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)**:**	*Linaria vulgaris* P. Mill. (USDA 2005)
Synonyms:	*Linaria linaria* (L.) Karst. (USDA 2005)
Common names:	Yellow toadflax, butter and eggs, common toadflax, ramsted, flaxweed, wild snapdragon, Jacob's ladder
Evaluation date (mm/dd/yy)**:**	05/17/04
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Committee review date:	06/24/03 and 06/23/04
List date:	06/23/04
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:** **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:* **16 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	**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	**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:** **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: Yellow toadflax populations have the potential to alter fire characteristics depending on the ecosystem. Yellow toadflax is capable of both increasing and preventing soil erosion surface runoff and sediment yield depending on the site and vegetation type.
Rationale: Yellow toadflax may alter fire intensity or slightly modify an existing fire regime in ecosystems where it replaces plants with similar fuel characteristics. However, it has the potential to completely alter the fire regime if yellow toadflax offers unique characteristics to the invaded ecosystem (D'Antonio 2000). There are no specific examples of fire regimes altered by toadflax invasion described in the available literature, however, it is thought that yellow toadflax populations interrupt grassland/surface fire regimes as yellow toadflax was not widespread in these communities when historic fire regimes were functioning, but has established since habitat alteration and fire exclusion began. It is unclear how historic fire regimes might affect toadflax populations, and it is unclear how the presence of toadflax in native ecosystems might affect fire regimes. Dalmatian toadflax (*L. dalmatica*) occurs in ecosystems with historic fire regimes of varied frequency and severity; from frequent, low-severity fires in ponderosa pine ecosystems, to less frequent and more severe fires in bunchgrass and sagebrush ecosystems, to frequent and severe fires in plains and prairie grassland ecosystems (Zouhar 2003). Where sod-forming or bunchgrass communities are replaced by yellow toadflax, soil erosion, surface runoff, and sediment yield are likely to increase. Yet, yellow toadflax can actually help stabilize soil on steep, eroding banks and devegetated sites (Lajeunesse 1999).
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: Dense and established stands of yellow toadflax compete with native vegetation for resources and nutrients and can change the composition of a natural plant community.
Rationale: Yellow toadflax is a persistent, aggressive invader and capable of forming dense colonies through adventitious buds from creeping root systems. Yellow toadflax seedlings are considered ineffective competitors for soil moisture with established perennials and winter annuals, though mature plants are particularly competitive with winter annuals and shallow-rooted perennials (Morishita 1991). Colonies of mature, established yellow toadflax often outcompete native grasses and other perennials, and alter the species composition of natural communities. Mature yellow toadflax plants are considered strong competitors with an extensive root system. Taproots of a mature Dalmatian toadflax (*L. dalmatica*) plant may reach depths of 4 to 10 feet (1.3 to 3 m), and lateral roots can extend 12 feet (3.6 m) from the parent plant. Vegetative buds were found as deep as 6 feet (1.8 m) in coarse soil. However, most Dalmatian toadflax plants produced from vegetative buds occur on lateral roots that are found in the upper 2 to 12 inches (5 to 30 cm) of soil (Alex 1962, Robocker 1974). Mature yellow toadflax taproots may grow 3.3 feet (1 m) deep, and lateral roots can be several meters long. Once plants are established they can be capable of suppressing other vegetation mainly by intense competition for limited resources (Zouhar 2003).
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: Yellow toadflax can displace plant communities and associated animal life. This can result in a loss of forage in pastures and rangelands that can impact livestock and some big game species, especially on winter ranges.
Rationale: Although deer have been observed to graze Dalmatian toadflax (*L. dalmatica*), toadflax seed is used by some species of birds and rodents, and it can provide cover for small mammals, it is not

known to be heavily used by any native animal species (Lajeunesse 1999, Robocker 1974). A review by Saner and others (1995) points out that several secondary compounds present in yellow toadflax may explain why cattle avoid it. This review also indicates that cattle eat dried yellow toadflax, and that yellow toadflax is not generally poisonous to livestock, as it has been used as a medicinal plant for cattle that cannot ruminate. Occasional cases of mild poisoning from yellow toadflax have been reported for cattle, who sometimes browse flowering shoots, but such cases are rare because cattle usually avoid toadflax (Mitich 1993, Lajeunesse 1999).

Because cattle exhibit grazing preference and avoid toadflax, and by browsing on native plants and removing competition, this enables the yellow toadflax to establish readily. Heavy grazing creates more open areas with disturbance for toadflax to spread. Yellow toadflax is pollinated mostly by bumblebees and it is only of minor importance for honeybees (Saner et al. 1995).

Sources of information: See cited literature. Score also based on inference drawn from the literature as some of the information considered applied to *L. dalmatica*.

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

Identify impacts: According to Kearney and Peebles (1960), *Linaria texana* (Scheele), or Texas toadflax, is found in Graham, Gila, Maricopa, Pinal, Cochise and Pima counties from 1,500 to 5,000 feet. The current scientific name for this species is *Nuttallanthus texanus* (Scheele) D.A. Sutton (USDA 2005). It is unlikely that this could hybridize with *Linaria vulgaris* as they have completely different ranges and now have been separated into separate genera.

Rationale: No known hybridization.

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: Disturbance promotes toadflax invasion and may be necessary for establishment to occur. However once established, toadflaxes readily spread into adjacent non-disturbed areas. Much of this spread is by vegetative means, reflecting a vigorously-growing root system. Toadflax invasion is favored by disturbance and they invade degraded areas such as roadsides, abandoned lots and fields, gravel pits, clearings, and overgrazed rangeland. Toadflax invasion after fire may also be related to soil disturbances brought about by fire suppression activities.

Rationale: Toadflax evolved in areas where much of the land is cultivated and are adapted to the periodic disturbances of agriculture. In North America, they are most commonly found on disturbed sites such as roadsides, fencelines, areas near dwellings, vacant lots, cemeteries, gravel pits, croplands, clearcuts, pastures, waste areas, and other disturbed sites where removal of vegetation allows toadflax seedlings to establish. Similarly, typical yellow toadflax habitats in Europe include vineyards, woodland clearings, and clearcuts. In Europe, large populations of yellow toadflax were observed on fields where competing vegetation was depressed by grazing or fire, and on some sites (e.g. between trees in orchards or in train yards) that had been subject to regular application of broad-action herbicides (Saner et al. 1995, Carpenter and Murray 1998, Lajeunesse 1999).

Toadflax can also establish and spread in sparsely vegetated areas and sites with naturally-occurring disturbances, small openings, and/or little competition between species. Examples of such sites include dry, open areas in grassland and bunchgrass communities, sagebrush, open coniferous forests, sand dunes, riparian areas, and borders of woods (Lajeunesse 1999, Tyser and Worley 1992).

Sources of information: See cited literature.

Question 2.2 Local rate of spread with no management *Score:* **A** *Doc'n Level:* **Other pub.**
Describe rate of spread: Vegetative propagation can allow a stand of toadflax to spread rapidly. In one study, a stand of *L. vulgaris* increased by 418% in a single season, and a patch that was originally one acre in size expanded to cover 85 acres in a five-year period.
Rationale: Increases rapidly, populations doubling in less than 10 years. For five of the yellow toadflax sites reported in the Southwest Exotic Plant Mapping Program (SWEMP; 2004) for 2003 in Arizona (including the ones near Lake Mary), three sites had doubled in size since the original reports, one was ~25% bigger, and the other ~40-50% bigger. All five sites also were infested with *L. damatica*.
Sources of information: Carpenter and Murray (1998). Also considered information from the 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 online on February 10, 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 in total area infested in <years.
Rationale: Lake Mary population in Coconino National Forest may be near the edge of *L. vulgaris*'s southern range in Arizona, but it still has the capability to invade areas south and east along the Mogollon Rim and in the White Mountains.
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:* **Rev. sci.pub.**
Describe key reproductive characteristics: Yellow toadflax is a deep-rooted, short-lived, herbaceous perennial that reproduces by seed, and can form colonies by means of adventitious buds on roots.
Rationale: Average number of seeds produced per yellow toadflax stem may range from 165 to 5,584. Nadeau and King (1991) found that seed production of 210,000 seeds per m^2 within a 0.5 m radius around yellow toadflax parent plants. Many seed studies fail to differentiate between viable and nonviable seeds. Seeds remain viable in the soil for 10 years. Yellow toadflax plants typically produce 90 to 100 secondary shoots from the root system in the 1st year and 200 to 250 shoots by the 2nd year. Nadeau and King (1991) found 40 to 51% average seed viability (by tetrazolium chloride test) in yellow toadflax seed collected throughout the season in Alberta). Clements and Cavers (1990) observed seasonal differences in number of viable seeds produced by yellow toadflax and attributed these differences to differential seed development in response to variable resource availability. Capsules formed later in the growing season tend to produce more viable seed. Some populations of yellow toadflax may never produce more than 25% viable seed (Cements and Cavers 1990). However, vegetative reproduction in yellow toadflax is more important than seedling establishment for maintaining populations. Yellow toadflax plants typically produce 90 to 100 secondary shoots from the root system in the 1st year and 200 to 250 shoots by the 2nd year (Zouhar 2003).
Sources of information: See cited literature.

Question 2.5 Potential for human-caused dispersal *Score: A* *Doc'n Level:* **Other pub.**
Identify dispersal mechanisms: There are numerous opportunities for dispersal to new areas. Yellow toadflax is spread via fire suppression and thinning activities and trail construction. Yellow toadflax continues to be sold in nurseries and seed catalogs. For example, one publication lists "*Linaria vulgaris* (common toadflax or butter-and-eggs)" as a plant that is well suited for xeriscaping (Gutknecht 1989). The spread of toadflax was facilitated by its use as an ornamental, medicinal, magical, and dye plant,

although accidental introduction and distribution along roads and railway corridors, or in crop seed, baled hay, ship ballast, and clothing likely increased its spread.
Rationale: Seed dispersal via farm equipment is likely an important mode of dispersal in agricultural areas. Cutting equipment in forest thinning projects can transport yellow toadflax populations via root fragments. It is planted as an ornamental. Because of its propensity to establish in dry, open areas with little plant competition, toadflax has high potential for establishing after fire (when competition from other vegetation is removed or reduced) either by seed imported to the site by fire suppression equipment or by soil-stored seed. Disturbance associated with trail construction has also created new infestations of yellow toadflax.
Sources of information: See cited literature; also see Carpenter and Murray (1998) and Zouhar (2003). Also considered the observations of Working Group members.

Question 2.6 Potential for natural long-distance dispersal *Score:* **C** *Doc'n Level:* **Other pub.**
Identify dispersal mechanisms: A review by Saner and others (1995) suggests yellow toadflax seeds may also be dispersed by water, ants, birds, and rodents. Vegetative structures in a riparian system can easily result in transplant populations established downstream; however, dispersal of more than 1 km via natural events is rare.
Rationale: Although the seeds are winged, and wind has not been considered a major means of seed dispersal for toadflax species (Robocker 1970, Allen and Hansen 1999).Nadeau and King (1991) observed that over 80% of yellow toadflax seeds fell within an 18-inch (50 cm) radius of the parent plant, and "very few" seeds fell more than 5 feet (1.5 m) from the parent plant. Toadflax is also capable of establishing either from on-site seed, or seed dispersed into a burned area. Seed may be dispersed by animals into recently burned areas where it is adapted to establish under conditions of reduced competition (Zouhar 2003).
Sources of information: See cited literature.

Question 2.7 Other regions invaded *Score:* **B** *Doc'n Level:* **Other pub.**
Identify other regions: Yellow toadflax is native to the steppes of southeastern Europe and southwestern Asia. The present world distribution includes most of Europe and Asia, and it has been introduced to Japan, Australia, New Zealand, South Africa, Jamaica, Chile and North America. In North America yellow toadflax is found throughout the continental United States and in every Canadian province and territory (Saner et al. 1995). The worst-infested western states are Idaho, Montana, Oregon, and Washington. *Linaria vulgaris* is listed as a noxious weed in Arizona and New Mexico. Both species have been cultivated as ornamentals for centuries and are widely distributed throughout the world. Yellow toadflax is most common in northeastern North America and is localized in other parts of the continent, particularly the western Canadian provinces (Lajeunesse 1999, Zouhar 2003). The northern limits of yellow toadflax's North American range are approximately 55° N to 65° N. In Utah yellow toadflax is found from 1270 to 3050 m in the central counties (Welsh et al. 2003). In Colorado yellow toadflax is found at elevations from 5,000 feet to over 10,000 feet. Yellow toadflax in particular has spread into high mountain valleys, river banks and parks. In Rocky Mountain National Park yellow toadflax is found at Upper Hollowell Park and is common around the Beaver Point, utility area and especially around old homesites. There are several widespread and dense populations in the park totaling an area of 11 to 50 hectares, including high quality areas with no known disturbance for last 100 years (Rutledge and McLendon 1996). Yellow toadflax infests over 40,800 acres in Colorado, with heaviest concentrations in Grand, Eagle, Pitkin, Garfield and Rio Blanco counties, also occurring in Gunnison, San Miguel, La Plata and Montezuma counties and often occurs in riparian areas in Colorado.

It is found, for example, on gravel bars in the south fork of the San Miguel River that are flanked by riparian forests of cottonwood (*Populus* spp.) and spruce (*Picea* spp.). In New Mexico yellow toadflax is found from 6000 to 7500 feet in northern counties of Rio Arriba and Sandoval (Martin and Hutchins 1981).
Rationale: In Arizona yellow toadflax is not known to occur in montane riparian or rocky mountain subalpine ecotypes.
Sources of information: See cited literature. Also considered information from the Colorado State University Cooperative Extension, Quadmapping project (available online at: http://www.ext.colostate.edu/pubs/natres/03114.html; accessed online on May 17, 2004) and the Atlas of the Vascular Plants of Utah (available online at: http://www.gis.usu.edu/Geography-Department/utgeog/utvatlas/ut-vascatlas.html; accessed February 10, 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: Yellow toadflax was introduced to New England in the late 1600s as an ornamental. The first collection of yellow toadflax in Arizona was by Thornber in 1930 from Coconino County (SEINet 2004). Toadflax is most commonly found in cultivated fields, roadsides, railways, "waste areas," clearcuts, overgrazed pastures and rangeland, and in plant communities that are typically open or disturbed. Neither *L. dalmatica* nor *L. vulgaris* occurs as frequently in intact wildlands and natural areas (Lajeunesse 1999). In central Europe, yellow toadflax prefers dry to moderately humid sandy loam soils that are moderate to rich in nutrients and minerals. Yellow toadflax may exhibit heavy metal tolerance. Yellow toadflax is more commonly associated with relatively summer-moist, coarse soils in the northwestern and north-central U.S. Yellow toadflax may grow well in moist areas of high fertility, but is more likely to be displaced by other species than on drier, less fertile sites. Yellow toadflax plants growing on dry sites are stunted but tend to be comparatively more persistent (Saner et al. 1995).
Rationale: Arizona populations of this species are confirmed from herbarium specimens in Ponderosa pine ecotype at Lake Mary in Coconino county. Earlier collections from 1938 and 1950 are from waste areas from Country Club in Coconino county. Distribution information is further complicated by the difficulty in distinguishing this species from *L. dalmatica*.
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 10, 2004).

Question 3.2 Distribution *Score:* **D** *Doc'n Level:* **Obs.**
Describe distribution: Arizona records are from Coconino County at Lake Mary Road.
Rationale: Limited observations in wildlands.
Sources of information: Kearney and Peebles (1960). Also considered information 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: 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	
	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	**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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