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		Something you should know.
2.6	Potential for natural long-distance dispersal	**B**	Other published material		
2.7	Other regions invaded	**C**	Other published material		
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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