2.6	Potential for natural long-distance dispersal	**C**	Other published material		
2.7	Other regions invaded	**B**	Other published material		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**B**	Observational	**“Distribution”** **Section 3 Score:** **B**	
3.2	Distribution	**C**	Observational		

Table 3. Documentation

Note: Working Group assigned scores were adjusted to fit new information resulting in an increase of overall score from **Low** to **Medium** as a result of Consistency Review Committee input on questions 1.2, 2.2, and 3.2.

Question 1.1 Impact on abiotic ecosystem processes *Score:* **C** *Doc'n Level:* **Other pub.**

Identify ecosystem processes impacted: Potential increase in soil moisture depletion and erosion.

Rationale: Congenerics are associated with depletion of soil moisture and increased susceptibility to erosion (Roche and Roche 1991). However, some researchers have inferred that *C. melitensis* is likely to have a smaller effect (than *C. solstitialis*) due to its shorter lifespan and smaller taproot (CDFA 2001).

Sources of information: See cited literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Identify type of impact or alteration: Reduced biomass of native grass (Callaway et al. 2001, 2003). Dense stands noted to displace native plants in California annual grasslands (DiTomaso and Gerlach 2000a) and locally in Southeastern Arizona (P. Guertin, personal communication, 2003).

Rationale: Biomass of Nassella pulchra was reduced when grown with *C. melitensis* in greenhouse particularly when naturally occurring Arbuscular mychorrhizal fungi were present (Callaway et al. 2001, 2003). These authors suggest that *C. melitensis* may be exploiting fixed carbon or other resources from the native grass via a common network of Arbuscular mychorrhizal fungi. In Saguaro National Park, East, a small thick patch about two meters wide circumnavigated a ponded area in to the apparent exclusion of native vegetation (P. Guertin, personal communication, 2003). However, dense monotypic stands are rare and primarily along roadsides.

Sources of information: See cited literature. Also considered personal observations by P. Guertin (Research Specialist, U.S. Geological Survey, Sonoran Desert Field Station, 2003).

Question 1.3 Impact on higher trophic levels *Score:* **D** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Negligible impacts.

Rationale: *Centaurea melitensis* can be poisonous to horses (DiTomaso and Gerlach 2000a), but because of the conditions in which this occurs long-term ingestion is probably unlikely with wildlife.

Sources of information: See cited literature.

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub.**

Identify impacts: No known hybridization.

Rationale: Arizona has two native species of *Centaurea*: *Centaurea americana* Nutt. and *Centaurea rothrockii*; however, these species occur at high elevations in the White Mountains and the Chiricahua and Huachuca Mountains, respectively (Kearney and Peebles 1960).

Sources of information: See cited literature.

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Obs.**

Describe role of disturbance: *Centaurea melitensis* is favored by human-mediated disturbance but can occasionally establish with natural disturbance.

Rationale: *Centaurea melitensis* most commonly occurs in cultivated and abandoned fields, along irrigation ditches and roads, and in other disturbed areas (Parker 1972, Felger 1990); however, it was also rarely observed in flat areas with finer soil textures along naturally disturbed washes (D. Foster, personal communication, 2004) and circumnavigating ponded areas in more remote locations in Saguaro National Park (P. Guertin, personal communication, 2003). Once it is well established in disturbed areas, it has been observed to establish to a limited degree in adjacent undisturbed areas in Apache County (B. Sorenson, personal communication, 2004).

Sources of information: See cited literature. Also considered personal communications with P. Guertin (Research Specialist, U.S. Geological Survey, Sonoran Desert Field Station, 2003), D. Foster (Restoration Ecologist, National Park Service, Saguaro National Park, 2004), and B. Sorenson (District Conservationist, U.S. Department of Agriculture, Natural Resources Conservation Service, Apache County, Arizona, 2004).

Question 2.2 Local rate of spread with no management *Score:* **A** *Doc'n Level:* **Obs.**

Describe rate of spread: Increasing, but rate of increase unclear.

Rationale: Resource managers report that their observations of this winter annual have varied greatly due to amount of winter precipitation in a given year (B. Sorenson and R. Adams, personal communications, 2004), thus making the rate of spread difficult to ascertain. Felger (1990) reports that it does not appear to be spreading in Organ Pipe National Monument; however, its rate of spread in other areas is not documented. Observations exist of its increase in wet winters in natural areas (Greasewood Park) within Tucson, Arizona (B. Tellman, personal communication, 2001).

Sources of information: See cited literature. Also considered personal communications with B. Sorenson (District Conservationist, U.S. Department of Agriculture, Natural Resources Conservation Service, Apache County, Arizona, 2004), R. Adams (Rangeland Management Specialist, U.S. Department of Agriculture, Natural Resources Conservation Service, Chino Winds Natural Resource Conservation District [NRCD] and Triangle NRCD, 2004), and B. Tellman (personal communication at a Pima Invasive Species Council Meeting, July 2001).

Question 2.3 Recent trend in total area infested within state *Score:* **B** *Doc'n Level:* **Obs.**

Describe trend: Increasing, but rate of range expansion is unclear due to lack of comprehensive information and its tight coupling with winter precipitation.

Rationale: Kearney and Peebles (1960) reported it from Apache, Yavapai, Maricopa, Pinal, Cochise and Pima Counties in 1969. Parker (1972) added Graham county in 1972. MacDougal (1973) added Mojave County in 1973. Felger (1990) added Yuma County in 1990. New observations have recently been reported for the Cordes Junction area (R. Adams, personal communication, 2004).

Sources of information: See cited literature. Also considered personal communication with R. Adams (Rangeland Management Specialist, U.S. Department of Agriculture, Natural Resources Conservation Service, Chino Winds Natural Resource Conservation District [NRCD] and Triangle NRCD, 2004).

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: *Centaurea melitensis* is a winter germinating annual that flowers from April to June with hidden flowers in the rosette stage (DiTomaso and Gerlach 2000a). Plants can support 1 to 100 heads with 1 to 60 seeds per head (DiTomaso and Gerlach 2000a). *Centaurea melitensis* has a mixed mating system and is highly self-compatible (Gerlach and Rice 2003) with cleistogamous (remaining closed and obligate selfing,) early and late season flowers and chasmogamous (open and capable of out-crossing) peak-season flowers (Porras and Munoz 2000).

Rationale: *Centaurea melitensis* does not reproduce vegetatively but had compensatory growth when clipped to simulate grazing in the presence of a natural occurring Arbuscular mychorrhizal fungi and a native grass (Callaway et al. 2001). An infestation patch in Organ Pipe National Monument has been pulled for over three years in Organ Pipe National Monument prior to seed dehiscence; however, new plants continue to emerge (D. Casper, personal communication, 2003), indicating a seed longevity greater than three years.

Sources of information: See cited literature. Also considered personal communication with D. Casper (Invasive Species Specialist, National Park Service, Organ Pipe National Monument, Ajo, Arizona, 2003).

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Obs.**

Identify dispersal mechanisms: Non-certified (contaminated) hay and the transport thereof; road maintenance and off-road vehicles; and non-motorized recreation.

Rationale: Resource managers have observed Malta starthistle in contaminated hay (F. Archuleta, personal communication, 2004) and correlated observations with its initial appearance in irrigated pasture (B. Sorenson, personal communication, 2004). In conservation areas, seed transport is likely due to hikers and horseback riders (D. Foster, personal communication, 2004). These mechanisms have been clearly associated with *C. solstitialis* transport (DiTomaso and Gerlach 2000b) and likely occur with *C. melitensis* due to the very similar seed head morphology including spine-like phyllaries and bristles (DiTomaso and Gerlach 2000a).

Sources of information: See cited literature. Also used inference and considered personal communications with F. Archuleta (District Conservationist, Shiprock SWCD, U.S. Department of Agriculture, Natural Resources Conservation Service, 2004), B. Sorenson (District Conservationist, U.S. Department of Agriculture, Natural Resources Conservation Service, Apache County, Arizona, 2004), and D. Foster (Restoration Ecologist, National Park Service, Saguaro National Park, 2004).

Question 2.6 Potential for natural long-distance dispersal *Score:* **C** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Potential dispersal by animal in fur. Short distance by wind.

Rationale: Wind gusts up to 40 km/hour only move *C. solstitialis* seeds up to 5 m (Roche 1992 in DiTomaso and Gerlach 2000b). Seed head morphology of *C. melitensis* is comparable and likely illustrates a similar lack of wind dispersal efficiency (DiTomaso and Gerlach 2000a).

Sources of information: See cited literature.

Question 2.7 Other regions invaded *Score:* **B** *Doc'n Level:* **Other pub.**

Identify other regions: Occurs in *Adenostoma* chaparral communities in California which may be comparable to southwestern interior chaparral.

Rationale: Found in San Francisco Bay Area, North Coast Ranges and Sierra Nevada Foothills in California (DiTomaso and Gerlach 2000a).

Sources of information: See cited literature.

Question 3.1 Ecological amplitude *Score:* **B** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Observations from the Chihuahuan Desertscrub (M. Matthew, personal communication, 2004), Sonoran desertscrub (P. Guertin, personal communication, 2003), Mojave desertscrub (L. Walker, personal communication, 2004), and semi-desert grassland (R. Adams, personal communication, 2004). *Centaurea melitensis* is a winter annual that responds to winter rain, it is more frequent on deeper soiled bottoms than uplands, and occurs more commonly in mid-elevation ranges (1500 to 5,000 feet) (L. Walker and R. Adams, personal communications, 2004).

Centaurea melitensis is reported from Washington, Oregon, California, Nevada, Utah, Arizona, New Mexico, Texas, Missouri, Wisconsin, Alabama, Georgia, South Carolina, Pennsylvania, and Massachussets (USDA 2005). As an annual species is likely able to shift its activity across time to meet temperature requirements. It is widespread in California but forms the largest populations in the southwestern and central-western portions of California. Further, although it is found in the California annual grassland with the Mediterranean climate it is more common on disturbed or drier sites (DiTomaso and Gerlach 2000a).

Rationale: Observations from the Chihuahuan Desertscrub (M. Matthew, personal communication, 2004), Sonoran desertscrub (P. Guertin, personal communication, 2003), Mojave desertscrub (L. Walker, personal communication, 2004), and semi-desert grassland (R. Adams, personal communication, 2004). Occurs in two major types and four minor types.

Sources of information: See cited literature. Also considered personal communications with R. Matthew (U.S. Department of Agriculture, Natural Resources Conservation Service, Cochise County, 2004), P. Guertin (Research Specialist, U.S. Geological Survey, Sonoran Desert Field Station, 2003), L. Walker (Weed Specialist, Bureau of Land Management, Arizona Strip. St. George, Utah, 2004), and R. Adams (Rangeland Management Specialist, U.S. Department of Agriculture, Natural Resources Conservation Service, Chino Winds Natural Resource Conservation District [NRCD] and Triangle NRCD, 2004).

Question 3.2 Distribution *Score:* **C** *Doc'n Level:* **Obs.**

Describe distribution: In the Chihuahuan Desertscrub (R. Matthew, personal communication, 2004), Sonoran desertscrub (P. Guertin, personal communication, 2003), Mojave desertscrub (L. walker, personal communication, 2004), and semi-desert grassland (R. Adams, personal communication, 2004) it is infrequent.

Rationale: Appears to be much more common in disturbed or converted areas (Parker 1972) within where these ecological types would otherwise occur. Observations primarily in areas with increased moisture availability.

Sources of information: See cited literature. Also considered personal communications with R. Matthew (U.S. Department of Agriculture, Natural Resources Conservation Service, Cochise County, 2004), P. Guertin (Research Specialist, U.S. Geological Survey, Sonoran Desert Field Station, 2003), L. Walker (Weed Specialist, Bureau of Land Management, Arizona Strip. St. George, Utah, 2004), and R. Adams (Rangeland Management Specialist, U.S. Department of Agriculture, Natural Resources Conservation Service, Chino Winds Natural Resource Conservation District [NRCD] and Triangle NRCD, 2004).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ **Yes**]	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	[✓ **Yes**]	**No**	**2 pt.**
Populations of this species produce seeds every year.	[✓ **Yes**]	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**Yes**	[✓ **No**]	**1 pt.**
Seeds remain viable in soil for three or more years	[✓ **Yes**]	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	[✓ **Yes**]	**No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes**	[✓ **No**]	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	[✓ **No**]	**2 pt.**
Resprouts readily when cut, grazed, or burned	[✓ **Yes**]	**No**	**1 pt.**

Total pts: 8 Total unknowns: 0

Score : A

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	**D**
	Chihuahuan desertscrub	**D**
	Sonoran desertscrub	**D**
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	**D**
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	
	montane riparian	
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Warner, P.J., C. Bossard, M.L. Brooks, J.M. DiTomaso, J.A. Hall, A. M. Howald, D.W. Johnson, J.M. Randall, C.L. Roye, M.M. Ryan, and A.E. Staton. 2003. Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands. Available online at: www.caleppc.org and www.swvma.org. California Exotic Pest Plant Council and Southwest Vegetation Management Association. 24 p.

Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Centaurea solstitialis* L. (USDA 2005)
Synonyms:	*Leucantha solstitialis* (L.) A.& D. Löve (USDA 2005)
Common names:	Yellow starthistle, St. Barnaby's thistle
Evaluation date (mm/dd/yy)**:**	05/29/03
Evaluator #1 Name/Title:	Willie Sommers, Graduate Research Assistant
Affiliation:	School of Renewable Natural Resources, University of Arizona
Phone numbers:	(520) 400–9648; (520) 626–3948
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Evaluator #2 Name/Title:	
Affiliation:	
Phone numbers:	
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List committee members:	D. Backer, C. Barclay, K. Brown, P. Guertin, F. Northam, R. Parades, W. Sommers, J. Ward, P. Warren
Committee review date:	09/19/03
List date:	09/19/03
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**A**	Reviewed scientific publication	**“Impact”** **Section 1 Score:** **A**	**“Plant Score”** **Overall Score:** **High** **Alert Status:** **None**
1.2	Impact on plant community	**A**	Other published material		
1.3	Impact on higher trophic levels	**B**	Other published material		
1.4	Impact on genetic integrity	**U**	No information		
2.1	Role of anthropogenic and natural disturbance	**C**	Observational	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **15 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**A**	Observational		
2.3	Recent trend in total area infested within state	**B**	Observational		
2.4	Innate reproductive potential	**A**	Reviewed scientific publication		
2.5	Potential for human-caused dispersal	**A**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Reviewed scientific publication		
2.7	Other regions invaded	**C**	Observational		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**A**	Observational	**“Distribution”** **Section 3 Score:** **B**	
3.2	Distribution	**D**	Observational		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Identify ecosystem processes impacted: Hydrologic regime (soil water table levels); soil erosion and surface runoff.

Rationale: Research in California indicates that yellow starthistle infestations can deplete soil moisture more than rangeland dominated by annual grasses or perennial wheatgrass (DiTomaso et al. 2000). This results in less soil moisture recharge the following season. Furthermore, yellow starthistle, like other knapweed (*Centaurea*) species may accelerate soil erosion and surface runoff by virtue of a deep taproot (Lacey et al. 1989). Yellow starthistle roots extended beyond six feet after two months of growth when grown in tubes in a greenhouse (DiTomaso 2001). Yellow starthistle develops a single root which grows straight down relative to grasses which have a multi-branching fibrous root system. A single taproot holds less soil in place relative to fibrous roots.

Sources of information: See cited literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **A** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Ability to form stands dominated by the species; creation of a substantial thatch or litter layer; capability of germinating and flowering over a relatively long time period during the growing season even during dry conditions.

Rationale: This plant can form very dense stands which displace native plant communities and reduce plant diversity (Sheley et al. 1999). These stands also yield much litter or thatch that may reduce available sunlight to native seedlings. Yellow starthistle has also been observed germinating and flowering over much of the growing season. Yellow starthistle typically germinates in October, before many wildland plants, and harvests moisture when other species are not actively growing. This earlier germination period shifts the competitive balance in the favor of starthistle. In addition, yellow starthistle infestations can have taller plants (up to 3 feet) relative to native grass stands.

Sources of information: See cited literature. Also considered personal observation of dry-land pasture in Gila, New Mexico by W. Sommers (Graduate Research Assistant, University of Arizona, School of Renewable Natural Resources, 2001 to 2003).

Question 1.3 Impact on higher trophic levels *Score:* **B** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Spines that damage the mouth of native wildlife; reduction in forage production for native animals; provision of pollen and nectar for pollinators.

Rationale: The stiff and sharp spines on the flower of yellow starthistle discourage livestock grazing and are likely to have similar effects on native species such as elk, deer, and pronghorn antelope. Stiff, sharp spines can damage the mouth of these wildlife species. In addition, dense yellow starthistle stands in the Pacific Northwest reduce and eliminate forage production when compared to perennial grasslands (Lass et al. 1999). Therefore, it is likely that yellow starthistle infested areas will be avoided by wildlife. On the other hand, starthistle flowers provide nectar and pollen for bees (Sheley et al. 1999) and butterflies. However, research has shown that yellow starthistle flowers are very low in nectar production compared to many other plants used by honeybees (Lass et al. 1999). In addition, seed production can increase by more than 20 times when plants are visited by bees (Lass et al. 1999).

Sources of information: See cited literature.

Question 1.4 Impact on genetic integrity *Score:* **U** *Doc'n Level:* **No info.**

Identify impacts: Unknown

Rationale: There are eight *Centaurea* species in Arizona, of which only two are native to the state (Kearny and Peebles 1960). The remaining species are from Europe and Asia. It is unknown whether *C. solstitialis* can impact the genetic integrity of the natives.

Sources of information: No information on possible hybridization between *C. solstitialis* and *Centaurea* natives.

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **C** *Doc'n Level:* **Obs.**

Describe role of disturbance: Soil disturbance by cultivation and grazing, and altered hydrology due to dams, diversions, irrigation, etc.

Rationale: In Cliff-Gila, New Mexico yellow starthistle grows only in pastures and fallow fields, and along roadsides and ditch banks. In this area, many farm fields were rested and this allowed yellow starthistle to establish (W. Sommers, personal observations, 2001 to 2003). Fields were rested because the land was acquired by a mining company for the water rights. In much of central and northern California, yellow starthistle is the most important roadside weed problem (DiTomaso 2001). There is concern that yellow starthistle could establish in undisturbed areas such as wilderness in the Gila National Forest which borders the Cliff-Gila River valley (BLM 1999). I have not seen any reports of yellow starthistle establishing in undisturbed areas.

Sources of information: See cited literature. Also considered personal observation of dry-land pasture in Gila, New Mexico by W. Sommers (Graduate Research Assistant, University of Arizona, School of Renewable Natural Resources, 2001 to 2003).

Question 2.2 Local rate of spread with no management *Score:* **A** *Doc'n Level:* **Obs.**

Describe rate of spread: Yellow starthistle populations can increase rapidly and double in less than 10 years even in the southwestern U.S.

Rationale: In the Cliff-Gila River valley of southwest New Mexico (elevation around 4500 feet; semidesert grassland) the estimated yellow starthistle infestation has doubled from 500 to 1000 acres since 1999 (R. Lamb, personal communication, 2002). Between 1991 and 2003, the estimated infestation in Young, Arizona (5200 feet; semidesert grassland) has increased from 300 to over 3,000 acres (F. Northam, personal communication, 2003).

Sources of information: Score based on personal observations by R. Lamb (County Program Director and Extension Agent, New Mexico State University, Grant County Cooperative Extension Service, 2002) and F. Northam (Noxious Weed Coordinator, Arizona Department of Agriculture, 2003).

Question 2.3 Recent trend in total area infested within state *Score:* **B** *Doc'n Level:* **Obs.**

Describe trend: Increasing but not doubling in less than 10 years.

Rationale: A 2001 map of the distribution and abundance of yellow starthistle in the west displays the plant in five counties (Lane 2001). The county with the most yellow starthistle, Gila County, has over a thousand acres impacted, and the other four counties have <100 acres impacted. Now Gila County has 3,000 to 4,000 acres of yellow starthistle and the other counties have a few hundred acres (F. Northam, personal communication, 2003).

Sources of information: See cited literature and personal observations by F. Northam (Noxious Weed Coordinator, Arizona Department of Agriculture, 2003).

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Describe key reproductive characteristics: Very prolific seed production; reaches reproductive maturity in less than one year; dense infestations can produce 50 to 100 million seeds per acre (DiTomaso 2001). A single large plant can produce over 100,000 seeds in less than a year (Sheley et al. 1999, DiTomaso 2001).

Rationale: See Worksheet A

Sources of information: See cited literature.

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Presence as a contaminant in bulk seed, hay, feed, and soil; spread along transportation corridors.

Rationale: Contaminated hay is suspected of bringing yellow starthistle to the Cliff-Gila area where it now thrives (BLM 1999). "Human activities are the primary mechanism for long distance movement of yellow starthistle seed (DiTomaso 2001:2)." Seed can be moved by road maintenance equipment, vehicles, and the transportation of contaminated hay or uncertified seed. Because yellow starthistle is found along highway rights-of-way in Arizona (F. Northam, personal communication, 2003), it is possible that seed will be moved by either motorists or the highway department.

Sources of information: See cited literature and personal observations by F. Northam (Noxious Weed Coordinator, Arizona Department of Agriculture, 2003).

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Identify dispersal mechanisms: Birds, mammals, and flowing water.

Rationale: Seed is consumed by pheasants, quail, house finches, and goldfinches and may take seeds several miles (Roche 1991). In southwest New Mexico, yellow starthistle has spread from Cliff-Gila down the Gila River several miles (BLM 1999). There is also a population of yellow starthistle further downriver in Duncan, Arizona, which may be the result of seed moving in the river water. "The short, stiff, pappus bristles are covered with microscopic, stiff, appressed, hair-like barbs that can adhere to clothing, hair, and fur (DiTomaso 2001:2)." Both seed types, however, have no long distance wind dispersal mechanism.

Sources of information: See cited literature.

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Obs.**

Identify other regions: Yellow starthistle has invaded parts of Colorado, Utah, and New Mexico, but only in ecological types already invaded in Arizona.

Rationale: Yellow starthistle has scattered, small (<1000 acres) populations in each the four corners states.

Sources of information: Score based on Lane (2001) and consensus of Working Group.

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: In Arizona, it is unknown when yellow starthistle was introduced to the state. Yellow starthistle can be found in seven minor ecological types. Introduced to Arizona in 1925 in Yuma County (SEINet 2004)

Rationale: See Worksheet B.

Sources of information: Score based on observations by F. Northam (Noxious Weed Coordinator, Arizona Department of Agriculture, 2003), W. Sommers (Graduate Research Assistant, University of Arizona, School of Renewable Natural Resources, 2001 to 2003), other Working Group members, and information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed January 2004).

Question 3.2 Distribution *Score:* **D** *Doc'n Level:* **Obs.**

Describe distribution: Scattered yellow starthistle populations occur throughout Arizona from high elevation Sonoran Desert (Arizona Upland subdivision) to montane conifer forest and the total invaded area is estimated to be less than 15,000 acres. In the Sonoran and Chihuahuan Desert portions of Arizona, yellow starthistle has invaded river valleys.

Rationale: Not widely established in any one particular ecological type.

Sources of information: Score based on observations by F. Northam (Noxious Weed Coordinator, Arizona Department of Agriculture, 2003), W. Sommers (Graduate Research Assistant, University of Arizona, School of Renewable Natural Resources, 2001 to 2003), and other Working Group members.

Research in Arizona

Research on yellow starthistle biology/control in Arizona has only occurred in Young, Arizona. Dr. Larry Howery (University of Arizona) and Dr. Richard Lee (formerly New Mexico State University, but now with the Bureau of Land Management) conducted an experiment involving integrated management of yellow starthistle using combinations of native grass reseeding and weed suppression treatments. The results of this study were not published. Because of the lack of detailed scientific studies, much of the information used in this evaluation comes from research and observations from California and New Mexico.

Misidentification (comments by W. Sommers)

I have seen two books where the authors or contributors may have confused *Centaurea solstitialis* and *C. melitensis* (Malta starthistle). Sheley et al. (1999) provide a map of the distribution of *C. solstitialis* by county in the west. This map has *C. solstitialis* occurring in Maricopa, Pima, and Yuma counties. I believe the weed authority surveyed in Arizona may have lumped together both of these starthistle species. Epple (1995) identified a photo of *C. solstitialis* as occurring at the Granite Reef Dam near the confluence of the Salt and Verde Rivers. The plant in the photograph is actually *C. melitensis*.

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**[✓ Yes]**	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**[✓ Yes]**	**No**	**2 pt.**
Populations of this species produce seeds every year.	**[✓ Yes]**	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**[✓ Yes]**	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	**[✓ Yes]**	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes**	**[✓ No]**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes**	**[✓ No]**	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	**[✓ No]**	**2 pt.**
Resprouts readily when cut, grazed, or burned	**[✓ Yes]**	**No**	**1 pt.**

Total pts: 8 Total unknowns: 0

Score : A

Note any related traits: The time period from flower initiation to the production of mature viable seed is only eight days; large plants can produce over 100,000 seeds (DiTomaso 2001). Over 90% of yellow starthistle achenes are germinable one week after dispersal (Benefield et al. 2001). Yellow starthistle produces dimorphic achenes, one type with a distinct pappus, and the other with a pappus either poorly developed or absent. The average longevity of non-pappus-bearing and pappus-bearing achenes was six and ten years, respectively (Callihan et al. 1993). In Cliff-Gila, New Mexico yellow starthistle seed production lasts June to August (W. Sommers, personal observation).

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	**Minor Ecological Types**	**Code***
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	**D**
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	**D**
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	
	montane riparian	
Woodlands	Great Basin conifer woodland	**D**
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

Note: The Peeples Valley population occurs in interior chaparral; the Camp Verde, Young, and Tonto Basin populations occur in semi-desert grassland; the Payson population is in the Great Basin conifer woodland; the Flagstaff population occurs in the montane conifer forest.

Distribution: In a telephone conversation with Dr. Francis E. Northam (F. Northam, Noxious Weed Coordinator, Arizona Department of Agriculture, 2003) he provided the locations of all known *Centaurea solstitialis* populations in the state. The populations with an asterisk (*) occur on or near roadsides or in suburban/rural areas and are not perceived to threaten wildlands.

1. Young – an infestation that was 300 acres in 1991 is now 3,000 to 4,000 acres
2. Tonto Basin (Pumpkin Center area) – a few hundred acres
3. Flagstaff – less than 100 acres
4. Wikieup* – less than 1/10 acre on a roadside
5. Payson – less than 100 acres
6. Camp Verde – a few hundred acres

7. Peeples Valley – 25 to 30 acres in irrigated pasture; 2 to 3 acres on rangeland
8. I-40 in Apache and Navajo counties* – small populations encountered by Arizona Department of Transportation
9. Duncan* – less than 10 acres
10. Phoenix* – small infestation

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial):	*Chondrilla juncea* L. (USDA 2005)
Synonyms:	None identified in USDA (2005).
Common names:	Rush skeletonweed, skeletonweed, hogbite
Evaluation date (mm/dd/yy):	05/15/04
Evaluator #1 Name/Title:	Christopher S. Laws / Conservation Biology Intern
Affiliation:	University of Arizona
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Evaluator #2 Name/Title:	
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List committee members:	6/23/04: W. Albrecht, D. Backer, J. Brock, J. Busco, J. Hall, C. Laws, L. Moser, B. Phillips, K. Watters 04/15/05: J. Hall, H. Messing, B. Munda, F. Northam
Committee review date:	6/23/04 and 04/15/05
List date:	04/15/05
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**B**	Reviewed scientific publication	**"Impact"** **Section 1 Score:** **B**	**"Plant Score"** **Overall Score:** **Medium** **Alert Status:** **Alert**
1.2	Impact on plant community	**A**	Reviewed scientific publication		
1.3	Impact on higher trophic levels	**U**	No information		
1.4	Impact on genetic integrity	**D**	Reviewed scientific publication		
2.1	Role of anthropogenic and natural disturbance	**B**	Observational	**"Invasiveness"** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **17 pts** **Section 2 Score:** **A**	
2.2	Local rate of spread with no management	**A**	Observational		
2.3	Recent trend in total area infested within state	**B**	Observational		
2.4	Innate reproductive potential	**A**	Reviewed scientific publication		
2.5	Potential for human-caused dispersal	**B**	Reviewed scientific publication		
2.6	Potential for natural long-distance dispersal	**B**	Reviewed scientific publication		
2.7	Other regions invaded	**A**	Other published material		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**B**	Other published material	**"Distribution"** **Section 3 Score:** **C**	
3.2	Distribution	**D**	Observational		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Identify ecosystem processes impacted: *Chondrilla juncea* causes hydrological changes in areas invaded by lowering the watertable due to its deep tap root. *Chondrilla juncea* absorbs large amounts of Nitrogen, lowering its level in adjacent soil.

Rationale: No known study has been conducted in Arizona to assess the impact on abiotic ecosystem processes. Studies conducted primarily in Australia found that *C. juncea* juncea causes changes in groundwater flow and level due to its deep tap root that can penetrate to a depth of seven feet or more (Old 1981, Macdonald et al. 1989). *Chondrilla juncea* out-competes native rivals for nitrogen, leading to a transformation of soil biochemisrty (McVean 1966, Panetta and Dodd 1987b, Sheley et al. 1999).

Sources of information: See cited literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Identify type of impact or alteration: *Chondrilla juncea* forms dense monocultures on rangelands. Outcompetes natve plants for both nitrogen and water, and out-reproduces native plants through production of large quantities of seed that can remain viable in dry climates for >8 years.

Rationale: *Chondrilla juncea* invasion of rangelands typically establishes monocultures in disturbed or degraded areas where nitrogen levels are low and shading plants are sparse (McVean 1966, Panetta and Dodd 1987b). Stands of *C. juncea* become dense, and because it is a competitor for water and nitrogen it pushes out native plant species and can drastically reduce the plant bio-diversity in an invaded area (Sheley et al. 1999). In sandy and gravely soils roots will branch from the taproot and are capable of spreading several feet, each one able to produce daughter rosettes. Rapid reproduction depletes nitrogen and moisture, displacing native species rapidly. When agricultural lands were invaded in Australia, wheat yields dropped by 80% (Sheley et al. 1999).

Sources of information: See cited literature.

Question 1.3 Impact on higher trophic levels *Score:* **U** *Doc'n Level:* **No info.**

Identify type of impact or alteration: *Chondrilla juncea* forms thick monocultures that can push out and reduce native forage, fibrous flowering stem may cause choking and loss of condition.

Rationale: No known formal studies have been conducted in Arizona to assess the impact on higher trophic levels. *Chondrilla juncea* forms thick monocultures that can drasticly reduce native forage (Sheley et al. 1999). Evidence presented in Australian and Canadian literature indicates that rush skeletonweed is consumed during particular growth phases by domestic sheep, goats, horses, and cattle, and by some wildlife species (Panetta and Dodd 1987b, McVean 1966, Martin 1997, Harris 2003). Rosette leaves and stems prior to flowering are more palatable to domestic sheep and other domestic animals, though domestic goats and wild herbivores will consume the older, more fibrous stems as well (McVean 1966, Harris 2003). The fibrous flowering stem may cause choking and loss of condition when eaten by dairy cattle (Panetta and Dodd 1987b).

Sources of information: See cited literature.

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Rev. sci. pub.**

Identify impacts: Typically does not hybridize. No known native congeners occur in Arizona.

Rationale: *Chondrilla juncea* is an apomict, reproducing without pollination or genetic recombination, and as a result forms distinct genetic bio-types and rarely hybridizes (McVean 1966, Cuthbertson 1974, Panetta and Dodd 1987b). Kearney and Peebles (1960) do not identify any native *Chondrilla* in Arizona.

Sources of information: See cited literature.

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Obs.**

Describe role of disturbance: Human disturbance is the primary means of spread. Road construction and field cultivation produces soil conditions susceptible to *C. juncea*. *Chondrilla juncea* thrives along roadsides and other disturbed areas, from which it spreads into adjacent areas.

Rationale: Lori Makarick (personal communication, 2004) reports that rush skeletonweed initially invaded the Grand Canyon National Park in the heart of the developed zone. The initial invasion of the park followed the well established pattern of *C. juncea* invasion documented in many studies (McVean 1966, Panneta and Dodd 1987a, b). McVean (1966) reports that the initial expansion of invasion in Australia by rush skeletonweed was facilitated by rail and stock movements. Human disturbance is the primary means by which *C. juncea* establishment as rush skeletonweed rarely invades healthy native vegetation (McVean 1966, Sheley et al. 1999). Although *C. juncea* can spread into undisturbed areas, the pattern of invasion is typically from roadsides into adjacent cultivated fields or heavily grazed rangeland (McVean 1966, Panetta and Dodd 1987a, b, Sheley et al. 1999). Cultivation of infested fields then becomes the primary factor of spread because *C. juncea* can produce shoots from root fragments created by mechanical injury of the plant (Old 1981).

Sources of information: See cited literature. Primary consideration also was given to a personal communication with L. Makarick (Below the Rim Vegetation Program Manager, National Park Service, Grand Canyon National Park Science Center, Flagstaff, Arizona).

Question 2.2 Local rate of spread with no management *Score:* **A** *Doc'n Level:* **Obs.**

Describe rate of spread: Under optimal conditions, skeletonweed can double in <10 years.

Rationale: Lori Makarick (personal communication, 2004) reports that an unmanaged patch of skeletonweed spread from ~ 4.43 m^2 to over 6,300 m^2 in just one year. According to McVean (1966), the initial spread of *C. juncea* in Australia was 15 miles (24 km) per year.

Sources of information: See cited literature. Primary consideration also was given to a personal communication with L. Makarick (Below the Rim Vegetation Program, National Park Service, Grand Canyon National Park Science Center, Flagstaff, Arizona, 2004)).

Question 2.3 Recent trend in total area infested within state *Score:* **B** *Doc'n Level:* **Obs.**

Describe trend: Actual observations, beyond that articulated by L. Makarick (personal communication, 2004) in question 2.2 are unavailable. Rate of spread is likely increasing, but less rapidly than doubling in <10 years.

Rationale: No specific information on trend is available at this time; however, the Working Group inferred, based on the example provided by L. Makarick (personal communication, 2004) in question 2.2, that total area infested in the state is likely not stable but that more information is needed before it can said the rate of range expansion statewide is doubling in <10 years.

Sources of information: Personal communication with L. Markarick (Below the Rim Vegetation Program, National Park Service, Grand Canyon National Park Science Center, Flagstaff, Arizona, 2004) and inference by members of the Working Group.

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Describe key reproductive characteristics: *Chondrilla juncea* reproduces sexually, asexually by apomictic seeds, and vegetatively from adventitious buds on roots. A single plant can produce up to 20,000 seeds, of which 90% germinate in the first year.

Rationale: *Chondrilla juncea* reproduces asexually by apomictic seed and vegetatively from adventitious buds on roots(self fertilization creates clones, giving rise to dominating well-adapted biotypes). One plant can produce as many as 20,000 seeds, of which ~ 90% germinate, and can grow from rosette to seed maturity in one month. (Dodd and Panetta 1987). In sandy and gravely soils roots will branch from the taproot and are capable of spreading several feet, with each one able to produce daughter rosettes, and a dense infestation has an estimated seed production of 70,000 m^2 (McVean 1966, Rosenthal et al. 1968 and other references in Old 1981, Panetta and Dodd 1987b). Furthermore, skeletonweeds that are injured mechanically form shoots from any part of the main root, lateral root, or root fragments that are viable until they desiccate (Cuthbertson 1972 in Zouhar 2003). One mature plant can colonize an area by vegetative reproduction through rosettes formed on its spreading lateral roots.

Sources of information: See cited literature.

Question 2.5 Potential for human-caused dispersal *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Identify dispersal mechanisms: Vehicles, farm and road maintenance machinery, railroads and grazing. *Chondrilla juncea* also contaminates hay that has been harvested from an invaded area.

Rationale: Lori Makarick(personal communication, 2004) reports that the initial invasion of Grand Canyon National Park was via anthropogenic vectors, primarily vehicular. *Chondrilla juncea* has the capability to spread long distances naturally, but once established in range, cultivated land, or on roadsides, its primary means of spread is by root fragmentation and seed contaminating fodder and farm and maintenance machinery (to the extent that machinery and vehicles in contact with, or passing through an area infested must be washed thoroughly and cattle grazing in infected areas quarantined for at least 14 days before moving into a new area) (McVean 1966, Old 1981, McLellan 1991, Sheley et al. 1999). *Chondrilla juncea* was first seen in Grand Canyon National Park along the rail tracks intersecting the park (K. Watters, personal communication, 2004).

Sources of information: See cited literature. Consideration also was given to personal communications with L. Makarick (Below the Rim Vegetation Program, National Park Service, Grand Canyon National Park Science Center, Flagstaff, Arizona, 2004) and K. Watters (Research Technician, National Park Service, Grand Canyon National Park, Flagstaff, Arizona, 2004).

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Identify dispersal mechanisms: Wind, animal fur, and passage through digestive tracts of animals. Root fragments created through any natural disturbance, such as flooding events, can be translocated down stream and produce viable plants.

Rationale: *Chondrilla juncea* seeds are light-weight, with parachute-like pappus that enables it to disperse by wind over great distances (McVean 1966, Groves and Williams 1975, Dodd and Panetta 1987).

Sources of information: See cited literature.

Question 2.7 Other regions invaded *Score:* **A** *Doc'n Level:* **Other pub.**

Identify other regions: Plant communities susceptible to invasion are: *Artemisia tridentata* (sage brush), *Stipa comata* (needle-and thread grass), *Aropyron spicatum* (bluebunch wheatgrass), *Poa secunda* (Sandberg's bluegrass), *Purshia tridentata* (bitterbrush), and *Agropyron spicatum* (bluebunch wheatgrass) (Sheley et al. 1999)

Rationale: Sheley et al. (1999) identified these specific plant communities, but do not document specific geographic regions or areas of infestation.

Sources of information: See cited literature.

Question 3.1 Ecological amplitude *Score:* **B** *Doc'n Level:* **Other pub.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: See Worksheet B and Zouhar (2003). *Chondrilla juncea* has a diverse geographic and environmental range, from Canada to the Southwest U.S. and up to 2000 feet in elevation. It prefers sandy or gravely well-drained soil, in climates with hot dry summers and cool winters without prolonged drought, and rainfall less than 250 mm (10 in) to more than 1200 mm (~50 in). The wide range of adaptability gives *C. juncea* an advantageous flexibility (McVean 1966, Panetta and Dodd 1987b).

General climate: Rush skeletonweed occurs over a wide range of climatic conditions. The greater part of its native range lies in Mediterranean and steppe climates. Rush skeletonweed does not occur in the cool, maritime climates of extreme western Europe nor in arid, desert climates of central Algeria, southern Iraq or central Australia. Humid, subtropical climates are apparently suitable for rush skeletonweed, provided the winters are cool. Optimum conditions for rush skeletonweed in Australia include cool winters, warm summers without severe summer drought, a distinct increase in precipitation at the onset of the cool season, and additional spring rainfall (Moore 1964, McVean 1966, Panetta and Dodd 1987b). Summer-dry montane and Mediterranean habitats are favored by rush skeletonweed in the western U.S. (Harris 2003).

Soil characteristics, soil moisture: Where rush skeletonweed is native, it appears to favor coarse-textured, well-drained soils such as sand dunes, granite outcrops, and other coarse soils (McVean 1966). In all parts of its native range the soils on which rush skeletonweed grows appear to be calcareous or only mildly acid (Moore 1964, McVean 1966). In general, the soils on which dense infestations of rush skeletonweed were found in Mediterranean Europe had a relatively high percentage of sand and were low in nutrients (Tu et al. 2001, USDA 2001). According to Wapshere et al. (1976), the optimal nutrient level for rush skeletonweed is relatively low, and competition (promoted by high nutrient levels) is of much greater relative importance to rush skeletonweed survival than is nutrient availability.

In Australia, rush skeletonweed occurs on all but heavy clay soils and develops best and is most abundant on deep sands, sandy loams, and sandy-clay loams (Moore 1964, Cullen and Groves 1977, Panetta and Dodd 1987b). Rush skeletonweed plants generally do not establish on undisturbed, fine-textured soils (McVean 1966, Panetta and Dodd 1987b).

Soil types that favor establishment and persistence of rush skeletonweed support mesic-xeric to xeric plant communities. These communities naturally display very low density plant cover which provides rush skeletonweed seedlings a favorable environment for establishment. The coarse textured soils also allow for lateral root growth and horizontal spread of rush skeletonweed (Old 1981, 1990). Rush skeletonweed also occasionally occurs in deeper and/or finer textured soils when spread by root fragments (Old 1990). Because of the high degree of conformity of rush skeletonweed infestation to shallow or sandy-gravelly soil types.

Precipitation: In the western Mediterranean, maximum densities of rush skeletonweed occur in areas with a relatively hot, dry summer without a heavy drought, with an average rainfall of 16 to 28 inches (400-700 mm), relatively evenly distributed throughout the year (Wapshere et al 1974). In Australia rush skeletonweed has been recorded from districts with mean annual rainfalls ranging from 9 to 60 inches (230-1520 mm) (Moore 1964, McVean 1966, Wells 1971).

Timing of precipitation is important for establishment and spread of rush skeletonweed. In areas where summer showers followed by severe drying are common, the rush skeletonweed seed bank is likely to be depleted since seedlings are likely to die of desiccation, thus limiting its spread by seed (Cuthbertson 1966, McVean 1966, Schirman and Robocker 1967, Panetta 1988).

Elevation/aspect: The elevational range of rush skeletonweed is from close to sea level in Australia and Europe up to 5,100 feet (1,550 m) in Central Europe, Cyprus and the Southern Highlands of New South Wales, and up to 5,900 feet (1,800 m) in Armenia. In Australia, infestations along roadsides and sheep tracks are common at 4,000 to 4,900 feet (1,200 to 1,500 m), but these plants do not flower until the end of March, by which time the flowering season below an altitude of 2,000 feet (600 m) has been completed. It has been observed that plants growing at elevations near 5,400 feet (1,650 m) in Australia may not flower until just before the onset of winter, so that little or no seed is set (McVean 1966). Rush skeletonweed occurs from sea level to 2,000 feet (0 to 600 m) in California (Hickman 1993) and up to 3,000 feet (950 m) in British Columbia (Harris 2003).

Germination: In general, rush skeletonweed seeds have high viability and high germination rates. Viability is not dependent on pollinators (Cuthbertson 1974) and does not appear to be affected by moisture availability during the growing season (Liao 1996), although it does appear to decrease during storage (Ballard 1956, Moore 1964, Cuthbertson 1970, Panetta 1989, Old 1981, 1990, Liao 1996). Germination of rush skeletonweed seeds does not require light (McVean 1966, Cuthbertson 1970) and occurs over a wide range of temperatures (Ballard 1956, Moore 1964, McVean 1966, Panetta 1987). Germination is sensitive to moisture availability and depth of seed burial (Cuthbertson 1970).

Cuthbertson (1974) found 95.8% seed viability from unstressed rush skeletonweed plants, while McVean (1966) found that, even under ideal germination conditions, up to 20% of ripe embryos may "remain dormant or die." Normally dispersed rush skeletonweed seeds collected in Washington gave no indication of innate dormancy. Immediately after collection, samples gave 95% germination on blotters (Schirman and Robocker 1967).

Germination of rush skeletonweed seed is sensitive to moisture availability. Cuthbertson (1970) found that rates and final percentages of germination were reduced progressively at osmotic tensions below -0.2 MPa, until germination ceased at -1.6 MPa. Buried rush skeletonweed seeds germinated readily following summer rainfall events of less than 0.4 inch (10 mm) in Australia (Ballard 1956, Panetta 1989). Moisture loss may be rapid when fully or partially imbibed rush skeletonweed seeds are exposed to drying influences, so germination may be promoted by slight burial (Ballard 1956, McVean 1966, Panetta and Dodd 1987b). In Australian studies, rush skeletonweed seeds lying on the surface were much less likely to germinate in response to small rainfall events (Ballard 1956, Panetta 1989). Seedlings emerged successfully from rush skeletonweed seeds buried up to about 2 inches (5 cm) in sandy soil, but did not emerge from seeds at this depth in soils of finer texture (McVean 1966). Maximum depth of seed burial resulting in rush skeletonweed seedling emergence was 1 inch (2.5 cm) in a medium-textured soil, and no emergence was observed from seeds buried below 0.75 inch (2 cm) in clay soils (Ballard 1956 and references therein, Moore 1964, Panetta 1989). Rush skeletonweed seeds are sensitive to reduced oxygen and fail to germinate below the surface of waterlogged soil (McVean 1966).

Rationale: Worksheet B and above. Observed in two major and minor ecological types within the Grand Canyon National Park: scrublands (Great Basin montane scrub) and forests (montane conifer forest) (K. Watters, personal communication, 2004).

Sources of information: See cited literature. Also considered personal observations from K. Watters (Research Technician, National Park Service, Grand Canyon National Park, Flagstaff, Arizona, 2004).

Question 3.2 Distribution *Score:* **D** *Doc'n Level:* **Obs.**

Describe distribution: Limited within the ecological types in which occurs.

Rationale: Observed only within the Grand Canyon National Park within two major and minor ecological types: scrublands (Great Basin montane scrub) and forests (montane conifer forest) (K. Watters, personal communication, 2004).

Sources of information: Personal observations from K. Watters (Research Technician, National Park Service, Grand Canyon National Park, Flagstaff, Arizona, 2004). No listings in SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed July 21, 2004).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**[✓ Yes] No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**[✓ Yes] No**	**2 pt.**
Populations of this species produce seeds every year.	**[✓ Yes] No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**[✓ Yes] No**	**1 pt.**
Seeds remain viable in soil for three or more years	**[✓ Yes] No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**[✓ Yes] No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**[✓ Yes] No**	**1 pt.**
Fragments easily and fragments can become established elsewhere	**[✓ Yes] No**	**2 pt.**
Resprouts readily when cut, grazed, or burned	**[✓ Yes] No**	**1 pt.**

Total pts: 12 Total unknowns: 0

Score : A

Note any related traits: Seed viability over time as documented in studies varied from a few days to over eight years.

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	**D**
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	
	montane riparian	
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Cirsium arvense* (L.) Scop. (USDA 2005)
Synonyms:	*Carduus arvensis* (L.) Robson, *Cirsium arvense* (L.) Scop. var. *argenteum* (Vest) Fiori, *Cirsium arvense* (L.) Scop. var. *horridum* Wimmer & Grab., *Cirsium arvense* (L.) Scop. var. *integrifolium* Wimmer & Grab., *Cirsium arvense* (L.) Scop. var. *mite* Wimmer & Grab., *Cirsium arvense* (L.) Scop. var. *vestitum* Wimmer & Grab., *Cirsium incanum* (Gmel.) Fisch., *Cirsium setosum* (Willd.) Bess. ex Bieb., *Serratula arvensis* L. (USDA 2005)
Common names:	Canada thistle, field thistle, creeping thistle, California thistle
Evaluation date (mm/dd/yy)**:**	06/20/04
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Committee review date:	08/06/04
List date:	08/06/04
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		**Score**	**Documentation Level**	**Section Scores**	**Overall Score & Designations**
1.1	Impact on abiotic ecosystem processes	**B**	Other published material	**“Impact”** **Section 1 Score:** **B**	**“Plant Score”** **Overall Score:** **Medium** **Alert Status:** **None**
1.2	Impact on plant community	**A**	Other published material		
1.3	Impact on higher trophic levels	**B**	Other published material		
1.4	Impact on genetic integrity	**U**	Observational		
2.1	Role of anthropogenic and natural disturbance	**B**	Other published material	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **14 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**A**	Other published material		
2.3	Recent trend in total area infested within state	**U**	No information		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**B**	Other published material		
2.6	Potential for natural long-distance dispersal	**C**	Other published material		
2.7	Other regions invaded	**A**	Other published material		RED FLAG **YES** Something you should know.
3.1	Ecological amplitude	**A**	Observational	**“Distribution”** **Section 3 Score:** **B**	
3.2	Distribution	**D**	Observational		

Red Flag Annotation

Cirsium arvense has been observed in a variety of ecosystems/plant communities across Arizona and in even more ecological types in other states, but it currently has few occurrences within any specific ecological type in Arizona. Above elevations of 1,525 meters (5,000 feet), *C. arvense* has a high potential to invade many ecological types. It may not have had, however, enough time or opportunity to exploit these types. Because this plant is extremely difficult to control, land managers currently without infestations may want to consider this plant as a priority for early detection and monitor accordingly.

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **B** *Doc'n Level:* **Other pub.**

Identify ecosystem processes impacted: Canada thistle significantly depletes soil nutrients and moisture.

Rationale: Canada thistle has dense horizontal roots and deep vertical roots that deeply penetrate the soil. Vertical roots can grow up to 22.5 feet below the surface and horizontally, roots ordinarily can grow as far as 20 feet in one season (Rogers 1928). Most patches spread at the rate of 1−2 meters/year (Amor and Harris 1975). The extensiveness of the root system makes it highly effective at uptaking soil moisture, minerals, and soil nutrients (Moore 1975). Although *Cirsium arvense* is primarily an economic concern to agricultural land in Canada. In crop situations (Canada) it uses light, moisture and nutrients needed by the crop thus reducing crop yield (Moore 1975). Where *C. arvense* forms dense stands in natural areas, similar impacts—the microclimate of the soil and air temperature will be cooler due to less light penetration—are expected. It is not clear what indirect or direct impacts can result from this effect.

Sources of information: See cited literature citations. The article by Moore (1975), cited often, is a review article; therefore, "Other published material" was used as the level of documentation.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **A** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Canada thistle alters community structure and composition, decreases species diversity, and directly competes with and displaces native vegetation.

Rationale: A single seedling can form a large patch of stems through the vegetative propagation of the root system. The spread of the clone may continue indefinitely, groups of stems becoming independent as the root system breaks up. Canada thistle usually occurs as a clump of stems and a large area may become infested by a single introduction but no seed will be produced [need both sexes] (Moore 1975). Several authors have identified this plant as "pervasive."

In an isolated undisturbed study area east of Fort Collins in Colorado, species diversity decreased with an increase in relative frequency of Canada thistle; this characteristic remained consistent throughout the growing season (Stachion and Zimdahl 1980). When litter from Canada thistle was incorporated into non-infested Canada thistle soil, the growth of some species (non-natives-green foxtail, *Amaranthus retroflexus* and *Hordeum jubatum*) were reduced but cucumbers were not (greenhouse experiment). Effects were correlated with the addition of litter (Stachion and Zimdahl 1980). Similar results occurred for the addition of Canada thistle root and foliage residues independent of soil or additional nutrients. This previous study and studies by Bendall (1975) demonstrated the toxicity of Canada thistle roots and foliage. Working Group members noted its ability to act as a natural herbicide.

Cirsium arvense is primarily an economic concern to agricultural land in Canada. In crop situations it uses light, moisture and nutrients needed by the crop thus reducing crop yield (Moore 1975). This situation is artificially maintained and may not hold true for natural settings.

From Nuzzo (1997): Canada thistle aggressively invades natural communities primarily by vegetative expansion and secondarily by seedling establishment. It competes by depleting soil moisture for the germination of native species, vegetatively expands by horizontal roots to form dense, closed stands, and appears to be mildly allelopathic (Stachion and Zimdahl 1980). Seedlings require high light and low competition to survive (Bakker 1960, Hodgson 1968, Moore 1975). Thus, it is often an edge of forest or early successional species.

Sources of information: See cited literature.

Question 1.3 Impact on higher trophic levels *Score:* **B** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Canada thistle reduces forage for native grazers and livestock (Hodgson 1968 in Stachion and Zimdahl 1980). It is unpalatable and the flower has spines.
Competes for foraging pollinators and is a host for predatory introduced and native insects.

Rationale: Although young thistle shoots are sometimes eaten by grazing animals (in Europe, Detmers 1927 in Moore 1975), spines on mature shoots can irritate grazing animals and cause skin inflammations and possibly infections (Rogers 1928, Moore 1975).

From Nuzzo (1997): Flowers of *C. arvense* are exclusively insect-pollinated (Lalonde and Roitberg 1994). More insect species visit *Cirsium arvense* than other *Cirsium* or *Carduus* species due to the "accessibility of its copious nectar" (Ellis and Ellis-Adam 1992). Although *Cirsium arvense* may help maintain diversity of pollinating insects in this way (Ellis and Ellis-Adam 1992), it negatively impacts native plant communities and may thus have a negative impact on overall insect diversity as well.

The flowering time of Canada thistle corresponds with the flowering times of native thistles and many other native plants (W. Litzinger, personal observations, 2004) thus competing for foraging pollinators.

Sources of information: See cited literature. Also considered the unpublished field observations of W. Litzinger (Environmental Studies Faculty, Prescott College, Prescott, Arizona, 2004).

Question 1.4 Impact on genetic integrity *Score:* **U** *Doc'n Level:* **Obs.**

Identify impacts: Because of its phenology and potential distribution Canada thistle could possibly hybridize with native species, but this has not been documented.

Rationale: Canada thistle can potentially occur in the same habitats and flower at the same time as native species, such as *Cirsium arizonicum*, and *Cirsium parryi* (Litzinger, personal observations, 2004).

From Moore (1975): Approximately nine hybrids between *C. arvense* and Old World species of C*irsium* have been reported in Europe (Hegi 1929) but only one of the latter species (*C. palustre*) has been introduced in North America and it is rare [and does not occur in Arizona].

Randall Scott (personal communication, 2004) has looked for *Cirsium* hybrids in northern Arizona and has not encountered any that appear to involve *C. arvense*. It is from a very different lineage within *Cirsium* from the native species of the Southwest and Scott suspects that given the period of time that it was separated from these species (and the resulting genetic differentiation they all have undergone) that it would be able to hybridize with them.

Sources of information: See cited literature. Also considered the unpublished field observations of W. Litzinger (Environmental Studies Faculty, Prescott College, Prescott, Arizona, 2004) and personal communication with R. Scott (Professor, Northern Arizona University, Falgstaff, Arizona, 2004).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Canada thistle needs disturbance for introduction and establishment.

Rationale: Canada thistle has difficulty establishing itself from seed in undisturbed areas whereas it has a high seedling establishment rate on bare soil (Amor and Harris 1974 in Nuzzo 1997). Plowing and other soil disturbances (soil relocation associated with construction, road building, etc.) can spread vegetative structures which can propagate and establish elsewhere. If an area is undisturbed but next to a disturbed area, *C. arvense* can spread into the undisturbed area via asexual reproduction (Working Group comments).

Sources of information: See cited literature. Also considered Working Group member observations.

Question 2.2 Local rate of spread with no management *Score:* **A** *Doc'n Level:* **Other pub.**

Describe rate of spread: Canada thistle spreads rapidly by the vegetative growth of its horizontal root system.

Rationale: Vegetative spread through horizontal growth of the root system can extend 4 to 5 m radially in one season (Bakker 1960); 6 meters (according to Hayden [1934] and Rogers [1928] in Moore 1975). Individual clones can reach up to 35 m in diameter in one growing season (Donald 1994).

Sources of information: See cited literature.

Question 2.3 Recent trend in total area infested within state *Score*: **U** *Doc'n Level:* **No info.**

Describe trend: Appears to be stable in Arizona, but remains undocumented.

Rationale: From Nuzzo (1997): From the 17th century to the present Canada thistle spread widely in North America. It was declared a noxious weed by the state of Vermont in 1795 (Hansen 1918). By 1918 it was a noxious weed in the 25 northern states and by 1991 in 35 states and 6 Canadian provinces. It is now in all U.S. states (Moore 1975).

Sources of information: See cited literature. The Working Group members thought that there is not enough evidence or personal knowledge of this plant in Arizona to respond to this question.

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: Canada thistle has a high innate reproductive potential both by seed and from vegetative structures.

Rationale: Canada thistle produces abundant seed from both female and hermaphroditic male flowers. Highly successful vegetative propagation by creeping horizontal roots which extend year after year, giving rise to numerous aerial shoots and thus establishing independent plants (Moore 1975).

From Nuzzo (1997): Annual seed production of single plants averages 1500 seeds and can be up to 5300 seeds per plant (Moore 1975). Seed viability and seedling establishment rates are high. Although *C. arvense* are obligate outcrossers, up to 26% of "male" plants are self-fertile hermaphrodites capable of producing seeds (Kay 1985). Germination and dormancy vary with ecotypes. Some ecotypes have lower germination rates and/or long dormancy periods (Hodgson 1964). Seed longevity appears to be a direct relation to the depth of the planting. Seed buried in the soil can remain viable for up to 21 years in the U.S. and percent germination after x number of years is a function of storage depth (Toole and Brown 1946). Viability is dependent on environmental conditions and depth of buried seed (Moore 1975). Canada thistle readily propagates from root fragments. Root fragments as small as 0.5 cm up to six weeks old can regenerate.

Sources of information: See cited literature.

Question 2.5 Potential for human-caused dispersal *Score:* **B** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Canada thistle seed is spread by: a contaminant in agricultural seed and hay; in livestock manure; fire suppression activities; and on farm and fire machinery (Nuzzo 1997). Vegetative propagules are spread by plowing and other soil disturbances, typically road construction.

Rationale: Increased road building, off road vehicle use, and disturbances such as from heavy equipment used to fight wild land fires, including activities such as constructing fire containment lines, can contribute to the spread of Canada thistle. Working Group members thought that hay for agricultural purposes had high human-caused dispersal potential but the other means were occasional.

Sources of information: See Nuzzo (1997). Also considered Working Group member discussion.

Question 2.6 Potential for natural long-distance dispersal *Score:* **C** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Canada thistle disperses long-distance by wind blown seeds (infrequent); water; and animals. Viable seed can pass through the digestive tract of grazing animals.

Rationale: From Nuzzo (1997): Most often the pappus breaks off easily from the seed, leaving the seeds in the flower head with most of the seeds landing near the parent plant. Some long distance dispersal occurs as evidenced by the 0.2% of seeds found with a pappus still attached 1 km from the parent plant (Bakker 1960). Seed viability is very low (0.5%) after passage through bovine digestive tracts (Lhotska and Holub 1989). Seeds may also be transported by water (Hope 1927).

Sources of information: See cited literature.

Question 2.7 Other regions invaded *Score:* **A** *Doc'n Level:* **Other pub.**

Identify other regions: Other ecological type invaded elsewhere but not in Arizona are montane wetland (assumed equivalent to sedge meadows; see below). And in New Mexico, pinyon-juniper (Great Basin conifer woodland) and southwestern interior riparian (assumed equivalent to *Populus-Fraxinus* habitats of California; see below).

Rationale: From Zouchar (2001): Southwest: In New Mexico, Canada thistle was found in pinyon-juniper (*Pinus-Juniperus* spp.) woodland, on an abandoned uranium spoil, with broom snakeweed (*Gutierrezia sarothrae*), Indian ricegrass (*Achnatherum hymenoides*), winterfat (*Krascheninnikovia lanata*), hairy goldenaster (*Heterotheca villosa*), scarlet globemallow (*Sphaeralcea coccinea*), black grama (*Bouteloua eriopoda*), and tall dropseed (*Sporobolus asper*) (Fisher and Fancher 1990). At Mesa Verde National Park in Colorado, Canada thistle is found in Colorado pinyon (*Pinus edulis*)-juniper (*Juniperus* spp.) habitats where it is most common in riparian corridors with species such as boxelder (*Acer negundo*), Utah serviceberry (*Amelanchier utahensis*), fendlerbush (*Fendlera rupicola*), Gambel oak (*Quercus gambelii*), Wood's rose (*Rosa woodsii*), mountain snowberry (*Symphoricarpos oreophilus*), true mountain-mahogany (*Cercocarpus montanus*), chokecherry (*Prunus virginiana*), and antelope bitterbrush (*Purshia tridentata*) (Floyd-Hanna and Hanna 1999). In the coastal redwood (*Sequoia sempervirens*) zone in California, Canada thistle may be found in cottonwood (*Populus* spp.)-ash (*Fraxinus* spp.) habitats (Waring and Major 1964) (assumed equivalent to southwestern interior riparian).

From Nuzzo (1997): Canada thistle is native to southeastern Europe and the eastern Mediterranean, possibly northern Europe, western Asia and northern Africa. From the 17th century to the present Canada thistle as spread widely in North America. It was declared a noxious weed by the state of Vermont in 1795 (Hansen 1918). By 1918 it was a noxious weed in the 25 northern states and by 1991 in 35 states and 6 Canadian provinces. It is now in all U.S. states and has near global distribution between 37 and 58−59 degrees north latitude and at latitudes greater than 37 degrees south, exclusive of Antarctica (Moore 1975).

Cirsium arvense is invasive in prairies and other grasslands in the midwest and Great Plains and in riparian areas in the intermountain west. It is particularly troublesome in the northwest and north-central states, and in southern Canada (Moore 1975). *Cirsium arvense* occurs in nearly every upland herbaceous community within its range, and is a particular threat in prairie communities and riparian habitats. In the Great Plains Canadian thistle invades wet and wet-mesic grasslands as well as prairie potholes in the Dakotas. It also invades riparian areas and along irrigation ditches from the western plains across the northern half of the intermountain west to the Sierra Nevada and Cascade ranges. In the upper Midwest (Wisconsin and Illinois) *Cirsium arvense* is found in degraded sedge meadows, growing on tussocks elevated above the normal high water line. In Canada, *Cirsium arvense* is frequent in prairie marsh (Thompson and Shay 1989) and sedge meadow (Hogenbirk and Wein 1991). Throughout its range it is common on roadsides, in old fields, croplands, and pastures, in deep, well-aerated, mesic soils. In eastern North America, it occasionally occurs in relatively dry habitats, including sand dunes and sandy fields, as well as on the edges of wet habitat, including stream banks, lakeshores, cleared swamps, muskegs and ditches (Moore 1975).

In Canada it is occasionally found in dry habitats-sand dunes and open sandy areas, although it prefers moister areas. It is found in grassy openings in woods and on forest margins both deciduous and conifer, edges of wet habitat, including stream banks, lakeshores, cleared swamps, muskegs and ditches (Moore 1975).

Sources of information: See cited literature.

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Invades three major ecological types. See Worksheet B.

From Nuzzo (1997): The species range is determined by rainfall, temperature, and day length (in Canada; Moore 1975). Based on optimal growth preferences (occurs at 77° F day and 59° F night, in mesic soil with high nitrogen (15–30 ppm) (Haderlie et al. 1987). In Montana the plant grows best where rainfall averages 50–75 cm/year (Hodgson 1968).

Thus, in Arizona, Canada thistle may be limited by high summer temperatures, short-day length, and low rainfall and may not invade other ecological types in Arizona in the short-term.

From Nuzzo (1997): *Cirsium arvense* grows on all but waterlogged, poorly aerated soils, including clay, clay loam, silt loam, sandy loam, sandy clay, sand dunes, gravel, limestone, and chalk, but not peat (Rogers 1928, Bakker 1960, Hodgson 1968, Moore 1975). It grows best on mesic soils: in a transplant experiment, Hogenbirk and Wein (1991) determined that *Cirsium arvense* cover increased 5- to 13-fold when sods were moved from a wetland to a mesic location.

Canada thistle was collected in Arizona near Flagstaff in 1920 and near Prescott in 1936 (Kearney and Peebles 1960). Litzinger (personal observations, 2004) collected Canada thistle in June, 2003 along a dry wash in an interior chaparral community near Prescott, Arizona.

Favorable conditions are unshaded, moist, aerated clay loam (Bakker 1960).

Rationale: The ecological types that Canada thistle invades in Arizona have not been formally documented beyond what can be inferred from herbaria records. The following information comes from Working Group member personal observations and herbaria records.

Areas of infestation: in Switzer Canyon—in an urban area (SFPWMA 2000); in the Prescott area it has not become locally common or locally widespread (W. Litzinger, personal observation, 2004)—potentially could invade montane forests and grasslands in the area; and Canyon Creek of Tonto National Forest (northeast Gila County) (F. Northam, personal communication, 2003.

Cirsium arvense is present in Yavapai (Prescott) and Coconino (Flagstaff) Counties (Kearney and Peebles 1960, SEINet 2004).

Sources of information: See cited literature. Also considered personal observations by W. Litzinger (Environmental Studies Faculty, Prescott College, Prescott, Arizona, 2004), personal communication with F. Northam (Noxious Weed Coordinator, Arizona Department of Agriculture, 2003), and information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed June 22, 2004).

Question 3.2 Distribution *Score:* **D** *Doc'n Level:* **Obs.**

Describe distribution: The frequency at which Canada thistle invades the ecological types listed in Worksheet B is low (<5%).

Rationale: The distribution within the state is not well documented. Although the actual distribution is considered low, the future potential is high.

Sources of information: The estimated distribution of Canada thistle as indicated in Worksheet B are based on field observations (see question 3.1) and Working Group member consensus.

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ **Yes**]	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	[✓ **Yes**]	**No**	**2 pt.**
Populations of this species produce seeds every year.	[✓ **Yes**]	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	[✓ **Yes**]	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	[✓ **Yes**]	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	[✓ **Yes**]	**No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	[✓ **Yes**]	**No**	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	[✓ **No**]	**2 pt.**
Resprouts readily when cut, grazed, or burned	[✓ **Yes**]	**No**	**1 pt.**

Total pts: 10 Total unknowns: 0

Score : A

Note any related traits: Could fragment but does not do so easily (Working Group consensus).

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	**D**
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	
	montane riparian	**D**
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Cirsium vulgare* (Savi) Ten. (USDA 2005)
Synonyms:	*Carduus lanceolatus* L., *Carduus vulgaris* Savi, *Cirsium lanceolatum* (L.) Scop., non Hill, *Cirsium lanceolatum* (L.) Scop. var. *hypoleucum* DC. (USDA 2005)
Common names:	Bull thistle, common thistle, spear thistle
Evaluation date (mm/dd/yy)**:**	12/14/04
Evaluator #1 Name/Title:	Debra L. Crisp, Botanist
Affiliation:	USFS, Coconino National Forest
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Evaluator #2 Name/Title:	F. E. Northam
Affiliation:	Weed Biologist
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List committee members:	J. Hall, P. Fenner, L. Making, F. Northam, T. Olson, G. Russell
Committee review date:	04/22/05
List date:	04/22/05
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**C**	Reviewed scientific publication	**“Impact”** **Section 1 Score:** C	**“Plant Score”** **Overall Score:** **Low** **Alert Status:** **None**
1.2	Impact on plant community	**C**	Reviewed scientific publication		
1.3	Impact on higher trophic levels	**C**	Reviewed scientific publication		
1.4	Impact on genetic integrity	**U**	Reviewed scientific publication		
2.1	Role of anthropogenic and natural disturbance	**B**	Reviewed scientific publication	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **13 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Other published material		
2.3	Recent trend in total area infested within state	**U**	Observational		
2.4	Innate reproductive potential	**A**	Reviewed scientific publication		
2.5	Potential for human-caused dispersal	**A**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Observational		
2.7	Other regions invaded	**C**	Reviewed scientific publication		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**A**	Observational	**“Distribution”** **Section 3 Score:** **B**	
3.2	Distribution	**C**	Observational		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **C** *Doc'n Level:* **Rev. sci. pub.**

Identify ecosystem processes impacted: Minor alteration of soil nutrients. The decay process of liter produced by dead leaves from adult bull thistle plants may immobilize soil nutrients, especially nitrogen (de Jong and Klinkhamer 1985).

Rationale: In an experiment in the Netherlands, the decay process of liter produced by dead leaves from adult bull thistle plants was thought to immobilize soil nutrients, especially nitrogen (de Jong and Klinkhamer 1985). However, results were inconclusive.

Sources of information: See cited literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **C** *Doc'n Level:* **Rev. sci. pub.**

Identify type of impact or alteration: Invades disturbed areas. Population numbers and density increase after disturbance. Occupies habitat otherwise used by native species. Competes with native plants for resources.

Rationale: Invades areas after disturbance including timber harvest, fire (Gluesenkamp 2001), grazing (George et al. 1970, Bullock et al. 1994). Increased bull thistle cover after disturbance (Petryna et al. 2002). Competition for resources between bull thistle and Suisan thistle (*Cirsium hydrophyllum* (Green) Jeps. var. *hydrophyllum*) a rare thistle in California contributed to the loss of the native species (Forcella and Randall 1994). May affect diameter growth in ponderosa pine plantations (Randall and Rejmanek 1993) Invading plants can compete with native species for water, light, nutrients, pollinators and space (Staphanian et al. 1998). Primary succession after fire (pumpkin Fire). Occupies niches available to native plants (D. Crisp, personal observation).

Sources of information: See cited literature. Also considered personal observations by D. Crisp (Botanist, U.S. Department of Agriculture, Forest Service, Coconino National Forest).

Question 1.3 Impact on higher trophic levels *Score:* **C** *Doc'n Level:* **Rev. sci. pub.**

Identify type of impact or alteration: Adults avoided by grazing animals, and may occupy growing space used by more favorable plants. Seeds are a food source for small animals.

Rationale: Spines on plant discourage use by grazing animals (Whitson et al. 1996). Bull thistle can occupy habitats that would otherwise support forage species for grazing animals (Bullock et al. 1994). In a study in California, seeds were eaten by several small mammals and insects (Gluesenkamp 2001), providing a food source that would not be available if exotic species was not present.

Sources of information: See cited literature.

Question 1.4 Impact on genetic integrity *Score:* **U** *Doc'n Level:* **Rev. sci. pub.**

Identify impacts: No hybridization documented, but potential exists.

Rationale: Nine hybrids between bull thistle and other species in the genus *Cirsium* have been described in Europe (Klinkhamer and de Jong 1993), but none have been documented in U.S. Forcella and Randall (1994) investigated hybridization between bull thistle and Suisan thistle (*Cirsium hydrophyllum* (Green) Jeps. var. *hydrophyllum*) as a cause for decline of the native species in California. However, solid evidence to support this hybrid is lacking.

Sources of information: See cited literature.

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Describe role of disturbance: Disturbance is necessary for the establishment of bull thistle. This can be either natural or anthropogenic.

Rationale: De Jong and Klinkhamer (1988) found that disturbance is necessary for establishment of bull thistle in its native habitat and it facilitates population persistence where it has been introduced. Some disturbances that facilitate bull thistle infestations disturbances are a result of human occupation and not related to a specific management activity (Doucet and Cavers 1996, Manku 1998) such as open lots and at the edges of golf courses which can be significant refugia for exotic plant infestations. Locally, bull thistle has been observed on recently developed golf courses (W. Albrecht, personal communication, 2005)

Management activities have been implicated for contributing to the establishment, spread and persistence of bull thistle. Some of these activities include grazing (George et al. 1970, Michaux, 1989, Gillman et al. 1993, Bullock et al. 1994), prescribed fire (Randall 2000, Gluesenkamp 2001, Laterra and Solbrig 2001, Petryna et al. 2002), timber activities (Gluesenkamp 2001) and reforestation (Randall 2000).

Disturbance that creates openings, removes competition or increases nutrient availability is needed for the establishment of new individuals or groups of bull thistle (de Jong and Klinkhamer 1988). The scale of disturbance can be small; the death of a parent plant or digging by an animal often provides enough disturbance to allow the establishment of a new seedling (de Jong and Klinkhamer 1988). Disturbance was also necessary for providing "safe sites" for bull thistle to become established (van der Meijden et al. 1992).

Seedlings and rosettes of bull thistle are susceptible to drought (Klinkhamer and de Jong 1993). George et al. (1970) found that bull thistle infestations increased after an extended period of drought. They attributed this to the decrease in vegetative cover and competition from other plants that allowed the bull thistle plants to become established.

Sources of information: See cited literature. Also considered personal communication with W. Albrecht (Natural Resources Educator and SFPWMA Coordinator, University of Arizona, Coconino Cooperative Extension, Flagstaff, Arizona, 2005).

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Other pub.**

Describe rate of spread: Common in disturbed areas. Bull thistle tends to become absent from a plant community after a disturbance passes, but persists in continuously or severely disturbed sites.

Rationale: Second most common noxious weed on Coconino and Kaibab national Forests in 1997 (Crisp 1997, Crisp and Lutz 1997), but some groups of bull thistle later disappeared from the documented locations. However, groups on severely disturbed sites tend to persist and provide seed sources for future infestations (Crisp 2004). New disturbances make new sites as old sites disappear. More disturbance equals more thistle. Management actions such as prescribed burning and thinning contribute to creation of new sites.

Sources of information: See cited literature.

Question 2.3 Recent trend in total area infested within state *Score:* **U** *Doc'n Level:* **Obs.**

Describe trend: Numerous locations of bull thistle documented in the northern half of the state Southwest Exotic Plant Mapping Program (SWEMP)-Cain Crisis map records (2005).

Rationale: Bull thistle occupies many disturbed areas in ponderosa pine forests in northern Arizona but the statewide trend is unknown.

Sources of information: SWEMP-Cain Crisis map records (available at: http://cain.nbii.gov/cgibin/mapserv?map=../html/cain/crisis/crisismaps/crisis.map&mode=browse&layer=state&layer=county; accessed online in 2005).

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Describe key reproductive characteristics: Bull thistle reproduces solely from seed and is a monocarpic biennial. Plants reproduce only once during their lifespan, but can form through apomixis or self-pollination.

Rationale: Bull thistle is monocarpic, monoecious, and reproduces solely from seeds. Because bull thistle seeds have little innate dormancy (Doucet and Cavers 1996), seed is capable of germinating as soon as it is dispersed if conditions are favorable (Klinkhamer and de Jong 1993). Persistence of bull thistle groups would be dependent on a continual supply of seeds from plants growing on the site or on seeds dispersed from other sites. Mortality in seeds and variability in seed production have a greater influence on population fluctuations than mortality in adult plants (Klinkhamer et al. 1988). Populations in areas such as in the Mediterranean region mature and reproduce as annuals (Wesselingh et al. 1994). Seeds form singly by apomixis, self-pollination or cross-pollination (van Leeuwen 1981) or by insects (Klinkhamer and de Jong 1993), but the potential for self-pollination is disputed (Michaux 1989). A successful bull thistle plant could form up to 8000 seeds (Klinkhamer et al. 1988). Bull thistle seeds can persist for periods from 30 months (Michaux 1989) to over three years (Doucet and Cavers 1996)

Sources of information: See cited literature.

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Contaminated seed and hay, vehicles, domestic animals, ship ballast (soil from foreign sources).

Rationale: The species entered North America in colonial times and has spread to many locations throughout the country. The source of introduction into the United States might have been from contaminated seed or from the ballast of a ship (Randall 2000). However, it is likely that multiple introductions from Europe occurred, perhaps over many years (Whitson et al. 1996). Bull thistle was documented in herbarium collections in the northwestern United States in 1882 in Oregon (Mitich 1998) and then spread eastward into most of the northwestern United States (Forcella and Harvey 1988). The presence of bull thistle seeds in adobe bricks in the southwestern United States provides evidence of the existence of the species in the region in the 1800s. Bull thistle seeds were found in adobe bricks used in construction during the post mission period, which occurred sometime after 1824 (Mitich 1998).

Sources of information: See cited literature.

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Obs.**

Identify dispersal mechanisms: Wind dispersed seeds, possibly water or an unknown source.

Rationale: Bull thistle seeds are equipped with pappi, specialized attachments that allow wind dispersal (Klinkhamer and de Jong 1993). Locally, bull thistle has been observed in Wilderness areas where the plants were greater than 1 km. from the nearest known population. An example of this is in the West Fork of Oak Creek where bull thistle has been found along creek banks. Therefore, wind, water or other unknown dispersal agents are present (B. Phillips and D. Crisp, personal observations).

Sources of information: See cited literature. Also gave consideration to personal communication with B. Phillips (Zone Botanist, U.S. Department of Agriculture, Forest Service, Coconino, Kaibab, and Prescott National Forests, Flagstaff, Arizona) and personal observations by D. Crisp (Botanist, U.S. Department of Agriculture, Forest Service, Coconino National Forest, Flagstaff, Arizona).

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Rev. sci. pub.**

Identify other regions: This species is now found in all 48 contiguous United States and in many foreign countries where it is exotic.

Rationale: Bull thistle has been studied as an invasive exotic in New Zealand (Michaux,1989), Australia (George et al. 1970), Argentina (Laterra and Solbrig 2001, Petryna et al. 2002), and Canada (Doucet and Cavers 1996, Manku 1998, Downs and Cavers 2000). Bull thistle was documented in herbarium collections in the northwestern United States in 1882 in Oregon (Mitich 1998) and then spread eastward into most of the northwestern United States (Forcella and Harvey 1988). Today it is widespread throughout the United States and Canada (Whitson et al. 1996). It is listed as a noxious weed in 10 states. This species invades elsewhere but only in ecological types already invaded in Arizona.

Sources of information: See cited literature.

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Observed in montane conifer forests, montane riparian areas and wetlands, and along lake shores.

Rationale: Widespread throughout the ponderosa pine forests (montane conifer forests) of northern Arizona (Crisp 2004). Also observed along lake shores (D. Crisp, personal observation) and in montane riparian areas (B. Phillips and D. Crisp, personal observations), and in wetlands.

Sources of information: See cited literature. Also gave consideration to personal communication with B. Phillips (Zone Botanist, U.S. Department of Agriculture, Forest Service, Coconino, Kaibab, and Prescott National Forests, Flagstaff, Arizona) and personal observations by D. Crisp (Botanist, U.S. Department of Agriculture, Forest Service, Coconino National Forest, Flagstaff, Arizona).

Question 3.2 Distribution *Score:* **C** *Doc'n Level:* **Obs.**

Describe distribution: See worksheet B.

Rationale: See question 3.1.

Sources of information: See question 3.1.

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**[✓ Yes]**	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**[✓ Yes]**	**No**	**2 pt.**
Populations of this species produce seeds every year.	**Yes**	**[✓ No]**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**Yes**	**[✓ No]**	**1 pt.**
Seeds remain viable in soil for three or more years	**[✓ Yes]**	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**[✓ Yes]**	**No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes**	**[✓ No]**	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	**[✓ No]**	**2 pt.**
Resprouts readily when cut, grazed, or burned	**Yes**	**[✓ No]**	**1 pt.**
	Total pts: 6	**Total unknowns: 0**	
	Score : A		

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	**D**
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	**D**
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	
	montane riparian	**C**
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**C**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Conium maculatum* L. (USDA 2005)
Synonyms:	None listed in USDA (2005).
Common names:	Poison hemlock, carrot fern, poison parsley, spotted hemlock, deadly hemlock, cigue maculae, cigue tachetee
Evaluation date (mm/dd/yy)**:**	02/08/04
Evaluator #1 Name/Title:	Dana Backer/Conservation Ecologist
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List committee members:	W. Albrecht, W. Austin, D. Backer, J. Crawford, H. Folger, L. Moser, F. Northam, B. Phillips, K. Watters
Committee review date:	02/17/04
List date:	02/17/04
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**U**	No information	**“Impact”** **Section 1 Score:** **B**	**“Plant Score”** **Overall Score:** **Medium** **Alert Status:** **Alert**
1.2	Impact on plant community	**C**	Other published material		
1.3	Impact on higher trophic levels	**B**	Other published material		
1.4	Impact on genetic integrity	**D**	Reviewed scientific publication		
2.1	Role of anthropogenic and natural disturbance	**C**	Observational	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **15 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Observational		
2.3	Recent trend in total area infested within state	**B**	Observational		
2.4	Innate reproductive potential	**A**	Reviewed scientific publication		
2.5	Potential for human-caused dispersal	**B**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Other published material		
2.7	Other regions invaded	**A**	Other published material		RED FLAG **NO** Information you should know.
3.1	Ecological amplitude	**B**	Observational	**“Distribution”** **Section 3 Score:** **C**	
3.2	Distribution	**D**	Observational		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **U** *Doc'n Level:* **No info.**

Identify ecosystem processes impacted: No known information.

Rationale: Several individuals were contacted, but not one person was able to provide any documentation or observations.

Sources of information: No literature or observations relevant to the question were found.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **C** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Minor alteration of community composition.

Rationale: Pioneer species that colonizes disturbed sites (biennial) and can displace natives during early successional stages (Pitcher 1989). In Australia: "Rapid establishment after autumn rains, particularly on disturbed sites or areas where there is little vegetation. Once firmly established under such conditions, hemlock can preclude most other vegetation and establish pastures" (Parsons 1973 in Pitcher 1989). **Note:** Working Group members interpreted pastures to mean dense monotypic stands and not open range.

Poison hemlock can spread quickly after the rainy season in areas that have been cleared or disturbed. Once established, it is highly competitive and prevents establishment of native plants by overshading (L. Serpa, letter to T. Thomas of The Nature Conservancy, 1989, as cited in Drewitz 2000). Field experiments have not established any allelopathic effects of poison hemlock (L. Serpa, letter to T. Thomas of The Nature Conservancy, 1989, as cited in Drewitz 2000).

Sources of information: See cited literature.

Question 1.3 Impact on higher trophic levels *Score:* **B** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Toxic to wildlife and degrades habitat quality.

Rationale: From DiTomaso (1999): poisonous to humans, wildlife, and livestock (contains eight alkaloids). The plant has a musty unpleasant odor associated with the alkaloids and because of this odor, animals will usually not consume the hemlock when other food is available (Panter and Keeler 1988, Jeffery and Robinson 1990). Poison hemlock can also cause skin irritations and rashes by simply brushing up against the plant.

Degrades habitat quality (Pitcher 1989; did not specify location). Wildlife is susceptible to the toxic effects of poison hemlock. Ten percent of an elk population on Grizzly Island, California, died from ingesting poison hemlock in 1985 (Parsons and Cuthbertson 1992 in Drewitz 2000).

In Arizona the current populations of poison hemlock do not form dense patches. More typically populations are considered patchy and sparse (Working Group discussion). The largest population is approximately two acres (Watson Woods, near Prescott; F. Northam, personal communication, 2004).

During testing of phytophagous insects as a biocontrol, it was noted that poison hemlock hosts few insect species (Goeden and Ricker 1982). A defoliating moth, *Agonopterix alstroemeriana,* is used as a biocontrol agent with good to excellent control in Oregon, Washington, and Idaho (William et al. 1998 in Makarick 1999).

Sources of information: See cited literature. Also considered personal communication with F. Northam (Weed Biologist, Tempe, Arizona, 2004).

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Rev. sci. pub.**

Identify impacts: No known hybridization.

Rationale: No known native *Conium* species in Arizona or in North America.

Sources of information: Kearney and Peebles (1960) and DiTomaso (1999).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **C** *Doc'n Level:* **Obs**.

Describe role of disturbance: Requires some degree of natural or anthropogenic disturbance to establish.

Rationale: Commonly occurs along roadsides, field margins, ditches and low-lying areas. Also invades native plant communities in floodplains and riparian areas in southern California (Goeden and Ricker 1982). It does best in disturbed areas where soil is moist with some shade. Poison hemlock is also able to form stands in dry, open areas (Parsons [and Cuthbertson] 1992 in Drewitz 2000).

Where currently established in Arizona, the areas where it invades have had both natural and anthropogenic disturbance. Working Group members inferred that natural disturbance needs to be coupled with an anthropogenic disturbance for *C. maculatum* to establish.

Sources of information: See cited literature. Also considered inference by Working Group members.

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Obs.**

Describe rate of spread: Increases but less rapidly than doubling in <10 years.

Rationale: In newly disturbed areas it can spread rapidly (DiTomaso 1999). In Australia: "Rapid establishment after autumn rains, particularly on disturbed sites or areas where there is little vegetation. Once firmly established under such conditions, hemlock can preclude most other vegetation and establish pastures" (Parsons 1973 in Pitcher 1989). **Note:** Working Group members interpreted pastures to mean dense monotypic stands and not open range.

In California poison hemlock can spread quickly after the rainy season in areas that have been cleared or disturbed. Once established, it is highly competitive and prevents establishment of native plants by overshading (L. Serpa, letter to T. Thomas of The Nature Conservancy, 1989, as cited in Drewitz 2000). Although poison hemlock was first documented in Arizona in 1938 (SEINet 2004), few documented locations exist (homesteads, highly disturbed sites). Several Working Group members commented that this species could be coming out of its lag phase and new populations may be occurring (see section 3).

Sources of information: See cited literature. Also considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed February, 2004). The documentation level reflects Arizona observations and Working Group member discussions, not the sources and rates of spread from other states reported in the literature.

Question 2.3 Recent trend in total area infested within state *Score:* **B** *Doc'n Level:* **Obs.**

Describe trend: Increasing but less rapidly than doubling the total area infested in <10 years.

Rationale: In the last several years, new populations have been documented in northern Arizona (see section 3). Poison hemlock may just now be beginning to spread into new areas. Awareness about this species is increasing and perhaps individuals are just now starting to become observant of this plant.

Sources of information: Personal communications with F. Northam (Weed Biologist, Tempe, Arizona, 2004), L. Moser (Botanist, U.S. Department of Agriculture, Forest Service, Coconino National Forest, Flagstaff, Arizona, 2004), and B. Phillips (Zone Botanist, U.S. Department of Agriculture, Forest Service, Coconino, Prescott, and Kaibab National Forest, Flagstaff, Arizona, 2004).

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Describe key reproductive characteristics: Biennial that reproduces only by seed.

Rationale: See Worksheet A.

Sources of information: See Worksheet A.

Question 2.5 Potential for human-caused dispersal *Score:* **B** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Moderate dispersal but not at a high level; disperses via humans, pets, livestock, vehicles, and farm and fire equipment.

Rationale: Seed is ribbed which enables it to adhere to clothing, fur, and vehicles (Pitcher 1989 in DiTomaso 1999). Significant problem in alfalfa fields during first cutting [in hay] (Jeffery and Robinson 1990). Can be found in grain fields where it can contaminate harvested seed (Panter and Keeler 1990, Lazarides and Hince 1993).

Sources of information: See cited literature.

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Occasional long-distance dispersal by animals and water.

Rationale: Seeds spread by animal fur, birds, water, and to a limited extent wind (Parsons 1973 in Pitcher 1989, Panter and Keeler 1988). No well developed mechanism for long-distance dispersal. Most seeds fall at the base of the plant (Panter and Keeler 1988).

Sources of information: See cited literature.

Question 2.7 Other regions invaded *Score:* **A** *Doc'n Level:* **Other pub.**

Identify other regions: Invades marshes, meadows [alpine/subalpine grasslands], semi-desert grasslands, and desert washes [Sonoran riparian] not yet invaded in Arizona.

Rationale: Native to Europe, western Asia, and North Africa (Pitcher 1989). Poison hemlock inhabits banks of streams and rivers in North and South America (Mitich 1998). It has spread to become naturalized (i.e., reproduce consistently and sustain populations over many life cycles without direct intervention by humans [Richardson et al. 2000]) in nearly every state in U.S. (DiTomaso 1999). Listed as noxious weed in Colorado, Iowa, Idaho, New Mexico, Nevada, Ohio, Oregon, South Dakota, and Washington, and it occurs in all conterminous states of the U.S. except Mississippi and Florida (USDA 2005).

From Drewitz (2000): "It was brought to the United States as a garden plant sometime in the 1800s and sold as a "winter fern" (Goeden and Ricker 1982, Parish 1920). In California the earliest poison hemlock collections were made in 1893 and 1897 in Berkeley and Truckee, respectively (Parish 1920). Poison hemlock has spread throughout the United States, Canada, Australia, New Zealand, and South America (Parsons [and Cuthbertson] 1992, Holm et al. 1979).

California ecological types invaded but not invaded in Arizona include: valley and foothill grassland (assumed comparable to semi-desert grasslands), meadow and seep, marsh and swamp, and desert washes (assumed comparable to Sonoran riparian) (DiTomaso 2003). Has been documented to invade native plant communities associated with riparian woodlands and open flood plains of rivers and streams in southern California (Goeden and Ricker 1982). In Utah poison hemlock is present in wet boggy meadows (Welsh et al. 1987).

Sources of information: See cited literature. Also considered information from J. DiTomaso (2003; draft plant assessment for *Conium maculatum* for California; available online at: http://www.cal-ipc.org; accessed January 2004).

Question 3.1 Ecological amplitude *Score:* **B** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Found in two major ecological types in Arizona (Forests and Riparian).

Rationale: In Utah found from 1400 to 2990 m (Welsh et al. 1993) and Arizona up to 2285 m (Epple 1995). Earliest record in Arizona collections is 1938 (SEINet 2004).

From Drewitz (2000): "Poison hemlock has spread throughout California in areas below 5,000 feet (1,500 m) elevation, excluding the Great Basin and Desert provinces (Pitcher 1989 [cited as 1986 by Drewitz], Hickman 1993). It is commonly found in dense patches along roadsides and fields. It also thrives in meadows and pastures and is occasionally found in riparian forests and flood plains (Goeden and Ricker 1982). It does best in disturbed areas where soil is moist with some shade. Poison hemlock is also able to form stands in dry, open areas (Parsons [and Cuthbertson] 1992)."

More competitive under wetter soil conditions, can survive in dry sites (Tucker et al. 1964 DiTomaso 1999). Does not require light to germinate and has a short lived seed bank (up to about three years; Baskin and Baskin 1990). *Conium maculatum* is present in areas dominated by cottonwood and willow; elevation 4000 to 5200 feet; 12 to 15 inches precipitation; moist soil; wetland obligate (M. Baker, personal communication, 2004).

Sources of information: See cited literature. Also considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed February, 2004) and personal communication with M. Baker (Botanist, consultant for the U.S. Department of Agriculture, Forest Service in northern Arizona, 2004).

Question 3.2 Distribution *Score:* **D** *Doc'n Level:* **Obs.**

Describe distribution: Present but less than 5% occurrence in all ecological types invaded.

Rationale: Currently has limited distribution in the ecological types where it is documented. Southwestern interior riparian: Watson Woods (Prescott) and Fossil Creek. Montane riparian: West Fork Oak Creek, Rio de Flag, Sinclair Wash (Flagstaff), and Delray Springs area. Montane conifer forest: McMillian Mesa;

Sources of information: Personal communications with F. Northam (Weed Biologist, Tempe, Arizona, 2004), L. Moser (Botanist, U.S. Department of Agriculture, Forest Service, Coconino National Forest, Flagstaff, Arizona, 2004), B. Phillips (Zone Botanist, U.S. Department of Agriculture, Forest Service, Coconino, Prescott, and Kaibab National Forest, Flagstaff, Arizona, 2004), M. Baker (Botanist, consultant for the U.S. Department of Agriculture, Forest Service in northern Arizona, 2004), and K. Watters (Biotech, Colorado Plateau Cooperative Ecosystem Studies Unit and National Park Service, Grand Canyon National Park, Flagstaff, Arizona, 2004).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ Yes]	No	1 pt.
Dense infestations produce >1,000 viable seed per square meter	[✓ Yes]	No	2 pt.
Populations of this species produce seeds every year.	Yes	[✓ No]	1 pt.
Seed production sustained for 3 or more months within a population annually	[✓ Yes]	No	1 pt.
Seeds remain viable in soil for three or more years	[✓ Yes]	No	2 pt.
Viable seed produced with *both* self-pollination and cross-pollination	Yes	No	1 pt.
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	Yes	[✓ No]	1 pt.
Fragments easily and fragments can become established elsewhere	Yes	[✓ No]	2 pt.
Resprouts readily when cut, grazed, or burned	Yes	[✓ No]	1 pt.

Total pts: 6 Total unknowns: 1

Score : A

Note any related traits: Produces over 38,000 seeds/plant (Whittet 1968 in Mitich 1998). The combination of long seed dispersal period, seed dormancy, and non-specific germination requirements enable poison hemlock seedlings to emerge in almost every month of the year. Germination takes place in all months of the year except April, May, and June, with late winter and early spring being the periods of greatest germination (Roberts 1979). In Arizona the poison hemlock population produces seed within a short window of time (approxmately one month after flowering).

From Baskin and Baskin (1990): plants disperse about 90 percent of their seed in September through December, with the remainder dispersed by late February. This lengthy dispersal period allows poison hemlock to produce new seedlings continuously for several months. Poison hemlock has a large range of environmental conditions in which it can germinate. It can germinate at mean daily maximum temperatures greater than 9.3˚C and lower than 33.8˚C. It can germinate in darkness as well as in light. About 85 percent of seed produced is able to germinate soon after it leaves the parent plant. The longer dispersal is delayed in time, the higher the germination percentage the following fall. Seed can remain viable in the soil for at least three years.

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	**D**
	montane riparian	**D**
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Convolvulus arvensis* L. (USDA 2005)
Synonyms:	*Convolvulus ambigens* House, *Convolvulus incanus* auct. non Vahl, *Strophocaulos arvensis* (L.) Small (USDA 2005)
Common names:	Field bindweed, possession vine, creeping jenny, creeping charlie, field morning-glory, orchard morning-glory, European bindweed, corn-bind, morning-glory, small-flowered morning-glory
Evaluation date (mm/dd/yy)**:**	05/28/03
Evaluator #1 Name/Title:	Kate Watters, Biotech/Plants
Affiliation:	National Park Service/GRCA/CPCESU
Phone numbers:	(928) 523–8518
Email address:	kw6@dana.ucc.nau.edu
Address:	P.O. Box 5765, Flagstaff, Arizona 86011–5765
Evaluator #2 Name/Title:	
Affiliation:	
Phone numbers:	
Email address:	
Address:	

List committee members:	06/24/03: W. Austin, D. Backer, J. Busco, P. Guertin, J. Hall, R. Haughey, L. Moser, F. Northam, R. Paredes, B. Phillips, K. Thomas, K. Watters 08/26/03: W. Albrecht, W. Austin, D. Backer, R. Hiebert, L. Makarick, L. Moser, T. Olson, B. Phillips, T. Robb, K. Thomas, K. Watters
Committee review date:	06/24/03 and 08/26/03
List date:	08/26/03
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**C**	Other published material	**“Impact”** **Section 1 Score:** **B**	**“Plant Score”** **Overall Score:** **Medium** **Alert Status:** **None**
1.2	Impact on plant community	**B**	Other published material		
1.3	Impact on higher trophic levels	**C**	Observational		
1.4	Impact on genetic integrity	**U**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Other published material	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **13 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Observational		
2.3	Recent trend in total area infested within state	**U**	No information		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**A**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Other published material		
2.7	Other regions invaded	**C**	Observational		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**A**	Observational	**“Distribution”** **Section 3 Score:** **A**	
3.2	Distribution	**B**	Observational		

Table 3. Documentation

Note: Comments by the Consistency Review Panel suggested this species should be rated higher because of its ability to encroach into uninfested land and its aggressive, smothering growth. These pestiferous characteristics are expressed in mesic temperate sites where moisture is naturally abundant or supplied by human means. Cropland, hay fields, nursery fields, landscaped areas, gardens, rights-of-ways, and turf can be dominated by field bindweed, but for this type of growth to occur in Arizona wildlands, susceptible sites need to be subjected to intense mechanical soil disturbance (i.e., removal of a majority of the natural vegetation), plus have a dependable source of water during its growing season. In other words, field bindweed encroachment into wildlands will follow disturbances such as road construction, ditch digging, mining, mechanical fire suppression, etc. Therefore, current scores are believed to properly reflect the threat of field bindweed in Arizona wildlands.

Question 1.1 Impact on abiotic ecosystem processes *Score:* **C** *Doc'n Level:* **Other pub.**
Identify ecosystem processes impacted: Soil moisture and geomorphological changes.
Rationale: Can form dense stands in disturbed areas. Extensive root system utilizes deep soil moisture (Swan 1980). Field bindweed can reduce the available soil moisture in the top 60 cm of soil to below the wilting point for many species (Weaver and Riley 1982). Under conditions of water stress, field bindweed can be a better competitor than cultivated crops (Stahler 1948 in Weaver and Riley 1982). These studies were experimental in cropland in Washington and Canada and in controlled greenhouse studies, so some inference has been made. Inferred that deep taproot may lend potential geomorphological changes such as sedimentation rate.
Sources of information: See cited literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **B** *Doc'n Level:* **Other pub.**
Identify type of impact or alteration: Plant community structure and interactions (resource competition). Much is known about the effects of *Convolvulus arvensis* on cropland, but little is known about its impacts on natural communities and wildlands (Lyons 1998).
Rationale: Vining habit chokes other plants and competes with native forbs and grasses for moisture, sunlight, and nutrients (Swan 1980). Field bindweed is primarily a problem at several Nature Conservancy preserves, found in riparian corridors and mountain-mahogany shrubland/grassland, where it has been noted to choke out native grasses and forbs (Lyons 1998). Field bindweed is also tolerant of a variety of environmental conditions, which makes it highly competitive for resources (USGS Undated).
Sources of information: See cited literature.

Question 1.3 Impact on higher trophic levels *Score:* **C** *Doc'n Level:* **Obs.**
Identify type of impact or alteration: May have some negative effects on foraging animals, though effects are largely unknown.
Rationale: Has been known to poison some grazing animals although effect is unknown on native ungulates (Cox 1915, Callihan et al. 1990) We do not know the impacts of mat-forming structures on nesting and forage or pollinators, though such dense structure could reduce food and habitat for native ground nesting species and pollinators.
Sources of information: See cited literature. Also used inference to assign the score.

Question 1.4 Impact on genetic integrity *Score:* **U** *Doc'n Level:* **Other pub.**
Identify impacts: Potential exists but hybridization unknown.
Rationale: There is a native species, *Convolvulus simulans*, in California (Jepson 1953) but there are no records of hybridization between plants. There are at least two native *Convolvulus* species in Arizona (Kearney and Peebles 1960) but it is unknown if they can hybridize with *C. arvensis*.
Sources of information: See cited literature.

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Establishes more frequently with disturbance, mostly anthropogenic, as *Convolvulus arvensis* is spread rapidly through agricultural practices (CDFA Undated).

Rationale: Occurs at roadsides, old agricultural fields, waste places, as well as disturbed rangelands and wildlands (Olliff et al. 2001). Field bindweed is more indicative of disturbed areas than natural systems (Pavek 1992). Working Group disagreed with "readily" to describe invasion of areas with natural disturbance, but recognizes that burrowing of prairie dogs, and root fragments transferred downstream from flooding events, can also produce new populations.

Sources of information: See cited literature.

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Obs.**

Describe rate of spread: Increases, but less rapidly than doubling in <10 years.

Rationale: Reproduces rapidly via underground rhizomes (Frasier 1943). Best (1963a) investigated the spread of field bindweed by monitoring 25 shoots growing from transplants under non-competitive conditions. In the first year, new shoots reached 46 to 130 cm from the parent plant and in the second year were as far as 180 to 290 cm from the parent plant. Brown (1946) found one plant was capable of producing 14 new shoots in one year. Lateral root growth per year was found to be on average 4.6 m although in Best's study (1963b) one plant's root grew to 7.0 m (Best 1963a). In disturbed areas on the North Rim of the Grand Canyon, documented *C. arvensis* populations that have been treated with Rodeo are increasing at slow, yet noticeable rates (K. Watters, personal observations, 2002 to 2003).

Sources of information: See literature citations. Also used inference based on personal observations by K. Watters (Research Technician, National Park Service, Grand Canyon National Park, Flagstaff, Arizona, 2002 to 2003).

Question 2.3 Recent trend in total area infested within state *Score:* **U** *Doc'n Level:* **No info.**

Describe trend: Although local population increases have been noted, information does not exist on the overall trend in the state.

Rationale: In disturbed areas on the North Rim of the Grand Canyon, documented *Convolvulus arvensis* populations that have been treated with Rodeo are increasing at slow, yet noticeable rates; however, the overall state trend is unknown.

Sources of information: North Rim observations by K. Watters (Research Technician, National Park Service, Grand Canyon National Park, Flagstaff, Arizona, 2002 to 2003).

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: Prolific vegetative reproduction, can regenerate from root fragments (Bellue et al. 1959), and seeds remain viable in the soil for long periods (Brown and Porter 1942).

Rationale: Can reproduce vegetatively and via seed dispersal (Weaver and Riley 1982).

Sources of information: See cited literature; also see DeGennaro and Weller (1984).

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Potential for human-caused dispersal is high along transportation corridors and irrigation canals.

Rationale: Field bindweed can contaminate nursery stock. (Callihan et al. 1990). Propagules may be carried by animals, humans and machinery (Swan 1980).

Sources of information: See cited literature.

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: New introductions of field bindweed are primarily by seed. Seeds can be transported by water or birds (Proctor 1968).

Rationale: Field bindweed seeds remain viable in the stomachs of migrating birds. Callihan et al. (1990) found that seeds can remain in Killdeer for up to 144 hours and can pass through animals with little or no damage. Quail may retain the seed for 24 hours, ducks, 5, geese, 19, lesser yellowlegs, 6, green jays, 13, ravens, 8, mocking birds, 2 and starlings 10 (Callihan et al. 1990). Flooding events could cause root fragments to move downstream and colonize streambanks in new areas.

Sources of information: See cited literature.

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Obs.**

Identify other regions: *Convolvulus arvensis* occurs in each state of the continental U.S. (USDA 2005). In Canada it is found in Alberta, British Columbia and Saskatchewan (Zamora 1991). *Convolvulus arvensis* is a serious weed in Argentina, Australia, Borneo, Sri Lanka, France, Germany, Greece, India, Iran, Lebanon, New Zealand, Pakistan, South Africa, the former Yugoslavia, and is a "principle" or "common" weed in thirty-four other countries including Japan, the former Soviet Union, and Finland (Holm et al. 1991) (Sa'ad 1967).

Rationale: *Convolvulus arvensis* is native to Eurasia and is now a cosmopolitan species that grows between 60^{o}N and 45^{o}S latitudes (Lyons 1998).

Sources of information: See cited literature. Score based on observations and inference from literature.

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Can range in elevation from 100 to 8,500 feet and has been documented at 10,000 feet (USGS Undated). Can be found mostly in dry soil along roadsides, in open fields or edges of cultivated fields, pastures, on fences, yards, and waste places of farms (Parker 1972). Lyons (1998) reports that *C. arvensis* is primarily a problem in riparian corridors and mountain-mahogany shrubland/grassland. Field bindweed is listed as a dominant forb in 12.4 percent of the sample sites in a riverine United States Fish and Wildlife Service deep water-wetland classification (Olson and Gerhart 1982). Because of its wide distribution, abundance, and economic impact *Convolvulus arvensis* is considered one of the ten 'world's worst weeds' (Holm et al. 1977). Introduced from Europe: thought to have been introduced to North America in 1870 in wheat from Turkey (USGS Undated). Introduced to Arizona in 1905 to Pinal County.

Rationale: See Worksheet B.

Sources of information: See cited literature. Score based on Working Group observations. Introduction date based on information in SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed 2003).

Question 3.2 Distribution *Score:* **B** *Doc'n Level:* **Obs.**

Describe distribution: Personal observations by K. Watters (2002 to 2003) from the North Rim of the Grand Canyon National Park and Southwest Exotic Plant Mapping Program (SWEMP) data records indicate that bindweed locations are at roadsides and disturbed slopes below roads.

Rationale: Most common in waste areas and cultivated fields, but has been documented to infest disturbed wildlands and natural areas (Parker 1972).

Sources of information: Score based on observations by K. Watters (Research Technician, National Park Service, Grand Canyon National Park, Flagstaff, Arizona, 2002 to 2003), other Working Group member observations, and SWEMP records (available online at: http://www.usgs.nau.edu/swepic/swemp).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**[✓ Yes]**	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**[✓ Yes]**	**No**	**2 pt.**
Populations of this species produce seeds every year.	**[✓ Yes]**	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**[✓ Yes]**	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	**[✓ Yes]**	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes**	**[✓ No]**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**[✓ Yes]**	**No**	**1 pt.**
Fragments easily and fragments can become established elsewhere	**[✓ Yes]**	**No**	**2 pt.**
Resprouts readily when cut, grazed, or burned	**[✓ Yes]**	**No**	**1 pt.**

Total pts: 11 Total unknowns: 0

Score : A

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	**U**
Scrublands	Great Basin montane scrub	**D**
	southwestern interior chaparral scrub	**D**
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	**D**
	semi-desert grassland	**D**
Freshwater Systems	lakes, ponds, reservoirs	**D**
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	**C**
	southwestern interior riparian	**B**
	montane riparian	
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial):	*Cortaderia selloana* (J.A. & J.H. Schultes) Aschers. & Graebn. (USDA 2005)
Synonyms:	*Cortaderia dioica* (Spreng.) Speg. (USDA 2005)
Common names:	Pampas grass, Uruguayan pampas grass, silver pampas grass, tussock grass
Evaluation date (mm/dd/yy):	04/29/04
Evaluator #1 Name/Title:	Kate Watters, Graduate student
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List committee members:	10/22/04: W. Albrecht, D. Backer, S. Harger, L. Moser, B. Phillips, J. Schalau, K. Spleiss 12/17/04: W. Albrecht, D. Backer, J. Crawford, D. Crisp, S. Harger, S. Masek-Lopez, F. Northam, T. Olson, B. Phillips
Committee review date:	10/22/04 and 12/17/04
List date:	12/17/04
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		**Score**	**Documentation Level**	**Section Scores**	**Overall Score & Designations**
1.1	Impact on abiotic ecosystem processes	**B**	Other published material	**“Impact”** **Section 1 Score:** **B**	**“Plant Score”** **Overall Score:** **Medium** **Alert Status:** **None**
1.2	Impact on plant community	**B**	Reviewed scientific publication		
1.3	Impact on higher trophic levels	**C**	Reviewed scientific publication		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Other published material	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **15 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Observational		
2.3	Recent trend in total area infested within state	**B**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**B**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Reviewed scientific publication		
2.7	Other regions invaded	**B**	Other published material		RED FLAG **YES** Something you should know.
3.1	Ecological amplitude	**A**	Observational	**“Distribution”** **Section 3 Score:** **B**	
3.2	Distribution	**D**	Observational		

Red Flag Annotation

Cortaderia selloana is widely sold as both a live plant or seed in Arizona and on the internet. It also is promoted as a low water-use plant in Arizona. As a relatively new plant to Arizona, *C. selloana* has only started to appear in wildlands. Based on the species broad ecological ecological amplitude, it potentially can become as problematic in Arizona as it now is in California and other places. At present *C. selloana* exists only in small patches in the state; however, plenty of unoccupied niches, such as riparian corridors, are available to this species to invade.

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **B** *Doc'n Level:* **Other pub.**

Identify ecosystem processes impacted: Pampas grass alters fire regimes. Deep root systems can change the soil water table level and cause geomorphological changes in river systems and deltas where it establishes on banks.

Rationale: In New Zealand and Australia where infestations are dense, pampas grass creates a fire hazard and increases fire frequencies with excessive build up of dry leaf litter and flowering stalks (Gadgil et al. 1984). By introducing fire to habitats that are not adapted, or increasing the frequencies of these events, native plants are disadvantaged through the alteration of competitive interactions caused by changes in resource availability. A single plant can occupy a soil area of about 1,100 square feet (103 m^2). Lateral roots can spread to thirteen feet (4 m) in diameter and eleven and one-half feet (3.5 m) in depth (DiTomaso 2000). This extensive perennial root system has the potential to change hydrological regimes. In New Zealand, pampas grass is used for erosion control (Gadgil et al.1984). It was planted by the Soil Conservation Service in 1946 (in Ventura and Los Angeles Counties) for soil erosion purposes (Costas-Lippmann 1977).

Sources of information: See cited literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Identify type of impact or alteration: Pampas grass competes with native vegetation communities in natural areas, and in ruderal habitats such as logged forest, where they inhibit natural succession.

Rationale: From Gadgil et al. (1984): Although no reliable data on pampas productivity is tree stands exist, pampas grass clearly has considerable potential for competing with trees for moisture and nutrients (New Zealand). Examination of nutrient levels in pampas grass leaves in New Zealand revealed high levels of nitrogen, and tree growth is limited by nitrogen availability. In New Zealand sand dune forests a perennial tree lupin (*Lupinus arboreus*) supplies the nitrogen required for other tree growth through biological fixation, and is likely to be reduced when in the presence of pampas grass. Pampas grass commonly suppresses growth in young trees, and although growth retardation in older trees is suspected, no quantitative data exist.

A study by Costas-Lippman and Baker (1980) found that *Cortaderia selloana* showed greater genetic diversity than *C. jubata*, another non-native species that invades California, New Zealand, and Australia. This may explain the ability of *C. selloana* to use water more efficiently by tolerating water stress during drought and ability to utilize water when it was plentiful (Lambrinos 2002, Costas-Lippman and Baker 1980). The presence of *C. jubata* individuals can significantly enhance the probability of future *Cortaderia* establishment. *Cortaderia* individuals already present in the Califronia landscape may greatly accelerate the conversion of native vegetation into *Cortaderia* dominated gasslands (Lambrinos 2002)

Seedling survival is low in shaded areas or in competition with grasses and sedges (Gadgil et al. 1990, DiTomaso 2000). Although logged forest is considered disturbed ruderal habitat, populations of pampas grass inhibit the natural succession process and prevent the establishment of new trees (Lambrinos 2001, Gadgil et al. 1984).

In New Zealand, it competes with and smothers other vegetation. It creates a fire hazard with excessive build-up of dry material (dry leaves, leaf bases and flowering stalks). Impacted in particular are plants growing in rocklands e.g. coastal cliffs, coastal dunes etc (Haley 1997; no empirical evidence was cited).

Observations by J. Agyagos (personal communication, 2004) suggest that pampas grass is displacing native species based on a monoculture with a 16 feet diameter in Dead Horse State Park.

Sources of information: See cited literature. Also considered personal communication with J. Agyagos (Wildlife Biologist, U.S. Department of Agriculture, Forest Service, Coconino National Forest, Red Rock Ranger District, 2004).

Question 1.3 Impact on higher trophic levels *Score:* **C** *Doc'n Level:* **Rev. sci. pub.**

Identify type of impact or alteration: Pampas grass provides habitat for exotic mice and rats in New Zealand. Rabbits feed on the seedlings in coastal scrub sites in California, which prohibits the expansion and colonization of pampas grass in these areas. Pampas grass is grazed by cattle in Australia.

Rationale: Pampas grass provides habitat for rats in New Zealand that predate birds and eggs and eat the fruits and seeds of forest plants, which prevents forest regrowth (Harradine 1991, New Zealand Department of Conservation website, 2004). In an experimental study, Lambrinos (2002) found that the invasive potential of pampas grass is "strongly moderated" by generalist herbivores in chaparral coastal sage scrub in California.

Sources of information: See cited literature. Also considered information from the New Zealand Department of Conservation website (available online at: http://www.doc.govt.nz/Conservation/003~Weeds/Pampas-Grass.asp; accessed May 2004).

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub.**

Identify impacts: No known hybridization.

Rationale: There are no native species of *Cortaderia* in Arizona.

Sources of information: Kearney and Peebles (1960).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Pampas grass establishes readily in disturbed areas. This species may occasionally establish in undisturbed areas but readily establishes with natural and anthropogenic disturbances.

Rationale: In New Zealand, pampas grass invasion is accelerated by disturbance and threatens the productivity of plantation forests and land of high conservation value. It has the ability to reach distant open spaces quickly and to blanket them with very rapid growth. Native turfland communities can be quickly overcome by the invasion of pampas. Pampas invades disturbed areas such as cleared bush margins, burned areas and firebreaks (New Zealand Department of Conservation website, 2004). Soil disturbance favors colonization (Gadgil et al. 1984).

In a study by Lambrinos (2002) in California, *Cortaderia selloana* seeds emergence were enhanced by soil disturbance (mechanically turning the soil) at a seasonal wetland, and maritime chaparral, but not in dune scrub sites. Based on herbarium records and new censuses in California, Lambrinos (2001) found that *C. selloana* has expanded at a greater rate than *C. jubata* but also a greater proportion of its populations have colonized relatively undisturbed native plant communities compared to *C. jubata.*

McKinnon (1984) notes that pampas grass does not appear to succeed on undisturbed ground cover.

Sources of information: See cited literature. Also considered information from the New Zealand Department of Conservation website (available online at: http://www.doc.govt.nz/Conservation/003~Weeds/Pampas-Grass.asp; accessed May 2004).

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Obs.**

Describe rate of spread: Increasing, but less rapidly than doubling in <10 years.

Rationale: Based on observations at Dead Horse State Park it is spreading downstream (J. Agyagos, personal communication, 2004). In California the invasiveness of C. selloana has increased over time, whereas that of C. jubata has remained relatively constant (Lambrinos 2002).

Sources of information: Personal communication with J. Agyagos (Wildlife Biologist, U.S. Department of Agriculture, Forest Service, Coconino National Forest, Red Rock Ranger District, 2004).

Question 2.3 Recent trend in total area infested within state *Score:* **B** *Doc'n Level:* **Obs.**

Describe trend: Increasing, but less rapidly than doubling its range in <10 years.

Rationale: A study by Lambrinos (2001) on the expansion history of *C. selloana* in California showed that the invasiveness of this species increased over time, occupying more vegetation types and non-ruderal habitats than closely related *C. jubata,* which were both introduced to California in the mid-1800s. In the case of *C. selloana*, populations have expanded spatially at twice the rate of asexual species *C. jubata*. The lag time from the point at which the species was introduced and when it began to naturalize and spread spatially was less than 50 years, demonstrating the need to control Arizona's relatively low-level infestation now.

Sources of information: See cited literature citations. Score based on Working Group member observations and inference.

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: Pampas grass is a perennial that reproduces sexually via seeds and cuttings. Produces large amount of seeds.

Rationale: Pampas grass produces a copious amount of small seeds, as much as one million/individual. Seed production occurs over two to three months in late summer and early fall (Lambrinos 2002). Seeds lack dormancy (Costas-Lippmann 1977 in Lambrinos 2002). The taxonomy of this species is often confused with *C. jubata,* which looks almost identical in appearance but the population is all female and it is obligate apomixic, whereas the population of *C. selloana* is dioecious and it is an obligate outcrosser (Lambrinos 2002). Vegetative reproduction can occur when moisture reaches fragmented tillers and develop adventitious roots at the base of the shoot. Plants can live for up to fifteen years (DiTomaso 2000). Can propagate by seeds or from root division (Starr et al. 2003). Capable of flowering after one to two years and has a life span of 10 to 15 years (Cowan 1976). In the nursery industry, pampas grass is also propagated through division of mature plants.

Sources of information: See cited literature.

Question 2.5 Potential for human-caused dispersal *Score:* **B** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Pampas grass is sold and planted as an ornamental grass (pink and white varieties). Seed is also available for sale on the internet. The blooms are also used in dried floral arrangements (Starr et al. 2003). Used for erosion control and cattle fodder (Lemon and Taylor 1949 in Starr et al. 2003, Gadgil et al. 1984).

Rationale: Pampas grass is currently sold as ornamental plants by nurseries on the internet, and in cities like Page, Arizona. Originally introduced to the U.S. (California) as an ornamental and initially populations did not escape or grow rapidly, but after a period of nearly 50 years, pampas grass has spread north and south down and up the coast and naturalized in many habitats.

It is propagated by division of mature plants. In recent years, however, some nurseries have propagated pampas grass from seed. Originally female plants were selected for but since propagation from seed was initiated and male and female plants are not distinguishable before they flower, the result is an increase in the proportion of male plants in the population. Consequently, there has been an increase in the amount of viable seed produced and the species has escaped to become an invasive problem along the California coast (DiTomaso et al. 1999).

Sources of information: See cited literature; also see Lambrinos (2001) and DiTomaso (2000).

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Identify dispersal mechanisms: Pampas grass seeds travel on the wind and in flowing water.

Rationale: The light seeds are carried by wind to new areas, and transported by water along river margins. Primarily wind dispersed (Lambrinos 2002). Seeds are light and capable of long distance dispersal. "At maturity seed-bearing female florets of *C. selloana* are quite readily wind-borne, and distribution can be effective over quite some distance. Winds need not be strong to be effective in dispersal, as slight updraughts can raise the florets quite markedly. Seed-bearing florets from hermaphrodites, however, tend to fall directly to the ground and dispersal is very restricted" (Connor 1973).

In New Zealand pampas grass infestations have been found on the Hen and Chicken Islands, more than 30 kilometers away from the main island, suggesting the wind blown seeds can be carried by wind long distances (McKinnon 1984). In California both *C. selloana* and *C. jubata* expanded in a pattern consistent with populations establishing by long-distance dispersal (natural or anthroprogenic) and then expanded independent of each other (Shigesada and Kawaskai 1997 in Lambrinos 2001).

Sources of information: See cited literature; also see DiTomaso (2000).

Question 2.7 Other regions invaded *Score:* **B** *Doc'n Level:* **Other pub.**

Identify other regions: This species invades two ecological types that exist, but are not yet invaded in Arizona. Pampas grass invades dunes and wetlands in California.

Rationale: From DiTomaso (2000): Pampas grass is native to Argentina, Brazil and Uruguay, where it grows in damp soils along river margins. It was first introduced into Europe by a Scottish horticulturist between 1755 and 1862. Pampas grass is also a weed problem in other areas of the world, naturalizing across New Zealand and Australia. It is listed as an invasive pest plant in New Zealand, Australia, South Africa, and Hawai'i (Starr et al. 2003).

Pampas grass came to California as an ornamental plant and commercial production for the nursery trade began in 1874. It was also planted by the Soil Conservation Service as dryland forage and to prevent erosion in 1946. In California populations of *C. selloana* now occur in more vegetation types and more non-ruderal habitats than *C. jubata* (Lambrinos 2002). It is reported from the coastal habitats of Oregon. In New Mexico it is reported from Bernalillo and eight southern New Mexico counties. The Grass Manual on the Web reports *C. selloana* in southern Nevada, southern New Mexico, northern Utah, and central Washington.

Sources of information: See cited literature; also see the Grass Manual on the Web (available online at: http://www.herbarium.usu.edu/webmanual/default.htm).

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: First record from Arizona is from 1960 (an ornamental plant from the University of Arizona campus [SEINet 2004]).

Pampas grass grows in subhumid and semi-arid subtropical regions in open sunny places receiving added moisture, becoming naturalized as a weed in damp places, depressions, along stream banks, the margins of mangrove swamps and, in particular, disturbed areas associated with roads, pipeline cuts and walking trails in forest areas and waste places. Pampas grass can tolerate winter frost, warmer summer temperatures, more intense sunlight and moderate drought.

In California, pampas grass is found in mesic habitats such as the upper vegetation zone of tidal wetlands as well as the inland riparian habitats of the San Francisco Bay delta region (Lambrinos 2001). *Cortaderia selloana* is more abundant in xeric plant communities than *C. jubata* and thus appears to have broader ecological tolerances (Lambrinos 2002). The distribution of *C. selloana* across vegetation types is more diverse and demonstrates greater genetic variability that of *C. jubata*. These results are consistent with the hypothesis that genetic variability enables better utilization of heterogeneous habitats, as well as promoting greater competitive abilities (Lambrinos 2001).

Rationale: This species is widespread, invading three major Arizona ecological types (see Worksheet B). It also persists in abandoned and waste areas (J. Agyagos, personal communication, 2004).

Sources of information: See cited literature; also see DiTomaso (2000) and Costas-Lippman (1977). Also considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed December 2004) and personal communication with J. Agyagos (Wildlife Biologist, U.S. Department of Agriculture, Forest Service, Coconino National Forest, Red Rock Ranger District, 2004). Score based on observations of numerous individuals (see question 3.2 below).

Question 3.2 Distribution *Score:* **D** *Doc'n Level:* **Obs.**

Describe distribution: In Arizona pampas grass herbarium specimens were collected from Highway 179 near the junction of 89A, at the junction of Interstate 17 and the Verde River 500 feet from the river, from Lake Powell, Wahweap Marina, and from city parks in Pima (Tumomoac Hill) and Maricopa County.

It was also collected from Grand Canyon National Park, just upstream of Diamond Creek along the river edge in 2003. In 2004 one plant was removed from side canyon in upper portion of Colorado River during September 2004 (K. Watters, personal communication, 2004). One plant removed from Cienega Creek (Bureau of Land Management land) during restoration work (D. Turner, personal communication, 2004). A population of pampas grass is present for approximately ¾ of a mile along the active stream channel of the Verde River in Dead Horse State Park (J. Brock and J. Agyagos, personal communications, 2004).

A couple of plants in Glen Canyon National Recreation Area up on a rock wall that is difficult to get to; been there approximately 12 years. One plant in the corridor upstream from Lee's Ferry (J. Spence, personal communication, 2004). Hasn't been seen in Oak Creek Canyon (J. Agyagos, personal communication, 2004).

Rationale: This species has a limited distribution in Arizona. Numbers at present are fairly low and populations are scattered to just a few individuals.

Sources of information: SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed September 2004) and personal communications with K. Watters (Research Technician, National Park Service, Southern Colorado Plateau Network, Flagstaff, Arizona, 2004), D. Turner (Conservation Planner, The Nature Conservancy, Tucson. Arizona, 2004), J. Brock (Professor, Applied Biological Science, Arizona State University-East, Mesa, Arizona, 2004), J. Agyagos (Wildlife Biologist, U.S. Department of Agriculture, Forest Service, Coconino National Forest, Red Rock Ranger District, 2004), and J. Spence (Botanist, National Park Service, Glen Canyon National Recreation Area, 2004).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ **Yes**]	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	[✓ **Yes**]	**No**	**2 pt.**
Populations of this species produce seeds every year.	[✓ **Yes**]	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	[✓ **Yes**]	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	**Yes**	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes**	[✓ **No**]	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	[✓ **Yes**]	**No**	**1 pt.**
Fragments easily and fragments can become established elsewhere	[✓ **Yes**]	**No**	**2 pt.**
Resprouts readily when cut, grazed, or burned	**Yes**	**No**	**1 pt.**

Total pts: 8 Total unknowns: 2

Score : A

Note any related traits: DiTomaso (2000) indicated that fire is not a long term control method because the plants resprout shortly thereafter (not sure if this is considered equivalent to "readily").

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	**D**
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	**D**
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	**D**
	southwestern interior riparian	**D**
	montane riparian	
Woodlands	Great Basin conifer woodland	**D**
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Cynodon dactylon* (L.) Pers. (USDA 2005)
Synonyms:	*Capriola dactylon* (L.) Kuntze, *Panicum dactylon* L. (USDA 2005)
Common names:	Bermudagrass, devilgrass, grama-seda, chiendent pied-de-poule, motie molulu, manienie, common stargrass, baramagrass, dhubgrass, bahama grass, dogtoothgrass, couch grass, vinegrass, wiregrass, scutchgrass
Evaluation date (mm/dd/yy)**:**	10/29/04
Evaluator #1 Name/Title:	Kim Klementowski, Natural Resource Specialist
Affiliation:	Bureau of Land Management
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Evaluator #2 Name/Title:	
Affiliation:	
Phone numbers:	
Email address:	
Address:	
List committee members:	11/19/04: D. Backer, G. Ferguson, P. Guertin, J. Hall, K. Klementowski, H. Messing 03/01/05: D. Baker, D. Casper, E. Geiger, J. Hall, H. Messing, B. Munda, F. Northam
Committee review date:	11/19/04 and 03/01/05
List date:	03/01/05
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		**Score**	**Documentation Level**	**Section Scores**	**Overall Score & Designations**
1.1	Impact on abiotic ecosystem processes	**B**	Other published material	**"Impact"** **Section 1 Score:** **B**	**"Plant Score"** **Overall Score:** **Medium** **Alert Status:** **None**
1.2	Impact on plant community	**B**	Other published material		
1.3	Impact on higher trophic levels	**U**	Observational		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Other published material	**"Invasiveness"** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **14 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Observational		
2.3	Recent trend in total area infested within state	**C**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**A**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Other published material		
2.7	Other regions invaded	**C**	Observational		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**A**	Observational	**"Distribution"** **Section 3 Score:** **A**	
3.2	Distribution	**A**	Other published material		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **B** *Doc'n Level:* **Other pub**.

Identify ecosystem processes impacted: Soil ecology, geomorphological and hydrological processes

Rationale: *Cynodon dactylon* (Bermudagrass) forms dense mats that displace native plants, alter the soil ecology, alter geomorphological and hydrological processes, and alter successional processes (Guertin and Halvorson 2003; no specifics were provided).

In Carey (1995): Belesky et al. (1991) has Bermudagrass being adapted to plant communities that regularly experience fire. Skousen and Call (1987) and Vogl (1974) state that Bermudagrass prevents soil erosion and stabilizes river banks. Carey (1995) cites multiple sources as saying fire may or may not increase the spread of Bermudagrass, depending on soil moisture following a fire (Morris 1968, Monson et al. 1974, Powell et al. 1979, Hamilton 1980). A fire will kill the above ground portion of Bermudagrass, leaving the rhizomes to reproduce quickly after a fire under favorable conditions (Van Rensburg 1972). Although there is a great deal of information on how fire affects Bermudagrass, this researcher found no information on how Bermudagrass affects the fire regime.

Bermudagrass prevents erosion through its thick and extensive root mass, so is used in bank stabilization projects and to revegetate lignite surface mine spoils (Vogel 1981, Skousen and Call 1987, Harris and Zuberer 1993, Guertin and Halvorson 2003).

Sources of information: See cited literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **B** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Moderate impact effecting plant composition, structure and interactions.

Rationale: Bermudagrass is an early successional species (Guertin and Halvorson 2003), which means it can colonize and take hold before other plant species can establish. Bermudagrass can develop into dense turf, which dominates an understory habitat (Guertin and Halvorson 2003). However, shade or a complete canopy closure could reduce or eliminate Bermudagrass (Burton et al. 1959).

In Carey (1995): Bermudagrass is frequently found as an understory plant in velvet mesquite bosques (Boeer and Schmidly 1977). Carey (1995) further cites the same source saying that Bermudagrass, combined with saltcedar and mesquite, is a new vegetation association that has replaced native associations. Bermudagrass is suspected of having allelopathic qualities (Weller et al. 1985, McDonald 1986), which may interfere with plant establishment and growth. Bermudagrass is said to have enhanced postflood development of aquatic macrophyte communities in Arizona riparian areas (D'Antonio and Vitousek 1992).

The Nature Conservancy (TNC 2001) researched the effects of Bermudagrass on the growth of young mesquite trees. They found that mesquite trees with a high (>40%) Bermudagrass grass cover experienced less growth, including shorter height, smaller stem diameters, and shorter mean shoot lengths than mesquite trees with low (<40%) Bermuda grass cover. This study shows that "…abundant Bermudagrass appears to depress mesquite growth rates…" (TNC 2001).

Guertin and Halvorson (2003) cited Weller et al. (1985) as having shown Bermudagrass to inhibit the growth of newly planted peach trees. It is uncertain where the allelopathic qualities originate, but may be from biologically active substances produced by living, and dead, subterranean tissue (Guertin and Halvorson 2003).

Personal observations (K. Klementowski, 2004) at the Pratt Nursery, in Yuma county found Bermudagrass to dominate the understory. The Pratt Nursery was converted from an agricultural field to an outdoor nursery dominated by cottonwoods and willow, with Bermudagrass making up the majority of the understory. Bermudagrass in this case, could be preventing the recruitment of other native plants.

Sources of information: See cited literature. Also considered personal observations by K. Klementowski (Natural Resource Specialist, Bureau of Land Management, Yuma, Arizona, 2004).

Question 1.3 Impact on higher trophic levels *Score:* **U** *Doc'n Level:* **Obs.**

Identify type of impact or alteration: Negligible, provides forage for desert tortoise.

Rationale: Because Bermudagrass changes large portions of the understory and forms monotypic stands, the Working Group (on 03/01/05) inferred that there would be some impact, though unknown at this time, on higher tropic levels.

Bermudagrass is commonly used as forage for captive desert tortoises (Van Devender 2002). Bermudagrass can be intensively grazed by livestock (Newman 1992). A combined diet of Bermudagrass, alfalfa, clover, dichondra, and ryegrass has shown to be adequate nutritional regime for captive tortoises over a 20 year period (Van Devender 2002). Sherry Barrett (personal communication, 2004) states that Bermudagrass is a diet item for backyard tortoises, in fact some exist almost solely on Bermudagrass. Cecil Schwalbe (personal communication, 2004) believes that tortoises "will eat it in the wild if it is in their home range". Matt Goode (personal communication, 2004) commented that there is no conclusive evidence of Bermudagrass affecting lizard movement. He further said "the existence of large stands of non-native plants [in general] certainly alter the habitat of a variety of species and I suspect there can be benefits or costs depending on the species and its biology...".

Because Bermudagrass is used as forage for cattle, the grass may be used by native ungulates.

Sources of information: See cited literature. Also considered personal communications with S. Barrett (Southwest Arizona Field Supervisor, U.S. Fish and Wildlife Service, Arizona Ecological Services Field Office, Tucson, Arizona, 2004), C. Schwalbe (Research Ecologist, U.S. Geological Survey, Sonoran Desert Research Station, Tucson, Arizona, 2004), and M. Goode (Assistant Research Specialist, University of Arizona, School of Natural Resources, Tucson, Arizona, 2004) and Working Group inference.

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub.**

Identify impacts: Bermudagrass has been known to produce 5,000 hybrids when crossing two variants (Burton 1993).

Rationale: Although Bermudagrass is a highly variant species, the literature cites only non-native hybridization. There are no native congeners in Arizona (Kearney and Pebbles 1960).

Sources of information: See cited literature.

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Requires anthropogenic or natural disturbance to establish

Rationale: Newman (1992) cites Bermudagrass as growing only in disturbed areas. Bermudagrass is typically found in disturbed areas where moisture collects, such as waterholes, springs, seeps, irrigation ditches, roadsides (Chambers and Hawkins 2002), landscapes, orchards, vineyards, gardens, turf, industrial areas, waste places, and riparian areas (Guertin and Halvorson 2003). Guertin and Halvorson (2003) cite the grass as being found in natural areas, along sandy washes of remote canyons and as an understory in mesquite bosques. Weber County Weed Abatement in Utah (2004) has stated that Bermudagrass "…does not, as a rule, invade natural grasslands or forest vegetation".

It is fair to say, according to the mixed reports in the literature, that Bermudagrass can be found in areas with or without human disturbance (Guertin and Halvorson 2003). Bermudagrass is mostly found in anthropogenically disturbed areas, but can be found in relatively natural areas. In its native region, Bermudagrass thrives in communities where fire is a regular occurrence (Carey 1995, Guertin and Halvorson 2003).

Sources of information: See cited literature. Also considered information from Weber County Weed Abatement on Bermudagrass (available online at: http://www.co.weber.ut.us/weeds/types/Bermuda grass .asp; accessed November 8, 2004).

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Obs.**

Describe rate of spread: Increases but less rapidly than doubling in <10 years.

Rationale: Guertin and Halvorson (2003) described an experiment by Horowitz (1996). In this study Bermudagrass formed a dense sod after 1 ½ to 2 ½ years measuring 13 and 25 m^2, respectively. The average expansion rate thereafter was approximately 1 m^2 per month and exceeded 2 m^2 in the warmer summer months.

In Newman 1992: The open growth pattern of Bermudagrass's stolons provides for greater land coverage than seen with species which lack stolons, such as *Sorghum halepense*; the average monthly area increase in the warm season for *Cynodon dactylon* and *Sorghum halepense* is 1.6 m^2 and 1.3 m^2, respectively (Horowitz 1973). Aerial growth from shoots, tillers and previous season's rhizomes produce an abundance of stolons, which in turn produce more shoots, rhizomes and roots (Horowitz 1972a). This growth pattern explains the tremendous spreading capacity of Bermudagrass; the highest monthly area increase was 6 m^2 during July and August (Horowitz 1972a). However, the average area increase for *Cynodon dactylon* is only 0.9 m^2 per month.

Although we don't know the locale of these growth/spread studies by Horowitz, Working Group members have observed increased spread of Bermudagrass but not doubling in size in less than 10 years.

Sources of information: See cited literature. Also considered Working Group member observations.

Question 2.3 Recent trend in total area infested within state *Score:* **C** *Doc'n Level:* **Obs.**

Describe trend: Bermudagrass is found throughout Arizona, below 6,000 feet elevation (Newman 1992).

Rationale: Discussion from the Working Group suggested that Bermudagrass occurs throughout the state and it occupies the full extent of its potential range.

Sources of information: See cited literature. Also considered Working Group member observations.

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: Bermudagrass reproduces through rhizomes and stolons, but is reported to be most effective by use of stolons (Fuls and Bosch 1990). There is some conflicting literature as to whether the seeds that are produced are viable or have a viable germination rate. However, it is reported that plants in the southwest produce a good seed set (Newman 1992).

Rationale: Guertin and Halvorson (2003) cite that *Cynodon dactylon* var. *dactylon* does not produce mature seeds, but *Cynodon dactylon* var. *aridus* will produce viable seeds in favorable conditions. Bermudagrass variations are known to hybridize extensively, producing sterile hybrids that depend on vegetative reproduction. Different variations and hybrids of Bermudagrass species may exist in Arizona, so seed reproduction ability and viability are unknown, but likely.

Seed set can be less than 1% in the rest of the U.S. and 95% in Arizona and California where it is grown as a seed crop. Carey (1995) cites Bermudagrass as producing viable seeds but with a low germination rate until scarified. The vegetative reproduction ability of Bermudagrass is more rapid than by seed reproduction. If the seeds are viable, they can survive and remain viable for three to four years under favorable conditions (Guertin and Halvorson 2003). Bermudagrass requires hot and dry conditions to produce viable seeds and are known to flower May through November in Arizona (Guertin and Halvorson 2003).

Horowitz (1972b in Newman 1992)) reported Bermudagrass, in the second year of growth, can produce 87 inflorescences per square meter (78 in the first year). Guertin and Halvorson (2003) cited the Institute of Pacific Islands Forestry (2001), which stated that each Bermudagrass inflorescence can produce an average of 230 seed per infloresence. With these two facts, one can infer that one Bermudagrass plant stand can potentially produce over 20,000 seeds per square meter.

Sources of information: See cited literature.

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Humans have played a major part in the increased spread of Bermunda grass. The seeds are dispersed by irrigation water, soil movement, agricultural and landscape machinery, as a commercial seed contaminant, in livestock feed and bedding, and various other human activities including ship ballast and packing materials (Guertin and Halvorson 2003).

Rationale: Bermudagrass is used as a lawn turf and forage crop (Newman 1992). Bermudagrass is readily available for use as a lawn grass and in fact its use is encouraged by the University of Arizona Cooperative Extension's Turf Tips (2004). It is used as a principal pasture grass in southeastern U.S. and as a seed crop in the southwestern U.S. (Guertin and Halvorson 2003). The Yuma County Cooperative Extension (2004) cites Bermudagrass as one of the best perennial grasses for irrigated summer pastures and recommends it for commercial pasture or hay production. Collection record in Bapchule, Pinal County (SEINet 2004) documented the 1989 collection from L. Enos' pasture, who was cultivating it for horse forage.

Sources of information: See cited literature. Other sources: Turf Tips (available online at: http://ag.arizona.edu/turf/tips203%20.htm; accessed November 12, 2004), Yuma County Cooperative Extension recommendations (available online at http://cals.arizona.edu/yuma/urbanhorticulture/Bermudaforage.htm, accessed November 12, 2004), and SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed October 14, 2004).

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Bermudagrass seeds are dispersed by water (especially on rivers), wind, soil movement and when eaten by animals (Guertin and Halvorson 2003).

Rationale: Because this plant is used as a crop plant, one can infer that plant material and seeds could readily fall from trucks transporting the Bermudagrass hay.

Sources of information: See cited literature.

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Obs.**

Identify other regions: Invades ecological types that are invaded already in Arizona.

Rationale: Working Group concluded that all Arizona ecological types that are susceptible to Bermudagrass are invaded. Therefore, no different ecological types which are invaded elsewhere have equivalent environments in Arizona.

Sources of information: Working Group consensus

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: The earliest herbarium collection date is documented as July 1891 by J. Toumey in Pima County. Bermudagrass is most likely native to Africa (Guertin and Halvorson

2003). Bermudagrass is able to tolerate a wide range of soils and soil conditions (Guertin and Halvorson 2003); however, there is no information on how this directly impacts the soil ecology. Bermudagrass is adapted to various soils, from fertile, sandy to silty soils or alluvium to heavy clay, acidic to alkaline, and arable to non-arable (Guertin and Halvorson 2003).

From SEINet (2004: based on over 1000 records from Arizona in Arizona's herbaria): Arizona Upland Sonoran desertscrub, in sand in arroyo bottom in Silver Bell Moutain ; along Colorado River (river mile 143.5), river right, below junction. of Kanab Creek and river, 50 to 60 m from river's edge at 8000 cfs; Santa Cruz floodplain at San Rafael State Park, King Canyon and Chimena Canyon, Saguaro National Park-moist areas; several collections from Dead Horse Ranch state park in Yavapai County; Sycamore Canyon Wilderness Area, Sycamore Creek, south of Summer Spring,. about 3 km southwest of Black Mountain (cottonwood-willow riparian area).

Tonto National Forest. Superstition Wilderness Area. Miles Ranch Trailhead, near Paradise Spring. Forest Rd. 287, approximatley 12 miles from U.S. Highway 60 turnoff to Magma Copper Mine. Trail 271. Associated Species**:** *Cupressus arizonicus, Juniperus erythrocarpa, Quercus dunnii, Quercus emoryi* (specimen collected by K. Rice in 1991).

Rationale: There are 4 major and at least 6 minor ecological types invaded.

Sources of information: See cited literature. Also considered collections records from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed October 14, 2004).

Question 3.2 Distribution *Score:* **A** *Doc'n Level:* **Other pub.**

Describe distribution: According to multiple herbarium records, Bermudagrass is found in 12 of the 15 counties in Arizona (SEINet 2004). Gould (1951) and Kearney and Peebles (1960) report Bermudagrass being distributed throughout all 15 counties in Arizona.

Rationale: Based on Working Group discussion and observations. See Worksheet B. Dave Madison (personal communication, 2004) has over 265 observations of Bermudagrass in and around Phoenix, including the banks of the Agua Fria River and on many roadsides.

Sources of information: See cited literature. Also considered collections records from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed October 14, 2004) and observations by D. Madison (Quarantine Program Manager, Arizona Department of Agriculture, Phoenix, Arizona, 2004).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**[✓ Yes] No 1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**[✓ Yes] No 2 pt.**
Populations of this species produce seeds every year.	**[✓ Yes] No 1 pt.**
Seed production sustained for 3 or more months within a population annually	**[✓ Yes] No 1 pt.**
Seeds remain viable in soil for three or more years	**[✓ Yes] No 2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes No 1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**[✓ Yes] No 1 pt.**
Fragments easily and fragments can become established elsewhere	**[✓ Yes] No 2 pt.**
Resprouts readily when cut, grazed, or burned	**[✓ Yes] No 1 pt.**
	Total pts: 11 Total unknowns: 1
	Score : A

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	**D**
	Sonoran desertscrub	**C**
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	**D**
	southwestern interior wetlands	**U**
	montane wetlands	**U**
	playas	
Riparian	Sonoran riparian	**B**
	southwestern interior riparian	**A**
	montane riparian	
Woodlands	Great Basin conifer woodland	**D**
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Cynoglossum officinale* L. (USDA 2005)
Synonyms:	None identified in USDA (2005).
Common names:	Houndstongue, hound's tongue, sheep lice, woolmat, beggar's lice, gypsyflower
Evaluation date (mm/dd/yy)**:**	04/30/04
Evaluator #1 Name/Title:	Kate Watters
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Evaluator #2 Name/Title:	
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List committee members:	10/22/04: W. Albrecht, D. Backer, S. Harger, L. Moser, B. Phillips, J. Schalau, K. Spleiss 03/02/05: W. Albrecht, S. Harger, L. Moser, F. Northam, T. Olson
Committee review date:	10/22/04 and 03/02/05
List date:	03/02/05
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**U**	Other published material	**“Impact”** **Section 1 Score:** **C**	**“Plant Score”** **Overall Score:** **Low** **Alert Status:** **None**
1.2	Impact on plant community	**B**	Reviewed scientific publication		
1.3	Impact on higher trophic levels	**C**	Reviewed scientific publication		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Other published material	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **15 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Observational		
2.3	Recent trend in total area infested within state	**C**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**B**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Reviewed scientific publication		
2.7	Other regions invaded	**A**	Other published material		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**D**	Other published material	**“Distribution”** **Section 3 Score:** **D**	
3.2	Distribution	**D**	Observational		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **U** *Doc'n Level:* **Other pub.**

Identify ecosystem processes impacted: It is unclear how houndstongue populations impact natural fire regimes in ecosystems adapted to fire.

Rationale: It is unclear how the presence of houndstongue may alter the fire regime of a given site, and it is unclear how a historical fire regime might affect the presence or abundance of houndstongue at a given site.

It has been suggested that the exclusion or alteration of natural processes, such as fire and flooding, can encourage the establishment and persistence of houndstongue on prairie sites in Colorado (Rice and Randall 1999). On a western juniper (*Juniperus occidentalis*)/mountain mahogany (*Cercocarpus* spp.)/bluebunch wheatgrass site in northeastern Oregon, houndstongue established 5 years after a wildfire of moderate severity, but did not establish on a similar site that was severely burned (Johnson 1998). Houndstongue did not occur in any of these communities at the time in which historic fire regimes were functioning, but established since fire exclusion began. More information is needed about ecosystems in which houndstongue is likely to be invasive in North America.

Sources of information: See cited literature; also see Zouhar (2002).

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Identify type of impact or alteration: Houndstongue can establish rapidly and form dense monocultures in disturbed habitats. Populations of houndstongue displace native plant species and hinder the re-establishment of valuable range species.

Rationale: Houndstongue can form relatively dense stands on disturbed ground, but studies have shown that houndstongue seedlings have a comparatively low growth rate and are not strongly competitive. Interspecific competition severely reduces the dry weight of 1st and 2nd year houndstongue plants (Upadhyaya et al. 1988).

Generalist herbivores play a positive role in the population dynamics of houndstongue by reducing competition from grasses in coastal dunes in the Netherlands (Prins and Nell 1990). Similarly, in exclosure studies in northeastern Oregon, percent canopy cover houndstongue increased over a 30-year period under grazing pressure from both cattle and wildlife (Riggs et al. 2000). These studies suggest, therefore, that planting and maintaining competitive species can effectively control houndstongue, although more research is needed.

Sources of information: See cited literature; also see Rice et al. (1999) and Zouhar (2002).

Question 1.3 Impact on higher trophic levels *Score:* **C** *Doc'n Level:* **Rev. sci. pub.**

Identify type of impact or alteration: Houndstongue is unpalatable to livestock and causes poisoning in horses and cattle (for example, see Stegelmeier et al. 1996). Some studies report minor herbivory by rabbits and Rocky Mountain mule deer, and insect species.

Rationale: Houndstongue is most damaging on rangelands because it is toxic to livestock (Stegelmeier et al. 1996). Generally, the fresh plant is avoided by livestock because it is considered unpalatable, although domestic sheep graze the leaves with no apparent negative effects. Green houndstongue plants have a distinctive odor that discourages animals from eating it, but when dried it becomes more palatable (Knight et al. 1984, Baker et al. 1989). Houndstongue contains various pyrrolizidine alkaloids (PAs), whose concentrations are highest during its rosette stage and decrease as the plant matures (Knight *et al* 1984). Pyrrolizidine alkaloids are known to cause liver damage or failure in livestock. Kedzie-Webb and Sheley (1999) suggest that PAs are toxic to horses and cattle but not to domestic sheep. Poisoning can occur when houndstongue is cut and dried with harvested hay, or when animals are confined to a small area lacking desirable forage. Most livestock poisonings occur from ingestion of contaminated hay or feed. Any level of houndstongue contamination in feed should be considered potentially lethal for all livestock (Prins and Nell 1990). The barbed seeds of houndstongue readily attach to wool and fur. The seeds can also attach to the eyelashes of animals and cause eye damage, and the foliage may cause dermatitis (Kedzie-Webb and Sheley 1999). It is unknown whether the toxic effects of houndstongue observed in domestic livestock are similar in native ungulate populations in the wild.

Houndstongue plants have a distinctive odor that discourages animals from eating it, but when dried it becomes more palatable. One study reports light use of houndstongue by Rocky Mountain mule deer in winter in Montana (Kufeld et al. 1973). A three-year study by Prins and Nell (1990) in the coastal dunes of the Netherlands indicates only low levels of leaf herbivory by rabbits on houndstongue, and no root consumption by rabbits was found. It is not normally eaten by rabbits (Boorman and Fuller 1984), though rabbits have been observed digging up taproots in winter (De Jong et al. 1986). Houndstongue is listed as the only food plant for the confused Haploa moth or (*Haploa confusa*), which is common in tallgrass prairie habitats in east-central Illinois during the month of July (Lindroth 1987). From June to November, larvae of the oligophagous Lepidopteran, *Ethmia bipunctella*, are the most important herbivores on houndstongue. Captive mice eat nutlets, but it is unknown whether this occurs in wild settings (Zouhar 2002).

Sources of information: See cited literature.

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub.**

Identify impacts: Hybridization of houndstongue has been reported in Europe, but not in North America.

Rationale: There are no plants in the genus *Cynoglossum* in Arizona.

Sources of information: Kearney and Peebles (1960) and Upadhyaya et al. (1988).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Houndstongue colonizes disturbed sites.

Rationale: Houndstongue is shade tolerant (Upadhyaya and Cranston 1991) but grows best in full sunlight, if sufficient water and nutrients are available. Houndstongue was significantly ($p<0.05$) positively associated with closed canopies at Mammoth campground in Yellowstone National Park. Here it was more consistently found under high canopy cover than any other nonnative species. Similarly, Lacey and Lacey (1985) describe occurrences of houndstongue in areas of thick litter accumulation (as might be found under a forest with high canopy cover) (Allen and Hansen 1999).

Historic overgrazing by livestock and native ungulates encourages invasion by houndstongue (Rice and Randall 1999). Grazed range provides an environment where gaps are repeatedly created and therefore suitable sites for establishment are usually available (van der Meijden et al. 1992 in Zouhar 2002). Where it has established on disturbed sites such as roads and around old buildings, it may persist indefinitely, as is evidenced by its continued presence in abandoned mining towns in southwestern Montana, even after 45 to 77 years of recovery (Knapp 1991). It has been suggested that the exclusion or alteration of natural processes, such as fire and flooding, can encourage the establishment and persistence of houndstongue on prairie sites in Colorado (Rice and Randall 1999).

Sources of information: See cited literature.

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Obs.**

Describe rate of spread: Increases, but less rapidly than doubling in <10 years.

Rationale: Although seed dispersal occurs slowly over time, colonization of disturbed sites can take place quickly.

Sources of information: Score based on inference by Working Group members.

Question 2.3 Recent trend in total area infested within state *Score:* **C** *Doc'n Level:* **Obs.**

Describe trend: With treatment, the trend is stable or slightly decreasing (L. Moser, personal communication,2004).

Rationale: A small population at the Arizona Snowbowl parking lot has persisted but not spread over several years. Hand control methods of digging rosettes with shovels and pulling bolting plants have resulted in a decline in numbers but not eradication at the site. No new sites have been noted getting established along trails in the vicinity.

Sources of information: Personal communication with L. Moser (Botanist, U.S. Department of Agriculture, Forest Service, Coconino National Forest, Flagstaff, Arizona, 2004).

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: Houndstongue is a biennial or short-lived perennial forb, which exclusively reproduces by seed.

Rationale: Seedlings are usually strongly clustered around parent plants in densities of up to 405 seedlings per ft^2 (4500/m^2). Plants produce a range of 174 to 1823 nutlets/plant and seeds may remain viable up to 3 years.

Sources of information: Zouhar (2002) and Rutledge and McLendon (Undated).

Question 2.5 Potential for human-caused dispersal *Score:* **B** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Nutlets break off at maturity, easily spread by clinging to animals' fur and human clothing. Spread along transportation corridors such as highways, railroads and trails.

Rationale: Houndstongue seeds are covered in a spiny husk and possess a protruding barb that enables the seed to adhere to humans and domestic animals thus promoting long-distance dispersal. Arizona Snowbowl parking lot population was probably established by human dispersal on vehicle tires, grading equipment, or personal articles since there is no known population within a hundred miles and the area is not grazed by domestic livestock (B. Phillips, personal communication, 2004).

Sources of information: Zouhar (2002). Also considered personal communication with B. Phillips (Zone Botanist, U.S. Department of Agriculture, Forest Service, Coconino, Kaibab, and Prescott National Forests, 2004).

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Identify dispersal mechanisms: Most seeds fall within close proximity from the parent plant soon after ripening; however, some seeds remain on plants for up to two years, especially in sheltered habitats (e.g. scrub), thus creating an above-ground seed bank. Spiny nutlets are picked up by animals to disperse to new areas.

Rationale: In one experiment, many nutlets were found within 2 m of parent plant, and in another study, the majority of houndstongue seeds (75%) fell into an area of radius 5 inches (12 cm) around the parent plant. Some houndstongue seeds remain on plants well into the winter (Boorman and Fuller 1984, DeJong et al. 1990, De Clerck-Floate 1997). These seeds are dispersed slowly over time by attaching to animal wool and hair. Evidence from a study in British Columbia indicates that cattle are important dispersers of houndstongue seed, picking up about 65% of seeds per stalk in grazed paddocks (De Clerck-Floate 1997). European studies, however, suggest that animal dispersal is rare in houndstongue and wind is considered to be the primary dispersal mechanism. The greatest recorded dispersal distance was 4.6 feet (1.4 m). Although Boorman and Fuller (1984) suggest that with such limited primary dispersal range, even rare dispersal events by animals could be important. Dispersal via streams and irrigation ditches is unlikely due to the high specific gravity of houndstongue seeds (Upadhyaya et al.1988).

Sources of information: Zouhar 2002.

Question 2.7 Other regions invaded *Score:* **A** *Doc'n Level:* **Other pub.**

Identify other regions: Found in a number of ecological types in Utah that are similar to types in Arizona not currently invaded.

Rationale: The center of origin of houndstongue is thought to be the mountains of western Asia and eastern Europe. Houndstongue also occurs in apparently natural communities in Great Britain. One account suggests houndstongue was introduced to North America as a crop seed contaminant from Europe. Herbarium specimens of houndstongue were collected in Ontario as early as 1859 and in the western provinces between 1922 and 1934. As of 1988, houndstongue occurred in all provinces in Canada except Prince Edward Island and Newfoundland. It appeared to be most abundant in southern British Columbia and Ontario. Houndstongue occurs throughout the contiguous U.S. in all but six southern states. Its occurrence has not been reported in Alaska or Hawaii. Houndstongue is reported as a problem plant in natural areas and parks in several states including Michigan, Missouri, Indiana, Colorado, and Oregon.

From Welsh et al. (1987): In Utah, houndstongue may be found in sagebrush (*Artemisia* spp.), pinyon-juniper (*Pinus* spp.-*Juniperus* spp.), cottonwood (*Populus* spp.), mountain brush, quaking aspen (*Populus tremuloides*), ponderosa pine, and spruce-fir (*Picea* spp.-*Abies* spp.) communities. It is a minor component in Gambel oak (*Quercus gambelii*) communities in central and northern Utah. On preserves in Colorado, houndstongue has been reported in shortgrass prairie, narrowleaf cottonwood/red-osier dogwood (*Populus angustifolia*/*Cornus sericea*) riparian forests, and riparian meadows. Plants are found at 1480 to 3000 m in Utah.

In Arizona could possibly establish in Great Basin desertscrub, Great Basin conifer woodland, southwestern interior riparian**,** montane wetlands, and plains and Great Basin shrub-grassland.

Sources of information: See cited literature; also see Zouhar (2002). Also see The Atlas of the Vascular Plants of Utah (available online at: http://www.gis.usu.edu/Geography-Department/utgeog/utvatlas/ut-vascatlas.html; accessed on February 10, 2004).

Question 3.1 Ecological amplitude *Score:* **D** *Doc'n Level:* **Other pub.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: In Grand Canyon National Park, houndstongue is found at about 2460 m. At the Arizona Snowbowl it is found at about 2940 m. The northernmost limit of the species is about 68°N. This plant is primarily found in temperate regions, and it often occurs in areas with hot dry summers and cold winters. It is commonly found in ponderosa pine and Douglas fir plant communities. Houndstongue thrives on gravely, somewhat limy soils (between 2 to 50% calcium carbonate).

Rationale: Although houndstongue's potential ecological amplitude is broad, it currently has only been documented from one ecological tyoe in Arizona (see Worksheet B).

Sources of information: Zouhar (2002), Welsh et al. (1987), and SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed February 10, 2004). Also considered personal communication with B. Phillips 2004 (Zone Botanist, U.S. Department of Agriculture, Forest Service, Coconino, Kaibab, and Prescott National Forests, 2004).

Question 3.2 Distribution *Score:* **D** *Doc'n Level:* **Obs.**

Describe distribution: In Arizona populations occur on the North Rim of the Grand Canyon and at Arizona Snowbowl parking lot at the top of the Snowbowl Road in the San Francisco Peaks area. The potential population in the Santa Catalina Mountains requires confirmation.

Rationale: Distribution is at present limited.

Sources of information: SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed February 10, 2004), personal communication with B. Phillips 2004 (Zone Botanist, U.S. Department of Agriculture, Forest Service, Coconino, Kaibab, and Prescott National Forests, 2004), and Southwest Exotic Plant Mapping Program (SWEMP)-Cain Crisis map (available online at: http://cain.nbii.gov/cgibin/mapserv?map=../html/cain/crisis/crisismaps/crisis.map&mode=browse&layer=state&layer=county; accessed on February 10, 2004).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ **Yes**]	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	[✓ **Yes**]	**No**	**2 pt.**
Populations of this species produce seeds every year.	**Yes**	[✓ **No**]	**1 pt.**
Seed production sustained for 3 or more months within a population annually	[✓ **Yes**]	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	[✓ **Yes**]	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	[✓ **Yes**]	**No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes**	[✓ **No**]	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	[✓ **No**]	**2 pt.**
Resprouts readily when cut, grazed, or burned	[✓ **Yes**]	**No**	**1 pt.**

Total pts: 8 Total unknowns: 0

Score : A

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	
	montane riparian	
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	**U**
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Echinochloa crus-galli* (L.) Beauv. (USDA 2005)
Synonyms:	*Panicum crus-galli* L. (USDA 2005)
Common names:	Barnyardgrass, Japanese millet, cockspur grass, cockspur panicum, barnyard millet, summer grass, watergrass, billion dollargrass, chickenpanicum grass
Evaluation date (mm/dd/yy)**:**	11/19/04
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Committee review date:	11/19/04 and 03/01/05
List date:	03/01/05
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**C**	Other published material	**"Impact"** **Section 1 Score:** **C**	**"Plant Score"** **Overall Score:** **Low** **Alert Status:** **None**
1.2	Impact on plant community	**D**	Other published material		
1.3	Impact on higher trophic levels	**D**	Observational		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**B**	Other published material	**"Invasiveness"** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **9 pts** **Section 2 Score:** **C**	
2.2	Local rate of spread with no management	**U**	Observational		
2.3	Recent trend in total area infested within state	**U**	Observational		
2.4	Innate reproductive potential	**A**	Reviewed scientific publication		
2.5	Potential for human-caused dispersal	**C**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Other published material		
2.7	Other regions invaded	**C**	Observational		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**A**	Other published material	**"Distribution"** **Section 3 Score:** **B**	
3.2	Distribution	**C**	Observational		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **C** *Doc'n Level:* **Other pub**.

Identify ecosystem processes impacted: Soil nutrients.

Rationale: Experiments have shown that heavy stands *of Echinochloa crus-galli* can remove 60 to 80% of nitrogen from the soil in a crop area as well as significant amounts of other macronutrients (Holm et al. 1991, Guertin and Halvorson 2003). No tests are known from native plant communities.

Sources of information: See cited literature. Also considered Working Group member observations and discussion.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **D** *Doc'n Level:* **Other pub**.

Identify type of impact or alteration: Local displacement of native vegetation; removal of nitrogen and soil nutrients may impact growth and productivity of adjacent native species.

Rationale: In some wetlands of North Dakota, barnyardgrass is the dominant species (Smeins 1971 and Great Plains Flora Association 1986 in Esser 1994). In the southern High Plains region of northern Texas and southern New Mexico, it is a codominant in wet meadow and prairie communities (Bryant and Smith 1988 and Bolen et al. 1989 in Esser 1994).

Although barnyardgrass likely replaces native wetland species in Arizona, no data were found on the magnitude of this impact (e.g. changes in species composition or density). According to Van Devender et al. (1997) barnyardgrass, as well as other species of non-native plants in riparian zones of the Sonoran Desert region, are "relatively innocuous with few serious impacts on the flora and vegetation."

Sources of information: See cited literature.

Question 1.3 Impact on higher trophic levels *Score:* **D** *Doc'n Level:* **Obs.**

Identify type of impact or alteration: No negative impacts have been documented although seeds may provide seasonal source of forage for bird species and possibly small mammals.

Rationale: Barnyardgrass is an important source of food and cover for waterfowl in the Sacramento Valley (Mushet at al. 1992), as well as in playa lakes of Texas and New Mexico (Bolen at al. 1989 in Esser 1994). Seeds are eaten by songbirds, waterfowl, and greater prairie chickens (Esser 1994). No references to wildlife species in Arizona were found; however, based on information from other areas, barnyardgrass likely provides a seed source for birds and small mammals.

Sources of information: See cited literature. Also considered Working Group discussion.

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub**.

Identify impacts: No information regarding potential for hybridization found in the available literature.

Rationale: The only congener, jungle-rice (*Echinochloa colona* (L.) Link), is also non native.

Sources of information: See Kearney and Peebles (1960) and Guertin and Halvorson (2003).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Fires and scouring floods in riparian areas can reduce or eliminate canopy and ground cover resulting in conditions favorable to colonization.

Rationale: Barnyardgrass is a pioneer species that readily invades disturbed sites. It is most often found in open, unshaded areas and is intolerant of dense shade (Mitich 1990, Esser 1994). Its growth rate and leaf area were reduced, assimilation rate slowed, and the number of tillers and panicles were lower in shady conditions (Maun and Barrett 1986). In an old-field succession deciduous forest in southwestern

Ohio, barnyardgrass was found growing in a two-year-old stand, but was absent in stands 10, 50, 90, or 200 years-old (Vankat and Walter 1991 in Esser 1994).

Barnyardgrass may colonize burned areas from soil-stored seed after fires. Fires that thin or remove canopy vegetation produce conditions that may be conducive to colonization by barnyardgrass (Esser 1994).

Maun and Barrett (1986) suggest that barnyardgrass's plastic response to environmental conditions enables the species to survive and reproduce under a wide range of conditions in unpredictable environments that are common in seasonally flooded lands. No observations have been made of barnyardgrass becoming established in vegetation communities outside of riparian areas or agricultural settings.

Sources of information: See cited literature. Also considered Working Group member observations and discussion.

Question 2.2 Local rate of spread with no management *Score:* **U** *Doc'n Level:* **Obs.**

Describe rate of spread: No published data found.

Rationale: According to F. Northam (personal communication, 2004) barnyardgrass is widespread and has been in Arizona for over 100 years, but is not a species that is "on the move." Because this species, however, is a minor part of the non-native flora in wetland, riparian, and aquatic sites, no one had a good estimate of its rate of spread in localized situations.

Sources of information: Personal communication with F. Northam (Weed Biologist, Tempe, Arizona, 2004) and Working Group discussion.

Question 2.3 Recent trend in total area infested within state *Score:* **U** *Doc'n Level:* **Obs.**

Describe trend: Unknown.

Rationale: The earliest known record in Arizona is from Pima County in 1891. The species can now be found in agricultural, riparian, and mesic situations throughout the state. No information was found to indicate an upward trend in area infested. Not a species that has received much attention in Arizona.

Sources of information: Personal communication with F. Northam (Weed Biologist, Tempe, Arizona, 2004) and Working Group discussion.

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Describe key reproductive characteristics: See Worksheet A.

Rationale: A warm-weather, C4, tufted, annual graminoid that is also self-pollinating, reproducing from seed (Guertin and Halvorson 2003). Seed production is highly variable, dependent and responding to site conditions, especially nutrient availability, day length, and plant density. Stevens (1932) reports that an average, well-developed barnyardgrass plant growing with little competition produces 7160 seeds/plant. A "healthy full-season barnyardgrass in California's Central Valley can produce 750,000 to 1,000,000 seeds" and up to "2,250,000 seeds under optimal conditions" (R. Norris, personal communication in Mitich 1990). Barnyardgrass seed is primarily water dispersed. Holm et al. (1991) state that single plants in the U.S. have produced 5,000 to 7,000 seeds and "such production, in a weedy field, could result in a yield of 1,100 kg of weed seeds per hectare."

Barnyardgrass can vegetatively propagate when possessing a prostrate growth habit by rooting at its nodes and producing new shoots (Holm et al. 1991). Roots of the weed can extend to 46 inches (116 cm) deep and 42 inches (106 cm) wide in porous, well-drained soil enabling the plant to withstand drought conditions (Maun and Barrett 1986). Barnyardgrass flowering dates in Arizona are from July to September and from July to October in California (Esser 1994).

Barnyardgrass seeds have an innate dormancy and Manidool (1992) reports that in the U.S. dormancy ranges from 4 to 48 months. Seeds germinate and seedling emergence is better when soil is compact (Holm et al. 1991). Germination occurs optimally when soil water-holding capacity ranges between 70 to 90% of its maximum (Arai and Miyahara 1963, Holm et al. 1991). Barnyardgrass seed germinates over a wide temperature range, 55 to 104°F with optimum germination occurring from 68 to 86°F (Esser 1994).

Seed viability in soil is variable. In Mississippi seed viability was 1% after burial for 2.5 years; less than 6% of seed survived 6 months or longer (Egley and Chandler 1978); however, according to Dawson and Bruns (1975) barnyardgrass seed may be viable in the soil for up to 13 years.

Sources of information: See cited literature.

Question 2.5 Potential for human-caused dispersal *Score:* **C** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Dispersed as a common contaminant of crop seeds or when used in erosion control (Guertin and Halvorson 2003). It is readily grazed by livestock in Arizona (Kearney and Peebles 1960).

Rationale: Barnyardgrass seed is primarily dispersed by water. Direct human spread to, within, and between agricultural landscapes is likely facilitated by irrigation systems. Movement of livestock from agricultural to natural areas could facilitate spread.

Spread to wildlands is possible from sumps adjacent to riparian areas during overbank flooding; however, successful establishment is considered to be infrequent due to flood frequency and seed viability factors. Other than riparian areas, spread into uplands would not be expected. Barnyardgrass is adapted to wet sites and waterlogged conditions, growing best where sites have 35 to 65% soil moisture (Maun and Barrett 1986).

Sources of information: See cited literature. Also considered Working Group discussion.

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Other pub**.

Identify dispersal mechanisms: Primarily water and birds.

Rationale: Seeds are easily dispersed in water, with seeds able to float, consequently being spread by flood or natural flows of rivers, creeks, etc. After four to five days, 50% of seed were documented to be afloat (Esser 1994). Could be spread by large ungulates at wallows; seeds have been found matted in fur/hair of bison (Ridley 1930 in Guertin and Halvorson 2003). Spread by ducks, waders, and seed-eating birds. Barnyardgrass is an important source of food and cover for waterfowl in the Sacramento Valley of California (Mushet et al. 1992). Draining barnyardgrass fields in the spring, followed by discing, is a management practice used to perpetuate stands of barnyardgrass in California to benefit waterfowl (Esser 1994).

Sources of information: See cited literature. Also considered Working Group discussion.

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Obs.**.

Identify other regions: Widespread species wherever moist soils occur. In the southern High Plains region of northern Texas and southern New Mexico it is also found in prairie communities and shinnery communities. In South Dakota it occurs in mixed-grass prairie dominated by blue grama (*Bouteloua gracilis*), buffalo grass (*Buchloë dactyloides*), western wheatgrass (*Agropyron smithii*), and needle grass (*Stipa* spp.). It is also found in tallgrass prairies of northeast Kansas. At Gettysburg National Military Park in Pennsylvania, barnyardgrass occurs in a variety of forest cover types as an understory species (Esser 1994).

Rationale: Equivalent sites in Arizona will be major ecological types with warm temperatures and soils that remain moist during the hot portions of the growing season (May to October) and include: freshwater systems, non-riparian wetlands and riparian sites. Herbarium records (SEINet 2004) indicate each of these ecological types have established populations of barnyardgrass (see rationale in questions 3.1 and 3.2). Therefore, this question is rated as **C** because all types of moist areas in Arizona's wildlands already have established barnyardgrass populations.

Sources of information: See cited literature. Score based on inference drawn from the literature, information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed December 17, 2004), and Working Group discussion.

Question 3.1 Ecological Amplitude *Score:* ***A*** *Doc'n Level:* **Other pub**.

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Barnyardgrass is now a common weed of most of the agricultural areas of the world except Africa. A native of Europe and India, it has a range extending from latitude 50N to 40S. It is a cosmopolitan weed that is troublesome in both temperate and tropical crops (Holm et al. 1991). On the North American continent, it is found throughout the United States, Canada, and Mexcio.

There apparently is no documented introduction into the United States (Guertin and Halvorson 2003). Barnyardgrass was recorded in various locations in eastern Canada from as early as 1829 (Maun and Barrett 1986). It was recorded in California between 1825 to 1848 (Guertin and Halvorson 2003).

Barnyardgrass is adapted to wet sites and waterlogged conditions, and it thrives in hot, wet conditions from sea level to 8,200 feet (Manidool 1992 in Guertin and Halvorson 2003), growing best where sites have 35 to 65% soil moisture (Maun and Barrett 1986 in Guertin and Halvorson 2003). In drier soils it is not as tall and the yield of seeds and the numbers of panicles and tillers are reduced. It grows best in rich, moist soils with a high nitrogen content, but it can also thrive on sand and loamy soils (Holm et al. 1991). Barnyardgrass is intolerant of dense shade (Mitich 1990).

In the southwestern U.S., barnyardgrass occurs in moist loamy soils (often disturbed), in marshes, seepage sites, and in the mud and water of lakes, ditches, and floodplains. It is a troublesome weed in the moist soils of all agricultural areas in Arizona, found in irrigated fields and orchards, pastures, roadside swales, ditches and also reservoirs and streams to 7,000 feet (Parker 1972). Based on the collections accessed through SEINet (2004), there is a record of barnyardgrass from Apache County (Reservation Ranch on the "Apache Indian Reservation") from 9500'.

According to SEINet (2004) the earliest documented record of the species in Arizona is a record from "Pima County, Tucson" from 1891. It also was collected from Walnut Canyon in Coconino County in 1898.

Rationale: Barnyardgrass populations have been observed in three major Arizona ecological types, Freshwater Systems, Riparian, and Non-Riparian Wetlands, and seven minor ecological types. See Worksheet B.

Sources of information: See cited literature. Also considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed December 17, 2004), personal communication with F. Northam (Weed Biologist, Tempe, Arizona, 2004), and Working Group member observations.

Question 3.2 Distribution *Score:* **C** *Doc'n Level:* **Obs.**

Describe distribution: In Arizona barnyardgrass is found in wet areas of every county except La Paz.

Rationale: Distribution records from the Arizona State University Vascular Plant Herbarium, University of Arizona Herbarium, and Northern Arizona University Vascular Plant Herbarium as recorded in SEINet (2004):

Cochise County: Ramsey Canyon, Huachuca Mountains, seep in pine-oak woodland, 6,300 feet; San Pedro River floodplain, near Cascabel, grassland with sparse tamarisk, at 150 m from river, 929 m;
Graham County: five miles south of Safford in cultivated field; Upper Turkey Creek, 5 miles west of Point of Pines, dry creek bed, Ponderosa Pine habitat, 6200 feet;
Greenlee County: Apache-Sitgreaves National Forest, along Coal Creek, at 2 km southwest of Arizona-New Mexico state line along Arizona Highway78, ponderosa pine-oak forest, “rooting in the water” 1700 m; US 666, 62 miles south of Alpine, 7.6 miles south of Hog Trail Saddle, roadside in juniper/grassland;
Apache County: Canyon de Chelly National Monument, very common along stream in upper Canyon del Muerto, 6900 feet; Hubbell Trading Post National Historic Site, Pueblo Colorado Wash, common along intermittent Stream, 6320 feet;
Navajo County: Clear Creek Reservoir, at 6 miles southeast of Winslow, mesic area around Reservoir, 4900 feet; Fort Apache Indian Reservation, pond on north side of Big Springs road, 6880 feet;
Coconino County: Lake Mary, in moist soil along lake, 6900 feet; Kaibab National Forest, Pine Flat Hunting Camp, in moist soil at stock reservoir, 6900 feet;
Mohave County: Clack’s Canyon, northwest of Kingman, in water near dairy; Grand Canyon, Hualapai Indian Reservation, Colorado River Mile 259.7, head of Burnt Canyon, 1100 feet;
Yuma County: “Along irrigated ditches” (1912); Cabeza Prieta Game Range (no additional data);
Yavapai County: Verde River, west of Perkinsville, wet bank at river’s edge, 3820 feet; Jerome, wet ground below storage tank;
Pima County: Cabeza Prieta National Wildlife Refuge, artificial dirt charco on San Cristobal Wash, 1090 feet; Santa Cruz River, 2160 feet;
Santa Cruz County: 1 km north of Canelo Pass summit, rocky slope on oak-juniper area, on the margin of a cattle Tank “full of water,” 1650 m; Nature Conservancy Patagonia-Sonoita Creek Sanctuary, southwest of Patagonia, 4000 feet;
Pinal County: Experimental farm near Sacaton, ditchbank; San Pedro River near Dudleyville, middle aged cottonwood woodland with tamarisk, 607 m;
Gila County: Tonto National Forest, Sierra Ancha Wilderness, along Forest Service Road 203 at 6.2 km south of Board Tree Saddle 4300 feet; Tonto National Forest, 3-Bar Watershed, “wet site in chaparral,” 3800 feet;
Maricopa County: Tonto National Forest, Seven Springs Wash, riparian, 3300 feet; edge of irrigation ditch between Tempe and Mesa.

Sources of information: SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed December 17, 2004).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**[✓ Yes]**	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**[✓ Yes]**	**No**	**2 pt.**
Populations of this species produce seeds every year.	**[✓ Yes]**	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**[✓ Yes]**	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	**[✓ Yes]**	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**[✓ Yes]**	**No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes**	**[✓ No]**	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	**[✓ No]**	**2 pt.**
Resprouts readily when cut, grazed, or burned	**Yes**	**[✓ No]**	**1 pt.**

Total pts: 8 Total unknowns: 0

Score : A

Note any related traits: Flowering dates in Arizona are between July and September (Kearney and Peebles 1960). Maun and Barrett (1986) suggest *Echinochloa crus-gallis*'s plastic response to environmental conditions enables the species to survive and reproduce under a wide range of conditions in unpredictable environments that are common in seasonally flooded lands. They also attribute this plant's success to heavy seed production, seed dormancy, its ability to grow and reproduce quickly over a wide range of photoperiods, and substantial herbicide resistance**.**

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	**C**
	rivers, streams	**C**
Non-Riparian Wetlands	Sonoran wetlands	**D**
	southwestern interior wetlands	**D**
	montane wetlands	**D**
	playas	
Riparian	Sonoran riparian	**C**
	southwestern interior riparian	**C**
	montane riparian	**U**
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial):	*Eichhornia crassipes* (Mart.) Solms (USDA 2005)
Synonyms:	*Eichhornia speciosa* Kunth, *Piaropus crassipes* (Mart.) Raf. (USDA 2005)
Common names:	Water hyacinth, common water hyacinth, floating water hyacinth
Evaluation date (mm/dd/yy):	02/16/04
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Committee review date:	03/26/04 and 05/21/04
List date:	05/21/04
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**A**	Other published material	**“Impact”** **Section 1 Score:** **A**	**“Plant Score”** **Overall Score:** **High** **Alert Status:** **Alert**
1.2	Impact on plant community	**A**	Observational		
1.3	Impact on higher trophic levels	**A**	Observational		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**A**	Other published material	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **11 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**U**	Observational		
2.3	Recent trend in total area infested within state	**C**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**B**	Observational		
2.6	Potential for natural long-distance dispersal	**C**	Observational		
2.7	Other regions invaded	**C**	Observational		RED FLAG **YES** Something you should know.
3.1	Ecological amplitude	**D**	Observational	**“Distribution”** **Section 3 Score:** **D**	
3.2	Distribution	**U**	Observational		

Red Flag Annotation

At present no wildland aquatic ecosystems within Arizona are known to be infested with *Eichhornia crassipes*. Records at the Arizona Department of Agriculture, however, indicate several small (<0.4 hectares [1 acre]) populations have been discovered and eradicated from Arizona wildland streams, park ponds, and irrigation tail-water pits during the past 20 years. *Eichhornia crassipes* is listed as a regulated and restricted noxious weed in Arizona.

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **A** *Doc'n Level:* **Other pub.**

Identify ecosystem processes impacted: No wildland aquatic ecosystems within Arizona are known to be infested with *Eichhornia crassipes* at this time (ADA Undated a; F. Northam, personal observations, 2004). Records at the Arizona Department of Agriculture, Noxious Weed Program Office, however, show several small (<1 acre) populations have been discovered and eliminated in Arizona streams, park ponds, and irrigation tail water pits during the past 20 years (ADA Undated b). Wastewater reclamation wetlands at Sahuarita High School and Arizona Desert Museum in Pima County maintain treatment ponds, which use *E. crassipes* as filter plants. Dense populations of this species produce thick mats that lower dissolved oxygen and pH, increase carbon dioxide, restrict water flow, and reduce sunlight to submerged species.

Rationale: In Arizona rapid vegetative growth will be the biological attribute by which *E. crassipes* will degrade natural ecosystem processes if this species escapes into permanent water bodies. The Working Group assumed the same water quality factors will be damaged in susceptible Arizona waters, as has been described in other North American regions and other continents. Rapid growth during summer creates a management problem requiring wasterwater reclamation populations to be periodically thinned (Holm et al. 1991, Parsons and Cuthbertson 1992, Godfrey 2000). One acre of *E. crassipes* mat can weight up to 200 tons; this further degrades water quality by reducing dissolved oxygen when large numbers of plants die and decompose (Ramey 2001). Evapotranspiration by dense colonies of *E. crassipes* is up to four times higher than from open non-infested water surfaces (DNRM 2005).

Sources of information: See cited literature. Also considered Arizona weed location records documented by F. Northam (Weed Biologist, Tempe, Arizona, 2004).

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **A** *Doc'n Level:* **Obs.**

Identify type of impact or alteration: As stated in question 1.1, aggressive rapid growth of *E. crassipes* is the competitive mechanism by which native aquatic Arizona plants will be physically displaced and normal sunlight penetration to submerged plants will be blocked. Equally aggressive growth by submerged *E. crassipes* roots will make inorganic nutrients less available for native aquatic plants.

Rationale: Reports of *E. crassipes* attributes from other regions are the basis of predictions of ecological damage to native Arizona aquatic plant communities by this introduced pest.

Sources of information: See sources cited in question 1.1.

Question 1.3 Impact on higher trophic levels *Score:* **A** *Doc'n Level:* **Obs.**

Identify type of impact or alteration: No information is available that documents *E. crassipes* effects on higher trophic organisms in Arizona; however, reports from other states and regions indicate Arizona aquatic habitats should be expected to have drastic reductions in organisms that use native aquatic plants for forage, breeding sites, escape areas, etc. if *E. crassipes* were to become established over large areas of Arizona surface waters (see references in questions 1.1 and 1.2.). *Eichhornia crassipes* also increases mosquito habitat, which can increase the potential for mosquito-borne diseases.

Rationale: See discussions in questions 1.1 and 1.2 concerning reduction of sunlight to submerged plants and elimination of dissolved oxygen for aerobic organisms due to decomposition of water hyacinth biomass. *Eichhornia crassipes* growth can produce dense mats that provide habitat for mosquitos. As this mosquito habitat increases, it becomes potential breeding sites for vectors of arthropod-borne diseases such as West Nile virus, malaria, and encephalitis (USGS 2001, DNRM 2005, Center for Disease Control Undated, Florida Department of Environmental Protection Undated).

Sources of information: See cited literature and other references cited in question 1.1. Also considered information from the Florida Department of Environmental Protection, Bureau of Invasive Plant Management. Undated. Weed Alert: Water-hyacinth (*Eichhornia crassipes*) (available online at: http://www.dep.state.fl.us/lands/invaspec/2ndlevpgs/pdfs/hyacinth.pdf; accessed March 2004) and Center for Disease Control, Division of Vector-Borne Infectious Diseases. Undated. Arboviral Encephalitides (available online at: http://www.cdc.gov/ncidod/dvbid/arbor/indes.htm; accessed March 2004).

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub.**

Identify impacts: None reported for Arizona.

Rationale: No native *Eichhornia* species occur in Arizona (Kearney and Peebles 1960).

Sources of information: See cited literature. See also USDA (2005).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **A** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Habitat disturbance is not required for an aquatic environment to become infested with *E. crassipes.* Observations and enforcement activities by Arizona Department of Agriculture inspectors show that *E. crassipes* is produced and traded by water garden hobbyists in central, south-central, and southwestern Arizona.

Rationale: As an obligate aquatic macrophyte, *E. crassipes* cannot survive extended periods out of water. Likewise, because of its tropical origin, this plant does not survive in regions where surface waters freeze far enough below the surface to kill plant crowns (rhizomes; Holm et al. 1991, Ramey 2001). As a result, dispersal to new watersheds in Arizona is a direct result of human transport from one water body to another and does not require disturbance for establishment. Anywhere humans can dump *E. crassipes* in natural waters and where annual temperatures are mild, this species will establish regardless of the ecological state of the site.

Observations of *E. crassipes* growth and reproduction in commercial ponds and constructed wetlands in Arizona suggest that this species will thrive and dominate natural aquatic ecosystems where current water velocity is none or slight (ADA Undated a; F. Northam, personal observations, 2003, 2004).

Field observations and enforcement activities by Arizona Department of Agriculture inspectors show that *E. crassipes* is produced and traded by water garden hobbyists in central, south-central, and southwestern Arizona (ADA Undated a). Acceptable climates for *E. crassipes* survival in Arizona wildlands occur below 2500 feet elevation. Once established, vegetative reproduction during June to October provides new plants for further infestations downstream. During cool-weather months (November through May), plants become dormant above water. In Arizona at elevations above 3000 feet, *E. crassipes* plants are killed by winter climate conditions (F. Northam, personal observations, 2003).

Sources of information: See cited literature. Also considered personal observations by F. Northam (during tenure as the Arizona Noxious Weed Program Coordinator, Arizona Department of Agriculture, Phoenix, Arizona, 2003) and Arizona weed location records documented by F. Northam (Weed Biologist, Tempe, Arizona, 2004).

Question 2.2 Local rate of spread with no management *Score:* **U** *Doc'n Level:* **Obs.**

Describe rate of spread: Stable

Rationale: No known infestations in natural freshwater habitats in Arizona.

Sources of information: See ADA (Undated a). Also considered personal observations by F. Northam (during tenure as the Arizona Noxious Weed Program Coordinator, Arizona Department of Agriculture, Phoenix, Arizona, 2003) and Arizona weed location records documented by F. Northam (Weed Biologist, Tempe, Arizona, 2004).

Question 2.3 Recent trend in total area infested within state *Score:* **C** *Doc'n Level:* **Obs.**

Describe trend: Stable

Rationale: No reports of recent increase or decrease of total area infested in Arizona (ADA Undated a; F. Northam, personal observations, 2003, 2004).

Sources of information: See cited literature. Also considered personal observations by F. Northam (during tenure as the Arizona Noxious Weed Program Coordinator, Arizona Department of Agriculture, Phoenix, Arizona, 2003) and Arizona weed location records documented by F. Northam (Weed Biologist, Tempe, Arizona, 2004).

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: Matures in<1 year, produces seed every year, produces seed at least 3 months per year, rapid vegetative reproduction, fragments easily and can establish elsewhere, and resprouts when cut.

Rationale: Seed production occurs, but seed and seedlings are rarely seen in wildland infestations (Batcher 2000). Descriptions of *E. crassipes* growth and reproduction in California and Florida indicate this weed is an economic and ecological threat to Arizona waters because of its rapid vegetative reproduction (Holm et al. 1991, Godfrey 2000, Ramey 2001).

Sources of information: See cited literature.

Question 2.5 Potential for human-caused dispersal *Score:* **B** *Doc'n Level:* **Obs.**

Identify dispersal mechanisms: Deliberate introduction into public waters, transport on boats and trailers, commercial sales, and aquarium hobbyists.

Rationale: Deliberate introduction of vegetative material into public waters, transport on boats and trailers, and commercial sales contribute to a high probability of human introduction into aquatic wildland habitats (Godfrey 2000). Anywhere humans can dump *E. crassipes* into natural waters and where annual temperatures are mild, this species will establish regardless of the ecological state of the site (F. Northam, personal observation, 2004).

Sources of information: See cited literature. Also considered Arizona weed location records documented by F. Northam (Weed Biologist, Tempe, Arizona, 2004).

Question 2.6 Potential for natural long-distance dispersal *Score:* **C** *Doc'n Level:* **Obs.**

Identify dispersal mechanisms: Flood dispersal can move *E. crassipes* many kilometers downstream, but this species cannot migrate upstream without human intervention.

Rationale: At this time, no known infestations occur in natural freshwater habitats in Arizona. As a result, dispersal by natural agents is unlikely (ADA Undated a; F. Northam, personal observations, 2003, 2004). Underwater seed dissemination and scarcity of seedlings suggest long distance dispersal from horticultural sites by wind, mammals, birds, etc. is unlikely (Batcher 2000).

Sources of information: See cited literature. Also considered personal observations by F. Northam (during tenure as the Arizona Noxious Weed Program Coordinator, Arizona Department of Agriculture, Phoenix, Arizona, 2003) and Arizona weed location records documented by F. Northam (Weed Biologist, Tempe, Arizona, 2004).

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Obs.**

Identify other regions: Invades similar ecological types in other states with appropriate warm temperatures during winter: streams, channels and lakes. *Eichhornia crassipes* invades elsewhere, but only in ecological types that are similar to where it will or has survived in Arizona (F. Northam, personal observation, 2004).

Rationale: *Eichhornia crassipes* is restricted to freshwater habitats that rarely freeze (Holm et al. 1991, Parsons and Cuthbertson 1992, Godfrey 2000).

Sources of information: See cited literature. Also considered Arizona weed location records documented by F. Northam (Weed Biologist, Tempe, Arizona, 2004).

Question 3.1 Ecological amplitude *Score:* **D** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Historically it was present in Arizona streams but has since been eradicated. Acceptable climates for *E. crassipes* survival in Arizona wildlands occur below 2500 feet elevation. Once established, vegetative reproduction during June to October provides new plants for further infestations downstream.

Rationale: Freshwater systems with little or no current are the only ecological types where *E. crassipes* will colonize in Arizona wildlands (F. Northam, personal observation, 2004). See Worksheet B.

Sources of information: See ADA (Undated a). Also considered Arizona weed location records documented by F. Northam (Weed Biologist, Tempe, Arizona, 2004).

Question 3.2 Distribution *Score:* **U** *Doc'n Level:* **Obs.**

Describe distribution: Unknown in natural waters of Arizona at this time.

Rationale: Not known to be inhabiting any natural or disturbed freshwater sites in Arizona, however, numerous private ponds and retailers who service the backyard pond market have been identified as distributors during the past three years.

Sources of information: Personal observations by F. Northam (during tenure as the Arizona Noxious Weed Program Coordinator, Arizona Department of Agriculture, Phoenix, Arizona, 2003) and Arizona weed location records documented by F. Northam (Weed Biologist, Tempe, Arizona, 2004).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ **Yes**]	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**Yes**	**No**	**0 pt.**
Populations of this species produce seeds every year.	[✓ **Yes**]	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	[✓ **Yes**]	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	**Yes**	**No**	**0 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes**	[✓ **No**]	**0 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	[✓ **Yes**]	**No**	**1 pt.**
Fragments easily and fragments can become established elsewhere	[✓ **Yes**]	**No**	**2 pt.**
Resprouts readily when cut, grazed, or burned	[✓ **Yes**]	**No**	**1 pt.**
	Total pts: 7	**Total unknowns: 2**	
	Score : A		

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	Dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	**U**
	rivers, streams	**D** (historical)
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	Playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	
	montane riparian	
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial)**:**	*Elaeagnus angustifolia* L. (USDA 2005)
Synonyms:	None identified in USDA (2005).
Common names:	Russian olive, narrow-leaved oleaster, oleaster, silverberry
Evaluation date (mm/dd/yy)**:**	05/6/2003
Evaluator #1 Name/Title:	Patty Guertin / Research Specialist (botany)
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Evaluator #2 Name/Title:	
Affiliation:	
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List committee members:	D. Backer, J. Brock, K. Brown, D. Casper, P. Guertin, M. Quinn, J. Ward, P. Warren
Committee review date:	11/21/03
List date:	11/21/03
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**A**	Reviewed scientific publication	**“Impact”** **Section 1 Score:** **A**	**“Plant Score”** **Overall Score:** **High** **Alert Status:** **None**
1.2	Impact on plant community	**A**	Reviewed scientific publication		
1.3	Impact on higher trophic levels	**B**	Reviewed scientific publication		
1.4	Impact on genetic integrity	**D**	Observational		
2.1	Role of anthropogenic and natural disturbance	**A**	Reviewed scientific publication	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **17 pts** **Section 2 Score:** **A**	
2.2	Local rate of spread with no management	**A**	Observational		
2.3	Recent trend in total area infested within state	**B**	Observational		
2.4	Innate reproductive potential	**B**	Reviewed scientific publication		
2.5	Potential for human-caused dispersal	**A**	Other published material		
2.6	Potential for natural long-distance dispersal	**A**	Reviewed scientific publication		
2.7	Other regions invaded	**C**	Observational		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**A**	Other published material	**“Distribution”** **Section 3 Score:** **B**	
3.2	Distribution	**C**	Observational		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Identify ecosystem processes impacted: *Elaeagnus angustifolia* can form extensive monotypic stands along riparian corridors which can alter system hydrology, nutrient cycling of a site, and fuel loads (which increase the potential for catastrophic wildfire) (Howe and Knopf 1991, Paschke 1997, Caplan 2002, Tu 2003).

Rationale: Research and subsequent publications are focused on areas outside of Arizona.
Tu (2003) notes that when *E. angustifolia* spreads throughout riparian woodlands it can connect lowland riparian forests with more open, upland areas; *E. angustifolia* contributes to stabilization of riverbanks against future flooding, changing the system hydrology (Howe and Knopf 1991, Tu 2003).
It is suggested that *E. angustifolia* has a higher evapotranspiration rate than the native trees it grows and competes with (Tu 2003). In a New Mexico study, annual evapotranspiration rates were measured to be at their highest on riparian sites having a dense stand of *Tamarix ramosissima*, and sites having a *Populus deltoides* spp. *wislizenia* with an extensive understory of *Tamarix* and *E. angustifolia*, versus a mature *Populus* closed-canopy stand. Although a less dense *Tamarix* stand had a lower annual evapotranspiration rate still (Dahm et al. 2002). Measurements were not taken for individual trees.

Paschke (1997) notes that species of the genus *Elaeagnus*, actinorhizal plants capable of forming symbiotic relationships with N2-fixing soil actinomycetes, genus *Frankia*, have the potential to add large amounts of fixed nitrogen and carbon to soils, ultimately changing the nutrient content and availability on a site. Simons and Seastedt (1999) report on research comparing litter decomposition and subsequent nitrogen release from *Populus deltoides* versus *E. angustifolia*. *Elaeagnus angustifolia* released more nitrogen per gram of tissue during the 1st year of decay than the *Populus* litter. They note that replacement of the *Populus* on a site with *E. angustifolia* would potentially increase the rate of nitrogen transferred from the litter to the soil. They hypothesize that *E. angustifolia*, by contributing much greater amounts of nitrogen to the soil, may also facilitate invasion by other exotic plant species.

Sources of information: See cited literature; also see Brock (1998).

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Identify type of impact or alteration: *Elaeagnus angustifolia* can form extensive monotypic stands along riparian corridors; as this change in vegetation occurs native species are displaced, crucial vegetation communities (riparian corridors and wetlands) are impacted along with a species diversity decline on a site, with resultant alterations in the physical architecture of a site (Shafroth et al. 1995, Brock 1998, Lessica and Miles 1999, 2001, Tu 2003).

Rationale: Research and subsequent publications are focused on areas outside of Arizona. *Elaeagnus angustifolia* can replace native riparian trees on a site through competition and exclusion, thus, interfering with natural plant succession. Biology/ecology of the riparian dominant *Populus* differs from *E. angustifolia. Elaeagnus angustifolia* is able to take better advantage of the alterations effected by river-flow restrictions and, over time, exclude recruitment and establishment of *Populus* seedlings on a ElaeAgnu invaded and dominated site (Shafroth et al. 1995, Brock 1998, Muzika and Swearingen 1998, Lessica and Miles 1999, 2001).

Shafroth et al. (1995) note that a vegetative change on a site from native riparian species to *E. angustifolia* would change the overall physical structure of a site; a monotypic site of *E. angustifolia* provides a structural habitat intermediate to grasses-low-shrubs type and large trees (large trees being typical of native riparian plant community). Brock (personal communication, 2003) notes that *E. angustifolia* is a facultative riparian tree, and can be found on 500 yr old floodplains.

Sources of information: See cited literature; also see Currier (1982). Also considered personal communication with J. Brock (Professor, Applied Biological Science, Arizona State University-East, Mesa, Arizona, 2003).

Question 1.3 Impact on higher trophic levels *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Identify type of impact or alteration: *Elaeagnus angustifolia* has reports of both beneficial and detrimental impacts to higher trophic levels; characteristics which affect insects, wildlife, and humans. Although positive characteristics have been reported, other research has shown that invertebrate and wildlife diversity, richness, and density decreases on *E. angustifolia* dominated sites (often adjacent to native riparian sites) when compared to native riparian community sites.

Rationale: All research and publications focused outside of Arizona.

(*Elaeagnus angustifolia*) benefits include:

- is a smaller sized plant which provides structural habitat intermediate to grasses and low shrubs (typical of upland sites) and the larger structural trees (typical of riparian sites) (Knopf and Olson 1984 in Shafroth et al. 1995, Brock 1998).
- provides abundant edible fruit for many birds and mammals (Borell 1962 in Shafroth et al. 1995, Brock 1998).
- provides a spring nectar source for insects/bees (Hayes 1976 in Brock 1998) and moths (J. Brock, personal communication, 2003).
- provides cover and nesting sites (Freehling 1982 in Brock 1998).

(*Elaeagnus angustifolia*) detriments include:

- tends to support fewer invertebrate species than native species do (Knopf and Olson 1984 in Stannard et al. 2002, Brown 1990 in Stannard et al. 2002, Waring and Tremble 1993 in Brock 1998), thus fewer resources are available to higher trophic levels (Brock 1998).
- provides inferior wildlife habitat when compared to native riparian vegetation types (Tesky 1992) with reports of fewer birds, less species richness, fewer foraging guilds, and fewer nesting guilds than sites having native plant species (Knopf and Olson 1984 in Stannard et al. 2002, Brown 1990 in Brock 1998, Stannard et al. 2002).
- Brock (1998) notes work by Kernerman et al. (1992) identifying *E. angustifolia* pollen as affecting public health with pollen as an allergen to many people.

Sources of information: See cited literature; also see Lesica and Miles (1999) and Olson and Knopf (1986). Also considered personal communication with J. Brock (Professor, Applied Biological Science, Arizona State University-East, Mesa, Arizona, 2003).

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Obs.**

Identify impacts: *Elaeagnus angustifolia* does not appear to hybridize with any other plants in Arizona.

Rationale: No native species of *Elaeagnus* occur in Arizona (Kearney and Peebles 1960). In addition J. Brock (personal communication, 2003) noted that there are no known reports of *E. angustifolia* hybridization in the United States, despite some *Elaeagnus* shrubs available as ornamentals.

Sources of information: See cited literature. Also considered personal communication with J. Brock (Professor, Applied Biological Science, Arizona State University-East, Mesa, Arizona, 2003).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Describe role of disturbance: *Elaeagnus angustifolia* can establish on riparian sites with or without natural disturbance. An aside to this: the anthropogenic alterations to natural hydrologic patterns that many western rivers have been placed under (damming and restricted flows) generally benefit *E. angustifolia* more than disturbance-dependent native *Populus* spp.

Rationale: All research and publications focused outside of Arizona.

During a research study along riparian sites in Montana, it appeared that *E. angustifolia* did not require disturbance to establish (Lessica and Miles 1999, 2001). Recruitment can occur under established trees (both *Populus* and *Salix*, and also *E. angustifolia*) and does not require uncommon flood events (Lesica and Miles 2001). Katz et al. (2001) reported that although *E. angustifolia* can establish on undisturbed plots, numbers of established seedlings were significantly higher on disturbed plots.

An anthropogenic alteration to historic, natural hydrologic regime: the natural disturbance regimes historically associated with native cottonwood gallery forests frequently due to river regulation have been noted to promote the invasion of *E. angustifolia* (Stannard et al. 2002 cited Knopf and Olson 1984, Shafroth et al. 1995, Lesica and Miles 1999); this primarily includes damming and de-watering of streams which in turn reduce flood events (Stannard et al. 2002). Flooding promotes exposure of bare soil and improved establishment of cottonwood seedlings. Stannard et al. (2002) also note that improper irrigation water management can elevate the water table and increase the accumulation of excess salts in soils; these conditions aren't conducive to species disliking saturated, saline soils. High water tables (gleying of soil as an indicator), seasonal or year-long, are common on sites where *E. angustifolia* has invaded.

Sources of information: See cited literature.

Question 2.2 Local rate of spread with no management *Score:* **A** *Doc'n Level:* **Obs**

Describe rate of spread: Given research from Montana (see below), a site with mature *E. angustifolia* has the potential to double under 10 years after initial introduction plus the years it takes to reach a mature stand. Lesica and Miles (2001) note that *E. angustifolia* is at its northern limit of naturalized range in North America (in Montana) and may potentially be more invasive in warmer, semi-arid regions of western North America.

Rationale: All research and publications focused outside of Arizona.

Tellman (1996) states after 1900 *E. angustifolia* was widely used as a landscape plant in Utah's and Arizona's Mormon communities, being passed among communities as a favorable plant, escaping cultivation to occur at its present distribution. In parts of the western United States it has naturalized and forms extensive monotypic stands along riparian areas (Shafroth et al. 1995). During field research in Montana, Lesica and Miles (2001) report a recruitment rate of 0 to 4.07 recruits per mature tree across 46 stands along the Yellowstone and Marias rivers with a mean of 0.69 recruits per year.

Sources of information: See cited literature; also see Christensen (1963), Knoph and Olson (1984), and Stannard et al. (2002). Score based on inference by Working Group members.

Question 2.3 Recent trend in total area infested within state *Score:* **B** *Doc'n Level:* **Obs.**

Describe trend: No published sources found. In a ranking of *E. angustifolia* by Grand Canyon National Park, it was assessed that by area infested this species was 'found in less than 5% of the state' (Ranking of *Elaeagnus angustifolia* at Grand Canyon National Park, Makarick 1999). At the University of Arizona Herbarium, there were *E. angustifolia* specimens from six northern counties in Arizona: Mohave, Coconino, Navajo, Apache, and Yavapai, with one specimen from Pima County (1914) with no location identified.

Rationale: Brock (personal communication, 2003) notes that *E. angustifolia* seems to presently occupy the habitats it prefers within Arizona, but is increasing in numbers within that range. So total area infested is increasing but not doubling in <10 years.

Sources of information: Personal communication with J. Brock (Professor, Applied Biological Science, Arizona State University-East, Mesa, Arizona, 2003). Also considered Makarick (1999. Ranking of *Elaeagnus angustifolia* at Grand Canyon National Park; available at: http://usgssrv1.usgs.nau.edu/swepic/asp/swemp/species.asp).

Question 2.4 Innate reproductive potential *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Describe key reproductive characteristics: *Elaeagnus angustifolia* has a strategy having potential for long-distance dispersed seeds that have an afterripening period and dormancy. The seeds are large with endosperm, and can germinate over a range of conditions and soil types, in disturbed or on undisturbed sites, when moisture is sufficient; there is low seedling mortality. The plants can become mature as early as three years (in some reports).

Rationale: All research and publications focused outside of Arizona.

Knoph and Olson (1984) report the average seed-bearing age for *E. angustifolia* becomes is between 3 to 5 years old (Knoph and Olson 1984); in Montana, *E. angustifolia* becomes reproductively mature between 7 to 10 years of age, with average age being about 10 years old, with 89% of trees more than 10 years old producing fruit (Lesica and Miles 2001). *Elaeagnus angustifolia* has large seeds with endosperm, enabling establishment in shade or in the open over a wider range of conditions, and can wait to germinate for conditions on a site to become suitable (Shafroth et al. 1995, Lesica and Miles 1999, 2001). Seeds germinate under a wide range of moisture conditions at different times of the growing season (Shafroth et al. 1995 in Lesica and Miles 1999).

Elaeagnus angustifolia reproduces primarily from seed, yet vegetative propagation can occur (Muzika and Swearingen 1998 in Tu 2003). *Elaeagnus angustifolia* sprouts from its root crown following fire and other disturbances or damage (Tesky 1992, Lesica and Miles 1999) and can also vegetatively reproduce by layering of branches (Brock 1998). *Elaeagnus angustifolia* can reproduce in shady environments, versus cottonwood's inability to do so (Montana study).

Sources of information: See cited literature.

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Human caused dispersal of *E. angustifolia* is presently still high: it is still being promoted for landscape restoration and as an ornamental.

Rationale: *Elaeagnus angustifolia* was used in revegetation projects and wildlife food/shelter projects, planted for windbreaks, shelterbelts, erosion control, and is still offered as a horticultural specimen for landscape planting (Stannard et al. 2002). Human-caused dispersal is presently occurring; *E. angustifolia* is presently offered at nurseries in states where it isn't restricted as a noxious weed (Stannard et al. 2002). On the University of Arizona Cooperative Extension, Yavapai County (2000) website it is presently noted as a landscape plant for 'Cold Mountainous Regions (elevation 6000 to 8000 feet).'

Sources of information: See cited literature; also see University of Arizona Cooperative Extension, Yavapai County. 2000. Arizona Plant Climate Zones. Available at: http://ag.arizona.edu/Yavapai/anr/hort/climate/zone1.html.

Question 2.6 Potential for natural long-distance dispersal *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Identify dispersal mechanisms: With *E. angustifolia* having both a potential to be carried by water and ingested and disseminated by animals, it has a fairly high potential for long-distance dispersal.

Rationale: *Elaeagnus angustifolia* has a fruit which is a small cherry-like drupe, which is subsequently eaten and disseminated by many species of birds (Shaforth et al. 1995, Muzika and Swearingen 1998) and animals (Shaforth et al. 1995). As stated previously, *E. angustifolia* 's benefits appear to include providing abundant edible fruit for many birds and mammals (Borell 1962 in Shafroth et al. 1995, Brock 1998). The outer layer of the seedcoat is impermeable in the digestive tract (Tesky 1992). Stannard et al. (2002) note several reports in which the establishment of plants by fruits consumed by birds has been implied (cited USDA 1974, Shafroth et al. 1995, Lesica and Miles 1999). Stannard et al. (2002) report by personal observation the dissemination of seeds after consumption by coyotes, deer, and raccoons. Stannard et al. (2002) cites Heekin's (personal observation) report that the fruit of *E. angustifolia* float, which indicates a potential for being dispersed by water transport.

Sources of information: See cited literature.

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Obs.**

Identify other regions: Only those ecological types also invaded in Arizona.

Rationale: No direct evidence, score based on the following (see also 3.1 and 3.2). *Elaeagnus angustifolia* 's range occurs across the United States and into Canada, and the species is extensively naturalized, especially in the western United States. It is most often associated with mesic meadows and floodplain forests, with perennial grasses tending to be predominant in the areas infested (Tesky 1992). Various sources seem to identify the *E. angustifolia* invasion along rivers, streams and irrigation canals, wetlands, in wet meadows, cropland, and fields, roadsides from its southern to northern extent on this continent. From east to west it seems to be located more along roadsides and fields to a more riparian habitat.

Sources of information: See cited literature; also see Kearney and Peebles (1960), McDougall (1973), Brown (1994), NPS (2002), and USGS-NPS (2003).

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Other pub.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Insufficient information. Sources identifying habitat from native areas were not found. See Worksheet B for current ecological types invaded in Arizona. Introduced to Arizona in 1914 to Pima County (SEINet 2004).

Rationale: Within the United States *E. angustifolia* is found along streams, fields, and open areas (Muzika and Swearingen 1998). *Elaeagnus angustifolia* was first cultivated in Germany in 1736 and was introduced into the U.S. in the late 1800s as an ornamental, which later escaped cultivation (Muzika and Swearingen 1998). The first records of *E. angustifolia* being planted in New Mexico, Nevada, and Arizona were from 1903, 1906, and 1909, respectively (Christensen 1963 in Stannard et al. 2002). Tellman (1996) notes that it was in Utah's and Arizona's Mormon communities after 1900 and was being passed between communities as a favorable ornamental species.

Elaeagnus angustifolia is native to temperate and tropical western Asia and southeastern Europe (GRIN 2000). *Elaeagnus angustifolia* is present primarily in the central and southern U.S. and also occurs in the eastern U.S. from Virginia to Pennsylvania; in the west it occurs primarily in the Great Basin Desert region at 800 to 2000 feet, along with being abundant in riparian zones of the Great Plants (e.g. Platte River in Nebraska) (Muzika and Swearingen 1998). In the western United States it has become naturalized in areas (Shafroth et al. 1995).

The Soil Conservation Service recommends this plant for wildlife plantings and windbreaks (Muzika and Swearingen 1998). It was widely used as an ornamental by the 1940s in many western U.S. cities and by approximately 1939 was promoted for windbreaks, erosion control, and wildlife; in the Intermountain West, Northern Great Plains and Great Basin states it is primarily used in dryland windbreaks, saline areas, and ornamental plantings (Stannard et al. 2002).

In Virginia typical habitats are disturbed areas, roadsides, pastures and fields in a wide range of soils (Virginia Native Plant Society 1997).

In western North America: invades riparian habitats usually dominated by pioneer woody species such as *Populus* (Katz et al. 2001). It has become naturalized in riparian areas in the western U.S. (Shafroth et al. 1995).

In California *E. angustifolia* is found in disturbed, seasonally moist places, usually below 5,000 feet; common on riparian sites and floodplain forests, sub-irrigated pastures and irrigation ditches, and is also found on drier sites such as railroad beds, fence lines, highway margins, in grasslands (Deiter 2000).

In Nebraska along the Platter River, *E. angustifolia* is a frequent invader of wetland meadows on the river, but is also found in adequately moist upland areas such as prairie sites, and near irrigated fields (Olson and Knopf 1986 in Shafroth et al. 1995).

In Montana *E. angustifolia* has been planted as windbreaks since at least 1953 (1997 Montana Department of Natural Resources and Conservation nursery data in Lesica and Miles 2001) and has naturalized along most of the major rivers occurring in the Great Plains regions of Montana (Olson and Knopf 1986 in Lesica and Miles 2001).

In Oklahoma *E. angustifolia* is found mostly along roadsides and abandoned fields; and is persistent in old shelterbelts and homesites (Oklahoma Biological Survey 1999).

In Virginia, typical habitats are disturbed areas, roadsides, pastures and fields in a wide range of soils (Virginia Native Plant Society 1997).

In Arizona, Kearney and Peebles (1960) notes its occurrence in Oak Creek Canyon (5500 feet; Coconino County). McDougall (1973) reports it in Apache, Navajo, and Coconino County (5500 to 7000 feet). *Elaeagnus angustifolia* was observed and included in the USGS-NPS Vegetation Mapping Program in Tuzigoot National Monument Vegetation Descriptions (Yavapai County), namely in the *Populus fremontii-Salix gooddingii* association bordered on the north by the Verde River, and the *Populus fremontii-Prosopis velutina* Woodland (USGS-NPS 2003). *Elaeagnus angustifolia* was found at Canyon de Chelly National Monument (NPS 2002).

Sources of information: See cited literature. Also considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed January 2004).

Question 3.2 Distribution *Score:* **C** *Doc'n Level:* **Obs.**

Describe distribution: Occurrence within ecological type is at the highest between 5 to 20% (see Worksheet B).

Rationale: See Worksheet B.

Sources of information: Based on Working Group member personal knowledge and observations.

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**Yes**	**[✓ No]**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**Yes**	**[✓ No]**	**2 pt.**
Populations of this species produce seeds every year.	**[✓ Yes]**	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**Yes**	**[✓ No]**	**1 pt.**
Seeds remain viable in soil for three or more years	**[✓ Yes]**	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes**	**[✓ No]**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes**	**[✓ No]**	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	**[✓ No]**	**2 pt.**
Resprouts readily when cut, grazed, or burned	**[✓ Yes]**	**No**	**1 pt.**

Total pts: 4 Total unknowns: 0

Score : B

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	**D**
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	**C**
	montane riparian	
Woodlands	Great Basin conifer woodland	**C**
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial):	*Elymus repens* (L.) Gould (USDA 2005)
Synonyms:	*Agropyron repens* (L.) Beauv., *Agropyron repens* (L.) Beauv. var. *subulatum* (Schreb.) Roemer & J.A. Schultes, *Elytrigia repens* (L.) Desv. ex B.D. Jackson, *Elytrigia repens* (L.) Desv. ex B.D. Jackson var. *vaillantiana* (Wulfen & Schreb.) Prokudin, *Elytrigia vaillantiana* (Wulfen & Schreb.) Beetle, *Triticum repens* L., *Triticum vaillantianum* Wulfen & Schreb. (USDA 2005)
Common names:	Quackgrass, dog grass, couchgrass, twitch, quickgrass, scutch, quitch.
Evaluation date (mm/dd/yy):	04/13/05
Evaluator #1 Name/Title:	Bruce Munda/ Plant Materials Specialist
Affiliation:	USDA, Natural Resources Conservation Service
Phone numbers:	(520) 292–2999 ext. 102
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Evaluator #2 Name/Title:	
Affiliation:	
Phone numbers:	
Email address:	
Address:	

List committee members:	J. Hall, H. Messing, B. Munda, F. Northam, J. Ward
Committee review date:	04/15/05
List date:	04/15/05
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		**Score**	**Documentation Level**	**Section Scores**	**Overall Score & Designations**
1.1	Impact on abiotic ecosystem processes	**U**	Other published material	**“Impact”** **Section 1 Score:** **C**	**“Plant Score”** **Overall Score:** **Low** **Alert Status:** **None**
1.2	Impact on plant community	**B**	Other published material		
1.3	Impact on higher trophic levels	**D**	Other published material		
1.4	Impact on genetic integrity	**U**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**C**	Other published material	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **8 pts** **Section 2 Score:** **C**	
2.2	Local rate of spread with no management	**U**	No information		
2.3	Recent trend in total area infested within state	**B**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**C**	Other published material		
2.6	Potential for natural long-distance dispersal	**U**	Observational		
2.7	Other regions invaded	**C**	Observational		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**B**	Other published material	**“Distribution”** **Section 3 Score:** **C**	
3.2	Distribution	**D**	Other published material		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **U** *Doc'n Level:* **Other pub.**

Identify ecosystem processes impacted: Unknown

Rationale: Reviewed literature did not indicate negative impacts on abiotic ecosystems processes. Because of its rhizomatous nature, quackgrass forms thick dense stands that minimize soil erosion. In cropland quackgrass is an effective competitor for nutrients, water, and light (Tardif and Leroux 1992). The ability to alter nutrient cycling, salinity, and/or light in wildland areas was not presented in the reviewed literature.

Sources of information: See cited literature; also see Snyder (1992).

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **B** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Quackgrass patches are typically monocultures and can reduce or occlude germination and/or establishment of native plants.

Rationale: Quackgrass is a strong competitor with existing native plants. Its aggressive root/rhizome system can eliminate less aggressive native plants and impede seedling recruitment of native plants. Rhizomes are known to produce allelopathic substances that suppress surrounding plants and enhance the competitiveness of quackgrass. Quackgrass, depending on the density of the stand, has a negative effect on growth and seed production of cultivated crops such as alfalfa, canola, corn and wheat (Moyer and Schaalje 1993).

Sources of information: See cited literature. Also considered information from Weber County Weed Abatement-Quackgrass (available online at: http://www.co.weber.ut.us/weeds/types/q_grass.asp; accessed March 2, 2005) and Yard & Garden Brief: Controlling Quackgrass in Gardens (available online at: http://www.extension.umn.edu/projects/yardandgarden/ygbriefs/h507quackgrass.html; accessed March 2, 2005) and inference based on the literature.

Question 1.3 Impact on higher trophic levels *Score:* **D** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Minor alteration of higher trophic populations, communities or interactions.

Rationale: Quackgrass is rated good to fair cover for small mammal, nongame birds, upland game birds, and waterfowl. Palatability is rated good for horses and cattle and fair for sheep. Quackgrass is rated fair in energy value and poor in protein value, though some studies have shown quackgrass, at certain periods of growth, can have crude protein values as high as alfalfa. (Snyder 1992)

Sources of information: See cited literature.

Question 1.4 Impact on genetic integrity *Score:* **U** *Doc'n Level:* **Other pub.**

Identify impacts: Unknown, but no known natural hybridization with native species.

Rationale: Quackgrass is a cross pollinated species which has been successfully crossed, in the laboratory, with bluebunch wheatgrass (native) as well as with crested wheatgrass (introduced) to form salt tolerant hybrids. 'Newhy' hybrid wheatgrass is an intentional cross between quackgrass and bluebunch wheatgrass. 'RS-Hoffman' is a genetically manipulated variety of quackgrass. Six forms and one variety of quackgrass have been recognized. Native *Elymus* do occur in Arizona (Kearney and Peebles 1960). Impact was considered Unknown because though intentional hybrids have been made, the reviewed literature did not indicate that natural hybridization has occurred or been found.

Sources of information: See cited literature; also see Snyder (1992) and Alderson and Sharp (1994).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **C** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Quackgrass requires anthropogenic disturbance to establish.

Rationale: Quackgrass is a pest of cultivated lands, road sides, and water conveyance ditches in cool, moist zones throughout the United States except the south eastern states. Literature indicates that an initial act of disturbance with the introduction of seed or rhizomes is needed for the plant to become established.

Sources of information: See Synder (1992). Also considered information regarding *E. repens* available online through U.S. Geological Survey's, Southwest Exotic Plant Information Clearinghouse at: http://www.usgs.nau.edu/swepic/asp/swemp/question.asp?Location=GRCA&Symbol=ELRE4; accessed April 15, 2005.

Question 2.2 Local rate of spread with no management *Score:* **U** *Doc'n Level:* **No info.**

Describe rate of spread: Unknown.

Rationale: No information

Sources of information: None.

Question 2.3 Recent trend in total area infested within state *Score:* **B** *Doc'n Level:* **Obs.**

Describe trend: Increasing but far less than doubling every 10 years.

Rationale: Herbarium specimens in Arizona herbaria indicate a presence of quackgrass in Arizona wildlands since the 1940s (SEINet 2005). However, during that 60-year time frame only 10 records were collected and only four of those were in wildlands. Likewise, field observations by F. Northam (personal communication, 2005) did not uncover any evidence that quackgrass populations have substantially increased during the past decade in wildlands.

Sources of information: SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed June 7, 2005). Also considered personal communication with F. Northam (2005, discussion of observations while serving as Arizona Department of Agriculture's Noxious Weed Program Coordinator 2000 to 2003).

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: Quackgrass has a high reproductive potential.

Rationale: Quackgrass reproduces by seed and rhizomes. One plant can produce 300 feet of rhizomes each year. Each rhizome bud can develop into a plant. Species is cross-pollinated and can produce over 1000 seeds per year but seed viability appears to be low with up to 25 viable seeds produced per shoot in a season. Dense patches can have over 900 shoots per square meter.

Sources of information: See Snyder (1992). Also considered information regarding *E. repens* available online through U.S. Geological Survey's, Southwest Exotic Plant Information Clearinghouse at: http://www.usgs.nau.edu/swepic/asp/swemp/question.asp?Location=GRCA&Symbol=ELRE4; accessed April 15, 2005, Weber County Weed Abatement-Quackgrass (available online at: http://www.co.weber.ut.us/weeds/types/q_grass.asp; accessed March 2, 2005), Yard & Garden Brief: Controlling Quackgrass in Gardens (available online at: http://www.extension.umn.edu/projects/yardandgarden/ygbriefs/h507quackgrass.html; accessed March 2, 2005), and Quackgrass Description (available online at: http://www.turf.uiuc.edu/weed_web/descriptions/quackgrass.htm, accessed March 2, 2005).

Question 2.5 Potential for human-caused dispersal *Score:* **C** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Human dispersal is infrequent.

Rationale: Quackgrass was introduced into the U.S. over 200 years ago and is a listed Prohibited and Restricted noxious weed in Arizona (USDA 2005). Possible contaminant in seed, hay, or straw mulch used for erosion control and revegetation practices.

Sources of information: See cited literature. Also considered information from Yard & Garden Brief: Controlling Quackgrass in Gardens (available online at:

http://www.extension.umn.edu/projects/yardandgarden/ygbriefs/h507quackgrass.html; accessed March 2, 2005).

Question 2.6 Potential for natural long-distance dispersal *Score:* **U** *Doc'n Level:,* **Obs.**

Identify dispersal mechanisms: Quackgrass potential for long distance dispersal mechanisms is unknown.

Rationale: Southwest Exotic Plant Information Clearinghouse data sheet for *E. repens* indicated little potential for long-distance dispersal. However, rhizome/root masses could be dislodged from an existing stream-side population and carried down-stream during flood events. Seeds are large and probably not subject to wind dispersal but may have some ability to float. Because of the plant's usefulness to waterfowl, other birds, and small mammals, it is suspected to have potential for natural dispersal but this was not documented in the reviewed literature.

Sources of information: Information from U.S. Geological Survey's, Southwest Exotic Plant Information Clearinghouse regarding *E. repens* is available online at: http://www.usgs.nau.edu/swepic/asp/swemp/question.asp?Location=GRCA&Symbol=ELRE4; accessed April 15, 2005. Score based on inference.

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Obs.**

Identify other regions: Occurs in all states except the Gulf Coast States (occurs in northern Texas), Alaska, and Canada.

Rationale: Reviewed literature and observations indicate it occurs in the montane wetlands and southwestern interior riparian ecological types in Arizona. Because of *E. repens* requirements for moist soils at elevations above 6,500 feet, it is inferred that it has potential to invade only in ecological types it has already invaded in the state.

Sources of information: See Synder (1992). Also considered personal communication with B. Phillips (Zone Botanist, U.S. Department of Agriculture, Forest Service, Coconino, Kaibab, and Prescott National Forests, 2005).

Question 3.1 Ecological amplitude *Score:* **B** *Doc'n Level:* **Other pub.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Two major types (Non-Riparian Wetlands and Riparian) known to be invaded.

Rationale: *Elymus repens* is a cool season perennial grass that is typically found at elevations above 6,500 feet growing on moist soils. It does not tolerate long, hot summers. Flowering typically occurs from June through August. Optimum temperatures for growth are between 68°F and 77°F. Growth ceases when temperatures fall below 35°F or go above 95°F. Rhizome growth occurs in late May or early June and then again in September and October when temperatures near 50°F and day length is long, approximately 18 hours. Herbarium records (SEINet 2005) indicate the earliest collection as August 1941 at Haystack Cienega, Navajo County, Fort Apache Indian Reservation.

Sources of information: See Snyder (1992). Also considered information from Yard & Garden Brief: Controlling Quackgrass in Gardens (available online at http://www.extension.umn.edu/projects/yardandgarden/ygbriefs/h507quackgrass.html; accessed March 2, 2005) and SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed April 15, 2005).

Question 3.2 Distribution *Score:* **D** *Doc'n Level:* **Other pub.**

Describe distribution: Known locations occur in higher elevation sites above 6,500 feet in cienegas and areas where soils are moist and cool.

Rationale: Fort Apache Reservation: Pachito Ranch (2 collections), Fort Apache-Haystack Cienega-

Navajo County (2 collections), Flagstaff-Coconino County, Fort Valley Station-Coconino County, Window Rock-Apache County, West of Happy Jack-Coconino County, Sierra Ancha Wilderness Area-Gila County, Grand Canyon National Park (specific location not shown).

Sources of information: SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed April 15, 2005) and information from U.S. Geological Survey's, Southwest Exotic Plant Information Clearinghouse regarding *E. repens* that is available online at: http://www.usgs.nau.edu/swepic/asp/swemp/question.asp?Location=GRCA&Symbol=ELRE4; accessed April 15, 2005.

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ **Yes**]	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	[✓ **Yes**]	**No**	**2 pt.**
Populations of this species produce seeds every year.	[✓ **Yes**]	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	[✓ **Yes**]	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	**Yes**	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes**	[✓ **No**]	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	[✓ **Yes**]	**No**	**1 pt.**
Fragments easily and fragments can become established elsewhere	[✓ **Yes**]	**No**	**2 pt.**
Resprouts readily when cut, grazed, or burned	[✓ **Yes**]	**No**	**1 pt.**

Total pts: 9 Total unknowns: 1

Score : A

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	**U**
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	**U**
	montane wetlands	**D**
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	**D**
	montane riparian	**U**
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands"
by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association
(Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial):	*Eragrostis curvula* (Schrad.) Nees (USDA 2005)
Synonyms:	*Eragrostis chloromelas* Steud, *Eragrostis curvula* (Schrad.) Nees var. *conferta* Stapf (USDA 2005); however, see Taxonomic Comment and Red Flag Annotation sections.
Common names:	Weeping lovegrass, zacate del amor
Evaluation date (mm/dd/yy):	05/08/04
Evaluator #1 Name/Title:	Dana Backer/Conservation Ecologist
Affiliation:	The Nature Conservancy
Phone numbers:	(520) 622–3861
Email address:	dbacker@tnc.org
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Evaluator #2 Name/Title:	
Affiliation:	
Phone numbers:	
Email address:	
Address:	

List committee members:	D. Backer, C. Laws, G. Ferguson, J. Hall, M. Van Glider, P. Warren
Committee review date:	07/16/04
List date:	07/16/04
Re-evaluation date(s):	

Taxonomic Comment

The Plants Database (USDA 2005) considers *Eragrostis curvula* var. *conferta* (Boer's lovegrass) as a synonym for *Eragrostis curvula.* Because of the differences in environmental tolerances and ploidy between *E. c.* var. *conferta* and the species as a whole (Guertin and Halvorson 2003); however, for the purposes of this assessment *E. c.* var. *conferta* is considered a separate taxon and is not evaluated as part of *E. curvula*. See the Red Flag Annotation for additional details.

Table 2. Scores, Designations, and Documentation Levels

Question		**Score**	**Documentation Level**	**Section Scores**	**Overall Score & Designations**
1.1	Impact on abiotic ecosystem processes	**D**	Other published material	**“Impact”** **Section 1 Score:** **C**	**“Plant Score”** **Overall Score:** **Low** **Alert Status:** **None**
1.2	Impact on plant community	**C**	Observational		
1.3	Impact on higher trophic levels	**C**	Observational		
1.4	Impact on genetic integrity	**U**	Observational		
2.1	Role of anthropogenic and natural disturbance	**C**	Other published material	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **11 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**C**	Observational		
2.3	Recent trend in total area infested within state	**C**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**A**	Other published material		
2.6	Potential for natural long-distance dispersal	**C**	Other published material		
2.7	Other regions invaded	**C**	Observational		RED FLAG **YES** Information you should know.
3.1	Ecological amplitude	**A**	Other published material	**“Distribution”** **Section 3 Score:** **B**	
3.2	Distribution	**C**	Observational		

Red Flag Annotation

This assessment does not pertain to *Eragrostis curvula* var. *conferta* (Boer lovegrass). This taxon has different moisture and temperature limits relative to the species as whole and likely behaves differently in regard to its ecological impacts, invasiveness, and ecological amplitude. *Eragrostis curvula* var. *conferta* as a valid taxon is ambiguous as the U.S. Department of Agriculture Plants Database regards it as a synonym of *E. curvula*. Because of the differences in environmental tolerances and ploidy between *E. c.*

var. *conferta* and the species as a whole, for the purposes of this list [assessment] *E. c.* var. *conferta* is considered a separate taxon and is not evaluated as part of *E. curvula*.

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **D** *Doc'n Level:* **Other pub.**

Identify ecosystem processes impacted: Minor alteration-erosion, infiltration.

Rationale: In Walsh (1994): *Eragrotis curvula* benefits from fire; it generally increases (Wright et al. 1978) following fire and contributes to positive fire feedback cycle. Other studies of the response of *E. curvula* to fire in Oklahoma (Wright et al. 1978) and in Texas (Roberts et al. 1988) showed that the presence of *E. curvula* is not reduced. At this time, there is no indication that *E. curvula* is altering fire regimes in Arizona because it is present in low abundances.

Although *E. curvula* was planted for soil conservation, no long-term studies have evaluated the efficacy of weeping lovegrass for soil conservation (W. Kruse, personal communication, 1994 in Walsh 1994). Whereas Garcia (1993) stated that weeping lovegrass provides excellent soil protection [New Mexico]. Moreover, Hitchcock (1951) identified weeping lovegrass as useful for erosion control.

Weeping lovegrass has been seeded in central Arizona chaparral after brush removal to increase annual stream flow. Heavily transpiring, deep-rooted evergreen shrubs were replaced with weeping lovegrass and other shallow-rooted vegetation. Streamflow increased, and the increase has lasted for 18 years with maintenance (Hibbert et al. 1982).

Sources of information: See cited literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **C** *Doc'n Level:* **Obs.**

Identify type of impact or alteration: Moderate alteration of plant community-composition, structure.

Rationale: From Guertin and Halvorson (2003): in one report (from Virginia) *E. curvula* was observed crowding out native grasses on site due to its aggressiveness, rapid growth and early establishment (VDCR 1999). Other reports from field experiments when *E. curvula* was grown as a crop, demonstrated western ragweed plants reduced *E. curvula* stands and productivity (Dalrymple 1970b), as did sandbur (Matizha and Dahl 1991).

From Walsh (1994): *Eragrotis curvula* has been used for grassland revegetation in southern US (Hitchcock 1951), particularly after invasion by woody shrubs (Cox et al. 1987). *Eragrotis curvula* was seeded after several fires in Arizona but because of grazing, drought, and time, the vigor of weeping lovegrass was not sustained and was considered fair (Pond and Cable 1962, Lavin and Pase 1963). Pond (1961) observed that *E. curvula* stands in converted Arizona chaparral tend to decline 3 to 4 years after establishment when protected from grazing or fire [see also observations by Pond below]. *Eragrotis curvula* should probably not be planted if the management objectives are to establish and maintain native grasses (W. Kruse, personal communication, 1994 in Walsh 1994).

Following a fire in Globe Arizona in 1952, the area was seeded with *E. curvula* in shrub-live oak. *Eragrotis curvula* tended to die out as the re-establishing oak brush thickened and, as a result, Pond (1961) noted an inverse proportion of *E. curvula* basal cover with shrub live oak cover. Thirty years after exotic plant seeding trials in the Tonto National Forest during 1945, E. curvula remained a component in the semi-desert grassland (Judd and Judd 1976).

Walsh (1994) contains an incorrect statement relative to *E. curvula* being planted at Appleton-Whittell Research Sanctuary. The studies (see Bock et al. 1986 and Bock and Bock 1992) were plant and animal responses to *E. curvula* var. *conferta* (Boer's lovegrass) and not *E. curvula*. Impacts of *E. curvula* on plant communities are not known but due to the similarity in morphology and physiology of the South African *Eragrostis* species and the documented impacts of *E. curvula* var. *conferta* and *E. lehmanniana,* it is inferred that these impacts would also apply to *E. curvula*. The following is from Bock et al. (1986):

> "Plant and animal populations were sampled between June 1984 and August 1985 in semidesert grasslands on mesas in Santa Cruz County, Arizona. Some areas had been seeded to weeping lovegrass [should be Boer's] and Lehmann lovegrass (*Eragrostis lehmanniana*); other areas had native grasses, forbs, and shrubs. The stands of exotic grasses differed consistently from native grasslands in terms of indigenous plants and animals. The exotic African lovegrasses covered more than 50 percent of the ground where they had been planted; they grew in tall, nearly monospecific stands. At these sites the native grass cover was reduced by nearly 60 percent compared to unseeded stands. Total native herb canopy, herb species richness, shrub density, and shrub canopy were significantly reduced on plots dominated by weeping lovegrass and Lehmann lovegrass."

Dan Robinett (personal communication, 2004) indicated he has not seen weeping lovegrass "act as an invasive species in the mountains of southern Arizona. In fact it usually persists only as a minor component of native communities in areas where it was seeded. I've seen it seeded at several locations in Cochise and Santa Cruz counties in the higher end of desert grasslands and lower end of plains grasslands and even where stands were established (in the 80s) they have died out by now."

Sources of information: See cited literature. Score based on inference drawn from the literature. Also considered personal communication with D. Robinett (Rangeland Management Specialist, U.S. Department of Agriculture, Natural Resources Conservation Service, Tucson, Arizona, 2004).

Question 1.3 Impact on higher trophic levels *Score:* **C** *Doc'n Level:* **Obs.**

Identify type of impact or alteration: Minor impact on higher trophic levels.

Rationale: From Walsh (1994): forage value is fair for livestock and relatively poor for wildlife (Stubbendieck et al. 1986). Walsh incorrectly identifies impacts of *E. curvula* on hispid cotton rat (increased abundance), grasshoppers (reduced abundance) and birds (species dependent effects) from Bock et al. 1986 (taxa studied were *E. lehmanniana* and *E. curvula* var. *conferta*). There are no known studies of the impact of *E. curvula* on native wildlife species. Yet the potential exists for *E. curvula* to have impacts similar to other non-native lovegrasses.

Sources of information: See cited literature. Score based on inference drawn from the literature.

Question 1.4 Impact on genetic integrity *Score:* **U** *Doc'n Level:* **Obs**.

Identify impacts: A potential exists for *E. curvula* to hybridize with native *Eragrostis* species.

Rationale: "*Eragrostis curvula* is truly a "complex" and contains many different types of plants at many ploidy levels. Thankfully, most of them are apomictic and so hybridization with *E. intermedia* would be a very unusual event. There are rare sexual weeping lovegrasses out there, so it's at least possible that *E. curvula* could be involved in an interspecific hybridization event. Much less—really almost nothing—is known about *E. intermedia's* reproductive biology. Don't know whether it's sexual or apomictic or even its ploidy. This makes it just that much harder to predict what might happen." (S. Smith, personal communication, 2004).

Furthermore, B. Munda (personal communication, 2004), based on his work at the Tucson Plant Material Center, does not recall hybridization occurring between any of the non-native *Eragrostis* species. He thought the score should be a **C** (minor) or **D** (no known hybridization); however, because several native *Eragrostis* species occur in Arizona in the same ecological types as *E. curvula* (Kearney and Peebles 1960), the Working Group could not completely rule out the possibility of hybridization with native Eragrostis even if such an event would be unlikely.

Sources of information: See cited literature. Also considered personal communications with S. Smith (Genetic Ecologist, University of Arizona, 2004) and B. Munda (Plant Resource Specialist, U.S. Department of Agriculture, Natural Resources Conservation Service, Plant Material Center, Tucson, Arizona, 2004).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **C** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Low invasive potential.

Rationale: In most places, weeping lovegrass does not actively colonize adjacent non-planted sites (Cox et al. 1988). In the past, weeping lovegrass was seeded in areas that had been disturbed by grazing, fire or erosion but this is not to imply that weeping lovegrass needs a disturbance to establish. In the Interior Chaparral zone under the Rim it persists where seeded but seems to only spread in disturbed areas (D. Robinett, personal communication, 2004). Where seeded along right-of-ways, it tends to stay there (B. Munda, personal communication, 2004).

Sources of information: See cited literature. Also considered personal communications with D. Robinett (Rangeland Management Specialist, U.S. Department of Agriculture, Natural Resources Conservation Service, Tucson, Arizona, 2004) and B. Munda (Plant Resource Specialist, U.S. Department of Agriculture, Natural Resources Conservation Service, Plant Material Center, Tucson, Arizona, 2004).

Question 2.2 Local rate of spread with no management *Score:* **C** *Doc'n Level:* **Obs.**

Describe rate of spread: Stable.

Rationale: Rate of spread by seeds is slow under the best conditions (Atkins and Smith 1967) and in most places weeping lovegrass does not actively colonize adjacent non-planted sites (Cox et al. 1988). Where seeded along right-of-ways, it tends to stay there (B. Munda, personal communication, 2004). *Eragrostis curvula* is not being used in seed mixes by the land management agencies (R. Lefevrer and L. Walker, personal communications, 2004).

Sources of information: See cited literature Also considered personal communications with B. Munda (Plant Resource Specialist, U.S. Department of Agriculture, Natural Resources Conservation Service, Plant Material Center, Tucson, Arizona, 2004), R. Lefevrer (Forester, U.S. Department of Agriculture, Forest Service, Coronado National Forest, Tucson, Arizona, 2004), and L. Walker (Weed Specialist, Bureau of Land Management, Arizona Strip, St. George, Utah, 2004). Score based on inference drawn from the literature and personal communications.

Question 2.3 Recent trend in total area infested within state *Score:* **C** *Doc'n Level:* **Obs.**

Describe trend: Stable.

Rationale: Although several varieties of *E. curvula* have been introduced into different ecological types, it is assumed the extent of the range of infestation is not expanding; that is, the range of exploitation has been reached.

Sources of information: Personal communications with D. Robinett (Rangeland Management Specialist, U.S. Department of Agriculture, Natural Resources Conservation Service, Tucson, Arizona, 2004) and B. Munda (Plant Resource Specialist, U.S. Department of Agriculture, Natural Resources Conservation Service, Plant Material Center, Tucson, Arizona, 2004).

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Other pub.**

Describe key reproductive characteristics: Produces seeds in excess of 1000 per plant, self- and cross- pollinates; apomitic.

Rationale: See Worksheet A.

Sources of information: See Worksheet A.

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Hay, transportation corridors, in soils, intentional planting, sold commercially.

Rationale: In the mid 1900s *E. curvula* was often seeded or was a component of a standard seed mix (including other non-natives such as *Melilotus officinalis*) for rangeland improvement and after wildfires (Hibbert et al. 1982; D. Robinett, personal communication, 2004).

Natural Resources Conservation Service is not recommending weeping lovegrass for the purpose of forage, soil erosion, or revegetation after fire; however, it is still available commercially (B. Munda, personal communication, 2004). Coronado National Forest (R. Lefevrer, personal communication, 2004) and Arizona Bureau of Land Management (L. Walker, personal communication, 2004) are not using *E. curvula* in their respective seed mixes for post-fire seeding.

From Guertin and Halvorson (2003): spread via animals (primarily livestock), hay, machinery and vehicles (Williamson 1997). *Eragrostis curvula* has been seeded extensively for erosion control along banks and slopes of highways and mine spoils, on revegetated sites (Dalrymple 1970a, Soil Conservation Service 1972), and range and pasture sites (Alderson and Sharp 1993).

From Walsh (1994): intentional seeding for erosion and siltation control and restoration of shrub encroached chaparral (Hitchcock 1951, Wasser 1982). Also, cultivated as an ornamental grass (Hitchcock 1951, Kearney and Peebles 1960).

Sources of information: See cited literature. Also considered personal communications with D. Robinett (Rangeland Management Specialist, U.S. Department of Agriculture, Natural Resources Conservation Service, Tucson, Arizona, 2004), B. Munda (Plant Resource Specialist, U.S. Department of Agriculture, Natural Resources Conservation Service, Plant Material Center, Tucson, Arizona, 2004), R. Lefevrer (Forester, U.S. Department of Agriculture, Forest Service, Coronado National Forest, Tucson, Arizona, 2004), and L. Walker (Weed Specialist, Bureau of Land Management, Arizona Strip, St. George, Utah, 2004).

Question 2.6 Potential for natural long-distance dispersal *Score:* **C** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Rare dispersal more than one kilometer.

Rationale: *Eragrostis curvula* seeds are spread short distances by wind (Williamson 1997 in Guertin and Halvorson 2003).

Sources of information: See cited literature.

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Obs.**

Identify other regions: No other ecological types besides those already invaded in Arizona.

Rationale: Weeping lovegrass associates are recorded in sand dune vegetation in Woodward County, Oklahoma (Savage and Heller 1947 in Walsh 1994); however, the vegetation in that community differs from the sand dunes in Arizona.

It is important to note that there are several varieties of *E. curvula* that were historically distributed as seed for forage, erosion control and revegetation. Each variety may have a range of tolerances and physical preferences.

Sources of information: See cited literature. Score based on inference drawn from the literature.

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Other pub.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: *Eragrostis curvula* is native to South Africa (Ruyle and Young 1997) and was purposefully brought from Africa to the U.S. in 1932 (Crider 1945 in Cox et al. 1988) for soil conservation. Earliest records in the University of Arizona herbarium are from 1936 (SEINet 2004) with Soil Conservation Service in Tucson as the source. Early post-fire seeding dates from literature include 1956 (Pase and Pond 1964) and 1959 (Lavin and Pase 1963).

Eragrostis curvula is well adapted to areas having 17 inches (432 mm) of precipitation or more (Ruyle and Young 1997) and well established stands persist with annual rainfall varying from 625 to 1075 mm in its natural communities of north central Tanzania (Cox et al 1988). When summer rainfall totals exceed 29.5 inches (750 mm), *E. curvula*'s plant production declines due to fungal infections, mites, nematodes, and plant competition (see authors in Cox et al. 1988). Mean minimum and mean maximum temperatures for *Eragrostis curvula* habitat is 10°C to 30°C (Cox et al. 1988). *Eragrostis curvula* is semi-hardy, moderately frost-resistant in southern areas; it most likely won't endure extended periods having temperatures below -10°F (-12.2°C) (Ruyle and Young 1997).

From Walsh (1994): *Eragrostis curvula* grows well on a wide variety of non-saline, well-drained soils (Dahl and Cotter 1984), on coarse sands to fine clays (Soil Conservation Service 1972). It is adapted to and most persistent on sandy soils, growing well on sandy to sandy loams (Atkins and Smith 1967, Cox et al. 1988, Dahl and Cotter 1984).

Rationale: Invades at least three major ecological types in Arizona. In Arizona *E. curvula* reported from elevation ranges of 1500 to 1981 m (4921 to 6500 feet) (Cox et al. 1987, Knipe 1982, and Pase and Pond 1964 all in Walsh 1994). U.S. Forest Service used *E. curvula* for years at elevations above 5000 feet. It has been seeded all across the mountains of central and southern Arizona (D. Robinett, personal communication, 2004). Also see locations listed in question. 3.2.

Common associates of weeping lovegrass include turbinella oak (*Quercus turbinella*), pointleaf manzanita (*Arctostaphylos pungens*), Pringle manzanita (*A. pringlei*), desert ceanothus (*Ceanothus greggii*), sugar sumac (*Rhus ovata),* skunkbush sumac (*R. trilobata*), hollyleaf buckthorn (*Rhamnus crocea),* Wright silktassel (*Garrya wrightii*), yellowleaf silktassel (*G. flavescens*), birchleaf mountain-mahogany (*Cercocarpus betuloides*), Mexican cliffrose (*Cowania mexicana*), and Lehmann lovegrass (*Eragrostis lehmanniana*) (Cable 1957, Davis 1989, Knipe 1982, Pond and Cable 1962 all in Walsh 1994).

Sources of information: See cited literature. Also considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed June 21, 2004) and personal communication with D. Robinett (Rangeland Management Specialist, U.S. Department of Agriculture, Natural Resources Conservation Service, Tucson, Arizona, 2004).

Question 3.2 Distribution *Score:* **C** *Doc'n Level:* **Obs.**

Describe distribution: Also noted in chaparral communities (Pond 1961), semi-desert grasslands (Judd and Judd 1976), and pinyon-juniper types in Arizona (Judd and Judd 1976, Voigt and Oaks 1985). Madrean woodlands and conifer forest (D. Robinett, personal communication, 2004). In Gila, Graham (Kearney and Peebles 1960), Coconino, and Yavapai Counties (McDougall 1973)

Rationale: From SEINet (2004): records have been collected from the following counties: Yavapai, Coconino, Gila, Graham, Pima, Cochise, Graham, Apache, Navajo, Santa Cruz. The following collection records were those that were not obviously found along the roads:

1. Beaver Creek (Stoneman Lake Road area)
2. Beaver Creek Watershed #1

3. Paradise Spring (Elden Mountain, Coconino County) along pipeline
4. Oak Spring (Elden Mtn, Coconino County)
5. Strawberry
6. Black Canyon on Mingus Mountain
7. APS site 15 miles east of Chino Valley
8. Oak Creek Canyon Switchbacks
9. Stocton Pass (9.5 miles east of Bonita)
10. Along Colorado River (122 river mile) in the Grand Canyon
11. Pine Valley/Jack's Canyon Wash (Sedona, Yavapai County)
12. Santa Cruz County, Sycamore Canyon, near Ruby, about 0.5 mile south of the Hank & Yank Springs entrance
13. Yavapai County, Lion Canyon, about 0.5 miles east of Weaver Creek, South Weaver Mountains, Yarnell 7.5' Quad
14. Santa Cruz County, Sycamore Canyon, W edge of Patagonia Mountains, along USFS-61, about 6 km east of National Forest boundary
15. Arizona, Santa Cruz County, about 2 miles SSE of Canelo in Coronado National Forest
16. Graham County, Jones Water Recreation Area-Crook National Forest
17. Gila County, U.S.Forest Service Experimental Area, Sierra Ancha Mountains
18. Gila County, Pinal Mountains, 12.8 miles south of Tonto National Forest boundary from Claypool along FR 651 at head of trail 193
19. Cochise County, Upper San Pedro River floodplain, Escapul Wash
20. Cochise County, Upper San Pedro River floodplain. Charleston Hills west, approximatey 1.5 miles north of Charleston Rd. approximately 20 miles west of San Pedro. Voucher for botanical inventory of San Pedro Riparian National Conservation Area.
21. Yavapai County, Munds Draw Quadrangle, northwest of Jerome, just west of Antelope Hills, 1.5 k southwest of Mormon Pocket Tank, Horseshoe Canyon, red sandstone canyon

Sources of information: See cited literature. Also considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed June 21, 2004) and personal communication with D. Robinett (Rangeland Management Specialist, U.S. Department of Agriculture, Natural Resources Conservation Service, Tucson, Arizona, 2004).

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ **Yes**]	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	[✓ **Yes**]	**No**	**2 pt.**
Populations of this species produce seeds every year.	[✓ **Yes**]	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	[✓ **Yes**]	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	**Yes**	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	[✓ **Yes**]	**No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes**	[✓ **No**]	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	[✓ **No**]	**2 pt.**
Resprouts readily when cut, grazed, or burned	[✓ **Yes**]	**No**	**1 pt.**

Total pts: 7 Total unknowns: 1

Score : A

Note any related traits: From Walsh (1994): reproduces by seeds, primarily by apomixis although some sexual reproduction does occur (Voigt and Oaks 1985). If adequate moisture, *E. curvula* can reproduce in its first year of growth (Shoop and McIlvain 1970, Wasser 1982). Produces 300 to 1000 seeds per panicle (Phillips et al. 1991).

Weeping lovegrass reproduces by seeds; it does not have rhizomes or stolons (Atkins and Smith 1967). Weeping lovegrass produces tillers which grow outward from the edge of the clump. Dead stems prevent production of new tillers to the inside. After a few years without grazing or burning, the only live shoots in the decadent plant are in an outside ring enclosing dead material (Dahl and Cotter 1984). Although Stubbendieck at al. (1992 in Guertin and Halvorson 2003) suggest *E. curvula* reproduces by tillers, there is no discussion of quick spread of these vegetative structures.

A long period of grazing causes some plants in the pasture to be repeatedly grazed. Whenever a shoot is grazed or mowed so that little or no green leaves are left, it is forced to draw upon its stored food to grow new leaves. Continued frequent use of stored food can cause the plant to starve to death. This is the cause of most spot die-out in continuously grazed pastures (Shoop and McIlvain 1970).

Even though seeds are produced apomictically, pollination appears to be necessary for seed development; embryos failed to develop until several hours following anthesis. In field trials, seed set was equally as good under self-pollinating conditions as cross-pollinating (Streetman 1970).

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	**U**
	southwestern interior chaparral scrub	**C**
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	**U**
	semi-desert grassland	**C**
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	
	montane riparian	
Woodlands	Great Basin conifer woodland	**U**
	Madrean evergreen woodland	**D**
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**C**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial):	*Erodium cicutarium* (L.) L'Hér. ex Ait. (USDA 2005)
Synonyms:	None identified in USDA (2005).
Common names:	Redstem filaree, cutleaf filaree, redstem stork's bill, heron's bill, cranesbill, pin-clover, pingrass, alfilaria
Evaluation date (mm/dd/yy):	05/08/03
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Committee review date:	07/10/03 and 09/19/03
List date:	09/19/03
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**D**	Other published material	**“Impact”** **Section 1 Score:** **C**	**“Plant Score”** **Overall Score:** **Medium** **Alert Status:** **None**
1.2	Impact on plant community	**C**	Other published material		
1.3	Impact on higher trophic levels	**C**	Other published material		
1.4	Impact on genetic integrity	**U**	No information		
2.1	Role of anthropogenic and natural disturbance	**B**	Reviewed scientific publication	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **14 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Other published material		
2.3	Recent trend in total area infested within state	**C**	Observational		
2.4	Innate reproductive potential	**A**	Reviewed scientific publication		
2.5	Potential for human-caused dispersal	**A**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Other published material		
2.7	Other regions invaded	**C**	Other published material		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**A**	Observational	**“Distribution”** **Section 3 Score:** **A**	
3.2	Distribution	**A**	Observational		

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **D** *Doc'n Level:* **Other pub.**

Identify ecosystem processes impacted: Fire.

Rationale: *Erodium cicutarium* can increase the fuel load in areas that are otherwise not susceptible to fire, thereby potentially increasing the spread, frequency, and intensity of wildland fire. Prostrate stems aid in spreading ground fire. Dead plants contribute to fuel loads but it was noted that the fuel load is not continuous.

(Frequent prescribed burning favors *E. cicutarium* and other herbs over annual grasses. Buried seeds, or seeds and seedlings under litter can escape light to moderate fires, and seeds buried more than 0.5 in. can escape severe fires enabling *E. cicutarium* to colonize a burned site and perpetuate its presence).

Because *E. cicutarium* is a potential forage plant, when it does respond to winter precipitation grazing pressure may keep the fuel load reduced. In areas where there is no grazing, fuel loads may be increased by a combination of winter annuals (mostly non-natives) of which *E. cicutarium* is one of several.

Sources of information: See Howard (1992).

Question 1.2 Impact on plant community composition, structure, and interactions *Score:* **C** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Potential impact of competing with or displacing native annual species.

Rationale: *Erodium cicutarium* can form a rapidly spreading and dominant ground cover in some areas, thereby inhibiting germination and survival of other desert annuals and grasses. Burgess et al. (1991) have observed that *E. cicutarium* is self-seeding in undisturbed habitats, occurring sometimes as frequently as common native species. *Erodium cicutarium, Schismus* spp. and *Bromus* spp. initiate vegetative growth earlier than most native species in the Mojahve Desert (Jennings 2001 in Brooks and Esque 2002). Established annual plants seedlings can inhibit the subsequent germination of annual plants seeds (in the Sonoran Desert; Inouye 1980), though specific effects of alien seedlings on germination of native seeds is unknown. *Bromus rubens, Schismus* spp. and *E. cicutarium* appear to compete effectively with native annuals for soil nitrogen in the Mojave Desert (Brooks 1998, 2000 in Brooks and Esque 2002). It is not well documented whether natives are out-competed explicitly by *E. cicutarium*. It is noted that the Mojave Desert experiences predominately winter rainfall. F. Northam (personal communication, 2003) suggested that in years of above-average winter precipitation, seeds of *E. cicutarium* are prolific and will remain viable in the soil for years, perhaps even to the point of accumulating in greater amounts than natives.

Sources of information: See cited literature. Also considered personal communication with F. Northam (Arizona Department of Agriculture, Noxious Weed Coordinator, 2003).

Question 1.3 Impact on higher trophic levels *Score:* **C** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Both positive and negative impacts on wildlife forage and cover.

Rationale: Foliage and seeds of *E. cicutarium* are used by wildlife, as well as by domestic livestock for forage. Some wildlife that have been documented as using the plant for food include elk, mule deer, pronghorn, desert tortoise, wood rats, songbirds, and numerous species of small rodents. *Erodium cicutarium* is rated as poor to good palatability cover for wildlife (Howard 1992). However, to the extent that *E. cicutarium* competes with native annuals and grasses for space, water, and nutrients, and thereby alters composition of flora, the availability of foods that native wildlife are adapted to may be negatively impacted, especially for the endangered desert tortoise.

Sources of information: See cited literature; also see Biswell (1956), Biswell and Gilman (1961), Inouye (1980), Longland (1987), Webb et al. (1988), Meyer and Karasov (1989), and Brooks and DeFalco (1999). Also considered information from K. Berry (1998. Alien annual plants and the Desert Tortoise. Notes from an Oct. 4, 1998 CALEPPC field trip.).

Question 1.4 Impact on genetic integrity *Score:* **U** *Doc'n Level:* **No info.**

Identify impacts: None known.

Rationale: *Erodium cicutarium* (2n=40) shares habitat with a native species, *E. texanum* (2n=20) (Kearney and Peebles 1960), in much of its range in Arizona. Plants often grow adjacent to each other and have similar phenology. Based on the reviewed literature, the opportunity to and possible occurrence of hybridization has not been studied to my knowledge.

Sources of information: See cited literature. No information available on the possibility of hybridization with the native taxon.

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **B** *Doc'n Level:* **Rev. sci. pub.**

Describe role of disturbance: Needs bare soil to establish; any anthropogenic or natural disturbance will do.

Rationale: *Erodium cicutarium* tolerates severely disturbed conditions, such as strip mines, as well as being opportunistic where minor natural disturbances occur, such as rodent burrows.

Sources of information: See Wagner et al. (1978) and Webb et al. (1988).

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Other pub.**

Describe rate of spread: Increases, but does not double in <10 years.

Rationale: Characteristics of prolific reproduction, long range animal dispersal, excellent seed viability, and generalist habitat preferences enable *E. cicutarium* to rapidly occupy and spread in open disturbed areas that do not experience long periods of freezing. Because *E. cicutarium* is already widely distributed it may not have the opportunities for doubling in <10 years.

Sources of information: See Howard (1992) and references therein.

Question 2.3 Recent trend in total area infested within state *Score:* **C** *Doc'n Level:* **Obs.**

Describe trend: Stable.

Rationale: *Erodium cicutarium* is found in a wide variety habitats in every county in Arizona. Where it can grow, it is most likely already growing. Found throughout Arizona, up to approximately 8300 feet; common and often abundant on plains and mesas (Kearney and Peebles 1960, SEINet 2003).

Sources of information: See cited literature; also see Howard (1992). Also considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed 2003), via search through University of Arizona Herbarium, 'In-State' folders of *Erodium cicutarium* collections; highest collection at 8320 feet in Barfoot Park, Chiricahua Mountains. Score based on inference based on literature and herbaria records.

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Describe key reproductive characteristics: Sexually reproduces; annual/biennial; rapid germination; high seed production (2400 to 9900 seeds per plant); self-fertile.

Rationale: Innate reproductive potential is high. See Worksheet A.

Sources of information: See Hull (1973), Roberts (1986), Stamp (1989), Felger (1990), Blackshaw and Harker (1998), and Drezner et al. (2001).

Question 2.5 Potential for human-caused dispersal *Score:* **A** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Easily catches on clothing, to be deposited in locations distant from source. Indirect dispersal by humans as in transportation with hay or by movement of livestock also occurs readily.

Rationale: Potential for human-caused dispersal is high.

Sources of information: See Howard (1992) and Guertin and Halvorson (2003) and references therein. Also considered information from the Environment News Service. April 18, 2003. Roads Open Up Paths for Weed Invasions. Available online at: http://ens-news.com/ens/apr2003/2003-04-18-09.asp.

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Seeds easily catch on animal fur and are transported in feces to be deposited in locations distant from source; rodent may also cache seeds in areas distant from source.

Rationale: Potential for natural long-distance dispersal is high.

Sources of information: See Howard (1992) and Guertin and Halvorson (2003) and references therein.

Question 2.7 Other regions invaded *Score:* **C** *Doc'n Level:* **Other pub.**

Identify other regions: *Erodium cicutarium* is found throughout North America and on nearly every continent on Earth. It is native to the Mediterranean region.

Rationale: *Erodium cicutarium* has a broad ecological distribution. Flourishes in semiarid climates yet will tolerate a broad range of climates. There are no known other ecological regions invaded outside Arizona that are not already invaded in Arizona.

Sources of information: See Howard (1992) and Guertin and Halvorson (2003) and references therein.

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: *Erodium cicutarium* has existed in North America since the early 1700s, coincident with early Spanish expeditions (Webb et al. 1988). The species probably arrived in Arizona during that time. The first record of the species in Arizona, however, is 1886. Native American tribes include the species in their medicinal and food plant knowledge, which indicates a long history of establishment for the species. The species is widespread in Arizona, occupying nearly all ecological and soil types in the state.

Rationale: *Erodium cicutarium* is widely established throughout Arizona. Occurs at or below 8300 feet in Arizona.

Sources of information: See cited literature; also see Kearney and Peebles (1960), Hodgson (2002), and Guertin and Halvorson (2003) and references therein. Also considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed 2003), via search through University of Arizona Herbarium, 'In-State' folders of *Erodium cicutarium* collections.

Question 3.2 Distribution *Score:* **A** *Doc'n Level:* **Obs.**

Describe distribution: Present in numerous habitats in Arizona (see Worksheet B), especially areas that have been disturbed by livestock grazing, but seems to be limited to areas at or below 8,300 feet.

Rationale: *Erodium cicutarium* is widespread in Arizona.

Sources of information: See Howard (1992) and Guertin and Halvorson (2003) and references therein. Also considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed 2003), via search through University of Arizona Herbarium, 'In-State' folders of *Erodium cicutarium* collections. See section below on *Erodium cicutarium* distribution references, with annotation.

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**[✓ Yes]**	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**[✓ Yes]**	**No**	**2 pt.**
Populations of this species produce seeds every year.	**[✓ Yes]**	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**[✓ Yes]**	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	**[✓ Yes]**	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**[✓ Yes]**	**No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes**	**[✓ No]**	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	**[✓ No]**	**2 pt.**
Resprouts readily when cut, grazed, or burned	**[✓ Yes]**	**No**	**1 pt.**
	Total pts: 9	**Total unknowns: 0**	
	Score : A		

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	**Minor Ecological Types**	**Code***
Dunes	dunes	**D**
Scrublands	Great Basin montane scrub	**A**
	southwestern interior chaparral scrub	**A**
Desertlands	Great Basin desertscrub	**A**
	Mohave desertscrub	**A**
	Chihuahuan desertscrub	**A**
	Sonoran desertscrub	**A**
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	**A**
	semi-desert grassland	**A**
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	**A**
	southwestern interior riparian	**A**
	montane riparian	**C**
Woodlands	Great Basin conifer woodland	**A**
	Madrean evergreen woodland	**A**
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Guertin, P., and W.L. Halvorson. 2003. Status of Fifty Introduced Plants in Southern Arizona Parks. U.S. Geological Survey, Sonoran Desert Research Station, School of Natural Resources, University of Arizona, Tucson. Available online at: http://sdrsnet.srnr.arizona.edu/index.php?page=datamenu&lib=2&sublib=13; accessed November 2004.

Hodgson, W.C. 2002. Food Plants of the Sonoran Desert. University of Arizona Press, Tucson.

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Sauer, J.D. 1988. Plant Migration: The dynamics of Geographic Patterning in Seed Plant Species. University of California Press, Berkeley. 282 p.

Shreve, F., and I.L. Wiggins. 1964. Vegetation and Flora of the Sonoran Desert: Vols. I and II. Stanford University Press, Stanford, California. 1740 p.

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Published Literature, Online Information, and Personal Communications Used to Determine the Distribution of *Erodium cicutarium* in Arizona, with Annotation (question 3.2)

Bowers, J. E., and S. P. McLaughlin. 1986. Flora and vegetation of the Rincon Mountains, Pima County, Arizona. Desert Plants 8:51–94. ***Present; to 8000 feet, but usually much lower; gravelly flats; in several plant communities.***

Daniel, T.F., and M.L. Butterwick. 1992. Flora of the South Mountains of south-central Arizona. Desert Plants 10:99–119. ***Occasional to locally common***.

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Felger R.S., D.S. Turner, and M.F. Wilson. 2003. Flora and vegetation of the Mohawk Dunes, Arizona. Sida 20:115−1187. **Erodium cicutarium** ***was not listed in the Mohawk Dunes, Arizona***.

Jenkins, P. 2003. Assistant Curator, University of Arizona Herbarium. Personal communication at the University of Arizona Herbarium on June 19,2003. **Erodium cicutarium** ***can be found up from the low elevations and up into the pines in Arizona.***

Johnson, W.T. 1988. Flora of the Pinaleno Mountains, Graham County, Arizona. Desert Plants 8:147−162 and 175-191. ***Present in Tripp Canyon at 4000 feet.***

Kearney, T.H., and R.H. Peebles (and collaborators). 1960. Arizona Flora. 2nd edition with supplement by J.T. Howell and E. McClintock and collaborators. University of California Press, Berkeley. 1085 p. ***Common and often abundant on plains and mesas; occurs throughout Arizona.***

Mauz, K. Sawtooth Mountains. Available online: http://eebweb.arizona.edu/HERB/SAWPAGES/flora3.html#gera. ***Describes*** **Erodium cicutarium** ***as growing on desert flats, mesas, and hillsides below 7000 feet. Describes its presence in the Sawtooth Mountains on alluvial flats and lower bajadas, with a few individuals in higher areas.***

McDougall, W.B. 1973. Seed Plants of Northern Arizona. The Museum of Northern Arizona, Flagstaff. 594 p. ***Found in all northern Arizona counties up to 7200 feet.***

McLaughlin, S. P. 1992. Vascular flora of Buenos Aires National Wildlife Refuge, Pima County, Arizona. Phytologia 73:353–377. ***Present.***

McLaughlin, S. P., and J. E. Bowers. 1990. A floristic analysis and checklist for the northern Santa Rita Mountains, Pima County, Arizona. The Southwest Naturalist 35:61−75. ***Present.***

McLaughlin, S. P., E. L. Geiger, and J. E. Bowers. 2001. A flora of the Appleton-Whittell Research Ranch, northeastern Santa Cruz County, Arizona. Journal of the Arizona-Nevada Academy of Science 33:113−131. ***Uncommon, mostly on disturbed sites.***

Phillips, B.G., A.M. Phillips, III, and M.A. Schmidt Bernzott. 1987. Annotated checklist of vascular plants of the Grand Canyon National Park. Grand Canyon Natural History Association. Monograph Number 7. ***Scattered on beaches, gravel bars, washes of Inner Gorge the length of the river, 1200 to 7600 feet; also found on North and South Rims. (North: western areas. South: west of El Tovar and Hermit's Rest).***

Rondeau, R.J., T.R. Van Devender, C.D. Bertelsen, P.D. Jenkins, R.K. Van Devender, and M.A. Dimmitt. Flora and Vegetation of the Tucson Mountains, Pima County, Arizona. Available online at: http://eebweb.arizona.edu/HERB/TUCSONS/tucsonsG-R.html. ***Describes Erodium cicutarium as being present in all habitats within the Tucson Mountains, Pima County, Arizona.***

Shreve, F., and I.L. Wiggins. 1964. Vegetation and Flora of the Sonoran Desert: Vols. I and II. Stanford University Press, Stanford, California. 1740 p. ***Common throughout Arizona.***

Tidestrom, I., and S.T. Kittell. 1941. A Flora of Arizona and New Mexico. The Catholic University of America Press, Washington, D.C. ***Fields, canyons, and mountain sides, up to the Yellow Pine belt.***

SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed 2003), via search through University of Arizona Herbarium, 'In-State' folders of *Erodium cicutarium* collections. ***Found in all deserts on flats and bajadas, and along desert washes; in grasslands and mesas, and along grassland rivers and drainages; along major rivers and lakes, agricultural, rangelands, and in cities and along roadways/highways; in major and smaller canyons along rivers and their tributary canyons; chaparral; pinyon-juniper; in Ponderosa pine vegetation, and the meadows in Ponderosa pine. Highest collection at 8320 feet in Barfoot Park, Chiricahua Mountains.***

Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial):	*Euphorbia esula* L. (USDA 2005)
Synonyms:	None identified at the species level by USDA (2005).
Common names:	Leafy spurge
Evaluation date (mm/dd/yy):	05/07/04
Evaluator #1 Name/Title:	Kate Watters
Affiliation:	Northern Arizona University
Phone numbers:	(928) 523–8518
Email address:	Kw6@dana.ucc.nau.edu
Address:	P.O. Box 5765 Flagstaff, Arizona 86011–5765
Evaluator #2 Name/Title:	
Affiliation:	
Phone numbers:	
Email address:	
Address:	

List committee members:	06/23/04: W Albrecht, D. Backer, J. Brock, J. Busco, C. Laws, J. Hall, L. Moser, B. Phillips, K. Watters 10/22/04: W. Albrecht, D. Backer, S. Harger, L. Moser, B. Phillips, J. Schalau, K. Spleiss
Committee review date:	06/23/04 and 10/22/04
List date:	6/23/04; revised 10/22/04
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		**Score**	**Documentation Level**	**Section Scores**	**Overall Score & Designations**
1.1	Impact on abiotic ecosystem processes	**A**	Other published material	**“Impact”** **Section 1 Score:** **A**	**“Plant Score”** **Overall Score:** **High** **Alert Status:** **Alert**
1.2	Impact on plant community	**A**	Reviewed scientific publication		
1.3	Impact on higher trophic levels	**B**	Reviewed scientific publication		
1.4	Impact on genetic integrity	**U**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**A**	Other published material	**“Invasiveness”** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **19 pts** **Section 2 Score:** **A**	
2.2	Local rate of spread with no management	**A**	Observational		
2.3	Recent trend in total area infested within state	**B**	Observational		
2.4	Innate reproductive potential	**A**	Other published material		
2.5	Potential for human-caused dispersal	**A**	Other published material		
2.6	Potential for natural long-distance dispersal	**A**	Other published material		
2.7	Other regions invaded	**B**	Other published material		RED FLAG **NO** Something you should know.
3.1	Ecological amplitude	**B**	Observational	**“Distribution”** **Section 3 Score:** **C**	
3.2	Distribution	**D**	Observational		

Table 3. Documentation

Note: Leafy spurge (*Euphorbia esula*) is well-studied in the Great Plains and Rocky Mountain geographic areas, where ecological impacts have been documented. Because extensive populations of this species have not gained a foothold in Arizona, a majority of the sources used in this document are from other western states. Although these studies were conducted outside of Arizona, the Working Group found the reported observations and trends compelling.

Question 1.1 Impact on abiotic ecosystem processes *Score*: **A** *Doc'n Level*: **Other pub.**

Identify ecosystem processes impacted: Deep, penetrating root system could potentially alter water table levels depending on local hydrology. Oils in the plant cause leafy spurge burn hot, which could affect natural fire regimes. It is suspected that leafy spurge alters soil chemistry by the production of alleopathic chemicals.

Rationale: Leafy spurge is a long-lived perennial herb with an extensive root system. Seedling roots without competition can penetrate to depths of 3 feet and 40 inches laterally in four months. Mature root systems can reach depths of 26 feet and lateral rooting extends at a rate of 15 feet per year. Infestations with stem densities of 1,000 plants per square yard are not uncommon (Butterfield and Strubbendieck 1999).
From Hirsch and Leitch (1998): As the vegetation cover changes from more diverse (on Conservation Reserve Program land in ND) to less diverse, increased soil erosion will result. "No research or case study describing a functional relationship between leafy spurge and water runoff and soil erosion exist, so an assumption was made by others (Leistritz et al. 1993) to quantify the overall effect. A leafy spurge monoculture would conservatively reduce the soil and water conservation benefits of post Conservation Reserve Program vegetation cover by 25% (Leistritz et al. 1993).

Leafy spurge has no historic fire regime in North America, because of this fact, leafy spurge may alter fire intensity within the communities where it occurs. Leafy spurge contains 7 to 9 % oil, which produces nearly as much energy (7758 BTUs per pound (4306 kcal/kg)) as wood when combusted. In the Arizona ecotypes of alpine and subalpine grasslands, and montane conifer forests where leafy spurge occurs, the presence of this plant could have the potential to increase the intensity of fire, thus negatively affecting native vegetation not adapted to burn as intensely (Davis 1990 in Simonin 2000).

A Montana study found that litter from leafy spurge did not effect native seed germination, but had subtle effects on growth of native grass seedlings, which may indicate that it has an unknown effect on soil properties (Butterfield and Stubbendieck 1999, Olson and Wallander 2002).

Sources of information: See cited literature.

Question 1.2 Impact on plant community composition, structure, and interactions *Score*: **A** *Doc'n Level*: **Rev. sci. pub.**

Identify type of impact or alteration: Leafy spurge is extremely competitive for resources, forming monospecific stands and displacing native vegetation in many cases (Hirsch and Leitch 1998).

Rationale: Euphorbia esula presents a management problem because it is a long-lived, aggressive perennial weed that tends to displace all other vegetation in pasture, rangeland, and native habitats (see Hirsch and Leitch 1998). Yield reductions of desirable forage species associated with stands of leafy spurge have been reported to decrease from 10 to 100% (Reilly and Kaufman 1979). Infestations with stem densities of 1,000 plants per square yard are not uncommon (Butterfield and Strubbendieck 1999). Forbs and grasses in natural areas overtaken by leafy spurge may be completely displaced in a few years if the infestation is left unchecked (Butterfield and Stubbendieck 1999). The western prairie fringed orchid (Platanthera praeclara Sheviak and Bowles) is a threatened species of the tallgrass prairie. Invasion by leafy spurge is a serious threat to western prairie fringed orchid habitat (Kirby et al. 2003).

Sources of information: See cited literature.

Question 1.3 Impact on higher trophic levels *Score*: **B** *Doc'n Level*: **Rev. sci. pub.**

Identify type of impact or alteration: Leafy spurge changes vegetation structure of native species that provide habitat and forage for wildlife, resulting in decreased use by ungulates and declines in nesting success with bird species. Leafy spurge plants produce milky sap which irritates the mouth and digestive tract of livestock and even causes death. It also is a nectar source for many species of insects. Documentation on the effects of leafy spurge outbreaks are not available for Arizona, as this species has not infested large areas in our state. Information on impacts to wildlife was taken from studies in other western states where leafy spurge populations are causing considerable problems for livestock and wildlife.

Rationale: A study in Theodore Roosevelt National Park in North Dakota, showed that leafy spurge infestations had significant impacts on forage values for bison, deer and elk, as bison and deer used leafy spurge infested areas 83% and 70% less than non-infested sites, respectively (Trammell and Butler 1995). A study by Scheiman et al. (2003) examined nest densities and success rates on grassland sites in North Dakota and found that nest densities of some species were lowest on highly infested sites, yet overall, leafy spurge presence did not affect nest site selection. However, the study did show that nesting success was negatively affected by spurge cover. Leafy spurge infestations cause structural changes in vegetation and alter resource availability affecting bird community composition.

The presence of leafy spurge influences foraging behavior of cattle as studies show cattle prefer foraging in areas without heavy infestations (Lym and Kirby 1987). Leafy spurge irritates the mouth and digestive tract of cattle. The milky latex, distributed throughout the plant, is a gastric irritant that may produce death in cattle (Caesar et al. 1993). Based on these studies involving livestock and data on ungulates from Theodore Roosevelt National Park (Trammell and Butler 1995), leafy spurge infestations are replacing native forage that is unable to be utilized.

Leafy spurge is palatable to goats and sheep, but the degree to which leafy spurge provides forage for livestock and wildlife was examined by the U.S. Fish and Wildlife Service in the western states of Montana, North Dakota, Utah, and Wyoming (Dittberner and Olson 1983). The degree of use by horses and cattle in all four states was poor, and use by pronghorn, elk, mule deer, and white-tailed deer was poor with the exception of white-tailed deer populations in North Dakota, which used leafy spurge a fair amount. The same authors examined the degree to which leafy spurge provides cover for wildlife, small mammals and small nongame birds and found leafy spurge cover was good for pronghorn in North Dakota, and poor for pronghorn and elk in Utah and North Dakota; good for mule deer in North Dakota and poor mule deer in Utah; good for white-tailed deer in North Dakota; fair for small mammals in Utah; and poor for those in Wyoming. Cover value was poor for both small non-game birds and upland game birds in Utah.

Leafy spurge reduces wildlife habitat benefits, affecting the kinds and numbers of animals the land can support (Wallace 1991 in Hirsch and Leitch 1998). Flowers of leafy spurge are insect pollinated. The flowers produce copious amounts of pollen and nectar. A survey in Saskatchewan showed 8 orders, 39 families, and 60 species of insects on the flowers of leafy spurge (Best et al. 1980).

Sources of information: See cited literature.

Question 1.4 Impact on genetic integrity *Score*: **U** *Doc'n Level*: **Other pub.**

Identify impacts: Impacts of leafy spurge hybridization with natives in the same genus are unknown.

Rationale: Leafy spurge may be confused with a native spurge, *Euphorbia lurida*, which grows in Apache, Coconino, Yavapai, Greenlee, Graham, Cochise, and Pima Counties. There are several other native species of Euphorbia in Arizona and genetic impacts are unknown.

Sources of information: Kearney and Peebles (1960).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score*: **A** *Doc'n Level*: **Other pub.**

Describe role of disturbance: Leafy spurge often dominates bottomlands, flood plains, and riverbanks. It is primarily found in pastures, abandoned cropland, and in areas disturbed by development, yet also invades sites that are undisturbed.

Rationale: This species can establish independent of any known natural or anthropogenic disturbance. Results from a study in Theodore Roosevelt National Park found that leafy spurge is able to invade sites within the wilderness area of a national park that received relatively little anthropogenic disturbance (Rabie 2002). Grazing lands, recreation areas, and wildlife areas are infested with leafy spurge (in North Dakota; Messersmith and Lym 1990 in Hirsch and Leitch 1998).

Sources of information: See cited literature; also see Lajeunesse et al. (1999), Hirsch and Leitch (1998), and DiTomaso (2000).

Question 2.2 Local rate of spread with no management *Score*: **A** *Doc'n Level*: **Obs.**

Describe rate of spread: Leafy spurge populations in Arizona are increasing, but less rapidly with management over the last 5 years. A 1990 survey found 44,000 acres in Colorado infested with leafy spurge. In 2002 the Colorado Department of Agriculture conducted a follow-up survey and found more than 73,800 infested acres of leafy spurge. Leafy spurge infestations now cover more than 1.1 million hectares in the northern Great Plains and the intermountain West. The rate of spread doubled every 10 years for the past 30 years (Wallace et al. 1992); infestation doubled in size in 10 years when left unchecked (in North Dakota; Leitch et al. 1994).

Rationale: Leafy spurge continues to spread at an estimated rate of 8 to 14 percent per year in the intermountain West (Whitson 1998).

Sources of information: See cited literature. Also considered personal communication with L. Moser (Botanist, U.S. Department of Agriculture, Forest Service, Coconino National Forest, Flagstaff, Arizona, personal observations from 1999 to the present on the Coconino National Forest, communicated 2004). Working Group members decided that their was enough evidence from other locations to infer the rate of spread of leafy spurge would double in <10 years in Arizona in the absence of management.

Question 2.3 Recent trend in total area infested within state *Score*: **B** *Doc'n Level*: **Obs.**

Describe trend: Increasing, but less rapidly that doubling its range in <10 years.

Rationale: Arizona's infested areas are located in Coconino and Apache Counties, which may be at the southern edge of leafy spurge's range. According to some sources, leafy spurge can spread rapidly as evidenced by the doubling of the acreage infested by leafy spurge in North Dakota from 1973 to 1982, a period of 9 years (reported in Biesboer [1996] without citation). Leafy spurge has been referred to as an "ecological generalist," with a range of environmental tolerances, which could allow for its spread to continue south to the Mogollon Rim. Observations from L. Moser (personal communication, 2004), report a leafy spurge infestation at Brolliar Park near Mormon Lake expanding to the south 1 to 2 miles in the last two years.

Sources of information: See cited literature. Also considered information from the Western Weed Coordinating Committee website (available online at: http://weedcenter.org/wwcc/docs/projects2001.html; accessed May 2004). Score based on personal communication with L. Moser (Botanist, U.S. Department of Agriculture, Forest Service, Coconino National Forest, Flagstaff, Arizona, 2004) and Working Group discussion.

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level*: **Other pub.**

Describe key reproductive characteristics: Leafy spurge reproduces via seed and vegetatively from shoots arising from root buds.

Rationale: Although most seed production is the result of cross-pollination, self-pollination can produce viable seed in great numbers. One study estimated that within one dense patch of leafy spurge, 2500 seeds were produced in a single square meter of land. Seeds in soil remain viable 5 to 8 years. Despite the potential for great amounts of seed production, vegetative reproduction is the primary means by which this species takes over an area. Plants rarely produce flowers the first year unless there is a lack of competition from other plants (Butterfield and Stubbendieck 1999).

From Biesboer (1996): Fruits ripen and seeds are dispersed from mid- to late-July in the United States. The number of seeds produced per stalk varies from 252 seeds in habitats where spurge competes with native grasses to about 200 seeds where spurge competes with annual weeds and crested wheatgrass (Selleck et al. 1962). Seed yield can be very high. In Saskatchewan, leafy spurge patches were calculated to produce 24 to 3400 lbs of seed per acre (Selleck et al. 1962).

Seeds of leafy spurge have a rather high germination rate of 60 to 80% (Bakke 1936, Bowes and Thomas 1978). Seed may remain dormant for about 5 to 8 years following maturity, but 99% of the germination occurs within the first two years (Selleck et al. 1962). The optimal temperature for germination is 30 to 32 C.

Sources of information: See cited literature, also see Lajeunesse et al. (1999).

Question 2.5 Potential for human-caused dispersal *Score*: **A** *Doc'n Level*: **Other pub.**

Identify dispersal mechanisms: Seeds and root fragments are spread in mud on equipment, motorbikes, or regular vehicles. Leafy spurge is a contaminant in crop seed, feed grain, and hay. Sheep graze leafy spurge and are capable of spreading the seed in their fleece and feces.

Rationale: There are numerous opportunities for dispersal to new areas. Sheep can pick up leafy spurge seed in their fleece and will consume and pass viable seed. However, viability of seed recovered from feces was highly variable and almost always lower than seed collected in the field. Despite reduced seed numbers and viability, sheep have the potential to spread leafy spurge and should be managed accordingly (Olsen et al. 1997).

Sources of information: See cited literature; also see Lajeunesse et al. (1999).

Question 2.6 Potential for natural long-distance dispersal *Score*: **A** *Doc'n Level*: **Other pub.**

Identify dispersal mechanisms: Dispersal via animals or abiotic mechanisms is frequent; animals, water.

Rationale: From Biesboer (1996 and references cited therein): The seeds are forcibly ejected from the capsules and can travel up to 15 yards from the parental plant. The seed may be ejected up to 4.6 m from the parent and distributed fairly uniformly from 0.3 to 4.0 m from the plant. The seeds can also float and initial infestations often occur along stream or river banks where seeds have floated into appropriate habitat. Birds have been implicated in spreading seed but documentation is limited except for sharptail grouse.

Also spread on feet or fur of animals, including sheep. Viable seed is transported in dung of sheep, goats, rodents, birds and somewhat by whitetail deer that ingest the mature plants (Blockenstein et al. 1987, Olsen et al. 1997).

Sources of information: See cited literature; also see Lajeunesse et al. (1999).

Question 2.7 Other regions invaded *Score*: **B** *Doc'n Level*: **Other pub.**

Identify other regions: Leafy spurge was introduced to North America as an ornamental in 1829, and by as early as the 1900s infestations had spread to the west coast of North America. *Euphorbia esula* is presently a major economic concern in the northwestern and north-central states of the United States and in the adjacent prairie regions of the provinces of Canada. States with the greatest infestations include Colorado, Idaho, Minnesota, Montana, Nebraska, North Dakota, Oregon, South Dakota, Wisconsin, and

Wyoming (Biesboer 1996). It is found from 1300 to 2880 m in Utah (Welsh et al. 1987). A 2002 survey found that leafy spurge infests 78,000 acres of land in Colorado.

Rationale: Leafy spurge invades riparian habitats that are not yet invaded in Arizona.

Sources of information: See cited literature; also see Simonin (2000) for information about habitats from which leafy spurge is known to occur. Also considered information in The Atlas of the Vascular Plants of Utah (available online at: http://www.gis.usu.edu/Geography Department/utgeog/utvatlas/ut-vascatlas.html; accessed May 2004) and the Colorado State County Extension website (available online at: http://www.ext.colostate.edu/pubs/natres/ 03107.html; accessed May 2004).

Question 3.1 Ecological amplitude *Score*: **B** *Doc'n Level*: **Obs.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: There are only four records in Arizona herbaria of *Euphorbia esula*. The earliest one was collected in 1970 in Coconino County, 1/4 mile S. of Big Springs Ranger Station, Kaibab National Forest.

From Lajeunesse et al. (1999) and Biesboer (1996): Leafy spurge is well adapted to many habitat types ranging from riparian to dry hillsides. *Euphorbia esula* occurs primarily in untilled, non-cropland habitats, which include disturbed and undisturbed sites such as abandoned cropland, pastures, rangelands, woodlands, prairies, roadsides, and wastelands. It is tolerant of a wide range of habitats and may occur in rich damp soils such as on the banks of streams or on extremely nutrient poor, dry soils typified by the rangelands of the west. It is most aggressive in semi-arid situations where competition from associated species is less intense. For this reason, infestations generally occur and spread rapidly on dry hillsides, dry prairies, or rangelands. In Colorado it is known leafy spurge has become a serious weed in most western states because it tolerates a broad range of growing conditions. It is often associated with open habitats and is equally at home on dry sandy soils as on moist heavy clays. The plants tend to occur on all soils but tend to grow most rapidly in course- textured soils.

Rationale: This species invades only two major ecological types in Arizona at this time.

Sources of information: See cited literature. Also considered information from SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed October 2004) and observations by Working Group members.

Question 3.2 Distribution *Score*: **D** *Doc'n Level*: **Obs.**

Describe distribution: Only one general area of infestation is known in the Flagstaff region, and it is located on Forest Service land at Brolliar Park beyond Mormon Lake. Approximately 25 to 35 acres remain infested at this site. Leafy spurge is reported from the Big Springs area of the North Rim and in Kaibab National Forest near Grandview.

Rationale: Distribution is limited at this time in Arizona.

Sources of information: Northern Arizona Weed Council database (available online at: http://www.infomagic.net/~tnc/ weedcouncil/database.htm; accessed May 2004), SEINet (Southwest Environmental Information Network), Arizona herbaria specimen database (available online at: http://seinet.asu.edu/collections; accessed October 2004), and Western Weed Coordinating Committee website (available online at: http://weedcenter.org/wwcc/docs/projects2001.html; accessed May 2004). Score based on observations in Arizona.

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	**[✓ Yes]**	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**[✓ Yes]**	**No**	**2 pt.**
Populations of this species produce seeds every year.	**Yes**	**[✓ No]**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	**Yes**	**[✓ No]**	**1 pt.**
Seeds remain viable in soil for three or more years	**[✓ Yes]**	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**[✓ Yes]**	**No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**[✓ Yes]**	**No**	**1 pt.**
Fragments easily and fragments can become established elsewhere	**[✓ Yes]**	**No**	**2 pt.**
Resprouts readily when cut, grazed, or burned	**[✓ Yes]**	**No**	**1 pt.**

Total pts: 10 Total unknowns: 0

Score : A

Note any related traits:

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	
Grasslands	alpine and subalpine grassland	**D**
	plains and Great Basin shrub-grassland	
	semi-desert grassland	
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	
	montane riparian	
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	**D**
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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Plant Assessment Form

For use with the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" by the California Exotic Pest Plant Council and the Southwest Vegetation Management Association (Warner et al. 2003)

Printable version, February 28, 2003
(Modified for use in Arizona, 07/02/04)

Table 1. Species and Evaluator Information

Species name (Latin binomial):	*Euryops multifidus* (Thunb.) DC. (USDA 2005)
Synonyms:	*Euryops subcarnosus* DC. ssp. *vulgaris* B. Nord (USDA 2005)
Common names:	Sweet resinbush, hawk's eye
Evaluation date (mm/dd/yy):	09/17/04
Evaluator #1 Name/Title:	Bruce Munda/NRCS-Arizona-Plant Materials Specialist
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List committee members:	09/24/04: D. Backer, J. Brock, D. Casper, J. Hall, K. Klementowski, H. Messing, B. Munda, F. Northam, J. Ward 03/01/05: D. Backer, D. Casper, J. Filar, E. Geiger, J. Hall, H. Messing, B. Munda, F. Northam
Committee review date:	09/24/04 and 03/01/05
List date:	03/01/05
Re-evaluation date(s):	

Table 2. Scores, Designations, and Documentation Levels

Question		Score	Documentation Level	Section Scores	Overall Score & Designations
1.1	Impact on abiotic ecosystem processes	**A**	Other published material	**"Impact"** **Section 1 Score:** **A**	**"Plant Score"** **Overall Score:** **High** **Alert Status:** **None**
1.2	Impact on plant community	**A**	Other published material		
1.3	Impact on higher trophic levels	**A**	Other published material		
1.4	Impact on genetic integrity	**D**	Other published material		
2.1	Role of anthropogenic and natural disturbance	**A**	Other published material	**"Invasiveness"** *For questions at left, an A gets 3 points, a B gets 2, a C gets 1, and a D or U gets=0. Sum total of all points for Q2.1-2.7:* **13 pts** **Section 2 Score:** **B**	
2.2	Local rate of spread with no management	**B**	Observational		
2.3	Recent trend in total area infested within state	**C**	Other published material		
2.4	Innate reproductive potential	**A**	Reviewed scientific publication		
2.5	Potential for human-caused dispersal	**B**	Other published material		
2.6	Potential for natural long-distance dispersal	**B**	Other published material		
2.7	Other regions invaded	**D**	Other published material		RED FLAG **YES** Something you should know.
3.1	Ecological amplitude	**A**	Other published material	**"Distribution"** **Section 3 Score:** **B**	
3.2	Distribution	**D**	Other published material		

Red Flag Annotation

Only about 10 known populations of *Euryops multifidus* occur in Arizona. Those populations have been mapped and most locations have active control efforts. Vegetation survey projects should be aware that undocumented populations may exist on historic Civilian Conservation Corps project sites.

Table 3. Documentation

Question 1.1 Impact on abiotic ecosystem processes *Score:* **A** *Doc'n Level:* **Other pub.**

Identify ecosystem processes impacted: Increased soil erosion: Frye Mesa site has lost the A horizon.

Rationale: *Euryops multifidus* develops monoculture stands; dormant during initial monsoon events which leave soil unprotected and eliminates other plants in the inter-spaces between shrubs. Alters (decreases) fire regime, reduces soil-water infiltration, adversely impact hydrologic processes, and adversely impacts the ability of a site to support the identified plant community.

Sources of information: See Pierson and McAuliffe (1995) and McAuliffe (2000). Also considered personal communications with K. Fisher (District Conservationist, U.S. Department of Agriculture, Natural Resources Conservation Service, Safford, Arizona, 2004) and D. Robinett (Rangeland Management Specialist, U.S. Department of Agriculture, Natural Resources Conservation Service, Tucson, Arizona, 2004).

Question 1.2 Impact on plant community composition, structure, and interactions *Score*: **A** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: Change in plant community, composition, and structure.

Rationale: *Euryops multifidus* out competes all native vegetation, establishes monocultures, and keeps native plants (such as tobosa grass, ocotillo, mesquite) from re-establishing on the site. Alleopathic properties where evaluated by McAuliffe and Pierson with no evidence of alleopathy found. Endangered, threatened, and otherwise rare species could be eliminated. Pima pineapple cactus (*Coryphantha sheerii* Muehlenph. L.D. Benson var. *robustispina* L.D. Benson) and *Sophora arizonica* S. Wats are species that are known to occur on or near *E. multifidus* sites.

Sources of information: See Pierson and McAuliffe (1995), McAuliffe (2000), and Howery et al. (2003).

Question 1.3 Impact on higher trophic levels *Score:* **A** *Doc'n Level:* **Other pub.**

Identify type of impact or alteration: *Euryops multifidus* displaces native vegetation and establishes monocultures that would have negative effects on forage for livestock and habitat for wildlife. Sweet resinbush is not know to be grazed by any herbivores. It is used by insects and bees due to its habit of flowering during the winter months in response to adequate winter precipitation (B. Munda, personal observation, 2004).

Rationale: Sweet resinbush out competes native plants, keeps native plants for establishing, and is an unpalatable plant to domestic and wild herbivores.

Sources of information: See McAuliffe (2000) and Howery et al. (2003). Also considered personal observations by B. Munda (Plant Materials Specialist, U.S. Department of Agriculture, Natural Resources Conservation Service, Tucson, Arizona, 2004).

Question 1.4 Impact on genetic integrity *Score:* **D** *Doc'n Level:* **Other pub.**

Identify impacts: No known impacts on genetic integrity.

Rationale: Only one other introduced species (*Euryops chrysanthemoides* (DC.) B. Nordenstam) from the genus *Euryops* is known to occur in southern Florida. It is not known if they have the ability to cross.

Sources of information: Kearney and Peebles (1960) and USDA (2005).

Question 2.1 Role of anthropogenic and natural disturbance in establishment *Score:* **A** *Doc'n Level:* **Other pub.**

Describe role of disturbance: Disturbance is not necessary for sweet resinbush to establish and spread.

Rationale: Sweet resinbush invades intact plant communities such as semi-arid grasslands and eventually forms uninterrupted monocultures which exclude native grasses, shrubs, and succulents.

Sources of information: See Pierson and McAuliffe (1995) and Howery et al. (2003).

Question 2.2 Local rate of spread with no management *Score:* **B** *Doc'n Level:* **Obs.**

Describe rate of spread: Has the potential to increase dramatically with no management.

Rationale: Frye Mesa population spread slowly the first 40 years but exploded since the 1970s, encroaching on thousands of acres of rangeland.

Sources of information: Personal communication with C.Duncan (Range Staff Officer, U.S. Department of Agriculture, Forest Service, Safford Ranger District, Safford, Arizona, 1998).

Question 2.3 Recent trend in total area infested within state *Score:* **C** *Doc'n Level:* **Other pub.**

Describe trend: Locations under management are stable or decreasing. However, managed sites need follow up efforts every other year to control sprouts and or new plants.

Rationale: Based on the best available information, sweet resinbush is not establishing in new locations. But is does spread, in the area of infestation, where no management is being applied.

Sources of information: See Howery et al. (2003). Also considered information from the year 2000 Management Plan for the Sweet Resinbush and Karoo Bush Weed Management Area.

Question 2.4 Innate reproductive potential *Score:* **A** *Doc'n Level:* **Rev. sci. pub.**

Describe key reproductive characteristics: *Euryops multifidus* can reach reproductive maturity in two years of less. Seed appears to remain viable for over two years. It does not reproduce vegetatively.

Rationale: Plant mating system is not known. Plants can flower and produce seeds twice a year with adequate winter/spring and summer moisture. If the plant is mechanically controlled it is necessary to cut the plant below the crown (at or below the soil surface) to keep the plant from sprouting from the crown.

Sources of Information: See Nordenstam (1966), Pierson and McAuliffe (1995), and Parker and Hydock (2004).

Question 2.5 Potential for human-caused dispersal *Score:* **B** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Frye Mesa and Sabino Canyon sites are near high use recreation areas. Seeds (achenes) are covered with white hairs that can attach to clothing, animal fur, and vehicles.

Rationale: *Euryops multifidus* produces seed/achenes that are covered with white hairs. The hair can readily attach to clothing, animal fur, and to vehicle tires and be transported from the infestation site.

Sources of information: See Nordenstam (1966, 1968), Pierson and McAuliffe (1995), and Parker and Hydock (2004).

Question 2.6 Potential for natural long-distance dispersal *Score:* **B** *Doc'n Level:* **Other pub.**

Identify dispersal mechanisms: Hairs on achenes can be transported by wind, animal fur and water.

Rationale: The hairs on the achenes appear to be able to attach to animal fur and light enough to potentially be moved by wind. Water appears to also move seed during sheet flow. Seeds have been seen to collect in "debris dams" after rainfall events. The hairs on the achenes appear to have mucilaginous characteristics when soaked with water. This characteristic may serve to enhance germination with limited water.

Sources of information: See Nordenstam (1966, 1968), Pierson and McAuliffe (1995), and Parker and Hydock (2004).

Question 2.7 Other regions invaded *Score:* **D** *Doc'n Level:* **Other pub.**

Identify other regions: No other regions are known to have sweet resin bush.

Rationale: Pierson and McAuliffe (1995) looked at herbarium specimens in Arizona, California, New Mexico, and Texas and found no specimens outside of Arizona.

Sources of information: See cited literature. Also see USDA (1934–2002).

Question 3.1 Ecological amplitude *Score:* **A** *Doc'n Level:* **Other pub.**

Describe ecological amplitude, identifying date of source information and approximate date of introduction to the state, if known: Three major types (Scrublands, Desertlands, and Grasslands) and three minor types (southwestern interior chaparral scrub, Sonoran desertscrub, and semi-desert grassland).

Rationale: Eight known sites were planted to *E. multifidus* during the 1930s in the above ecological types. Elevation range for these types is between 2,300 to 4,900 feet. Soil types range from sandy loam to clay loam with or without gravel, cobbles or large rocks; the species does well on granitic soils. Reproduction method is not known (cross- or self-pollinated). Germination appears to occur in late fall, winter, or spring with adequate cool season precipitation. Seedlings are commonly found under the mature plants but are also found in areas between mature plants. The date for introduction was February 1935. During flowering *E. multifidus* produces an abundance of pollen which can be a problem to those people who suffer from pollen type allergies.

Sources of information: See USDA (1934–2002), Pierson and McAuliffe (1995), and McAuliffe (2000). Also considered information from the year 2000 Management Plan for the Sweet Resinbush and Karoo Bush Weed Management Area.

Question 3.2 Distribution *Score:* **D** *Doc'n Level:* **Other pub.**

Describe distribution: Known sites are: Sabino Canyon (U.S. Forest Service Ranger Station and Fenster School), Six-shooter Canyon (Globe), Punkin Center, Montezuma School (Cottonwood), Marijilda Canyon (Mt. Graham), Gravelly Ridge (SRER), Boyce-Thompson (observational planting), Oak Flats (Superior), Miami cemetery (Hwy 60, Miami), Frye Mesa (largest site) near Safford, Arizona.

Rationale: See above. Sites have been inspected, mapped, and most are under management. The Tonto National Forest sites (Punkin Center, Oak Flats, and Miami cemetery) are mapped and proposed for management.

Sources of information: USDA (1934–2002) and the year 2000 Management Plan for the Sweet Resinbush and Karoo Bush Weed Management Area.

Worksheet A. Reproductive Characteristics

Complete this worksheet to answer Question 2.4.

Reaches reproductive maturity in 2 years or less	[✓ **Yes**]	**No**	**1 pt.**
Dense infestations produce >1,000 viable seed per square meter	**Yes**	**No**	**2 pt.**
Populations of this species produce seeds every year.	[✓ **Yes**]	**No**	**1 pt.**
Seed production sustained for 3 or more months within a population annually	[✓ **Yes**]	**No**	**1 pt.**
Seeds remain viable in soil for three or more years	[✓ **Yes**]	**No**	**2 pt.**
Viable seed produced with *both* self-pollination and cross-pollination	**Yes**	**No**	**1 pt.**
Has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes	**Yes**	[✓ **No**]	**1 pt.**
Fragments easily and fragments can become established elsewhere	**Yes**	[✓ **No**]	**2 pt.**
Resprouts readily when cut, grazed, or burned	[✓ **Yes**]	**No**	**1 pt.**

Total pts: 6 Total unknowns: 2

Score : A

Note any related traits: Seeds have fine hairs that become mucilaginous when wet. Germination tests have shown this species has a low germination percentage (below 20%).

Worksheet B. Arizona Ecological Types

(*sensu* Brown 1994 and Brown et al. 1998)

Major Ecological Types	Minor Ecological Types	Code*
Dunes	dunes	
Scrublands	Great Basin montane scrub	
	southwestern interior chaparral scrub	**D**
Desertlands	Great Basin desertscrub	
	Mohave desertscrub	
	Chihuahuan desertscrub	
	Sonoran desertscrub	**D**
Grasslands	alpine and subalpine grassland	
	plains and Great Basin shrub-grassland	
	semi-desert grassland	**D**
Freshwater Systems	lakes, ponds, reservoirs	
	rivers, streams	
Non-Riparian Wetlands	Sonoran wetlands	
	southwestern interior wetlands	
	montane wetlands	
	playas	
Riparian	Sonoran riparian	
	southwestern interior riparian	
	montane riparian	
Woodlands	Great Basin conifer woodland	
	Madrean evergreen woodland	
Forests	Rocky Mountain and Great Basin subalpine conifer forest	
	montane conifer forest	
Tundra (alpine)	tundra (alpine)	

*A means >50% of type occurrences are invaded; B means >20% to 50%; C means >5% to 20%; D means present but ≤5%; U means unknown (unable to estimate percentage of occurrences invaded).

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