NEW YORK
NON-NATIVE PLANT INVASIVENESS RANKING FORM

Scientific name:	Euphorbia esula	USDA Plants Code: EUES
Common names:	Leafy Spurge	
Native distribution:	Eurasia	
Date assessed:	March 10, 2009	
Assessors:	Steve Glenn, Gerry Moore	
Reviewers:	LIISMA SRC	
Date Approved:	1 April 2009	Form version date: 3 March 2009

New York Invasiveness Rank: High (Relative Maximum Score 70.00-80.00)

Distribution and Invasiveness Rank (*Obtain from PRISM invasiveness ranking form*)			
	Status of this species in each PRISM:	Current Distribution	PRISM Invasiveness Rank
1	Adirondack Park Invasive Program	Not Assessed	Not Assessed
2	Capital/Mohawk	Not Assessed	Not Assessed
3	Catskill Regional Invasive Species Partnership	Not Assessed	Not Assessed
4	Finger Lakes	Not Assessed	Not Assessed
5	Long Island Invasive Species Management Area	Restricted	Moderate
6	Lower Hudson	Not Assessed	Not Assessed
7	Saint Lawrence/Eastern Lake Ontario	Not Assessed	Not Assessed
8	Western New York	Not Assessed	Not Assessed

Invasiveness Ranking Summary (see details under appropriate sub-section)		Total (Total Answered*) Possible	Total
1	Ecological impact	40 (30)	17
2	Biological characteristic and dispersal ability	25 (22)	19
3	Ecological amplitude and distribution	25 (21)	19
4	Difficulty of control	10 (10)	8
	Outcome score	100 (83)[b]	63[a]
	Relative maximum score †		75.90
	New York Invasiveness Rank §	High (Relative Maximum Score 70.00-80.00)	

* For questions answered "unknown" do not include point value in "Total Answered Points Possible." If "Total Answered Points Possible" is less than 70.00 points, then the overall invasive rank should be listed as "Unknown."
†Calculated as 100(a/b) to two decimal places.
§Very High >80.00; High 70.00−80.00; Moderate 50.00−69.99; Low 40.00−49.99; Insignificant <40.00

A. DISTRIBUTION (KNOWN/POTENTIAL): Summarized from individual PRISM forms

A1.1. Has this species been documented to persist without cultivation in NY? (reliable source; voucher not required)	
☒	Yes – continue to A1.2
☐	No – continue to A2.1
A1.2. In which PRISMs is it known (see inset map)?	
☒	Adirondack Park Invasive Program
☒	Capital/Mohawk
☒	Catskill Regional Invasive Species Partnership
☒	Finger Lakes
☒	Long Island Invasive Species Management Area
☒	Lower Hudson
☒	Saint Lawrence/Eastern Lake Ontario
☒	Western New York

Documentation:
Sources of information:
Brooklyn Botanic Garden, 2009; Weldy & Werier, 2009.

A2.1. What is the likelihood that this species will occur and persist outside of cultivation, given the climate in the following PRISMs? (obtain from PRISM invasiveness ranking form)

Not Assessed	Adirondack Park Invasive Program
Not Assessed	Capital/Mohawk
Not Assessed	Catskill Regional Invasive Species Partnership
Not Assessed	Finger Lakes
Moderately Likely	Long Island Invasive Species Management Area
Not Assessed	Lower Hudson
Not Assessed	Saint Lawrence/Eastern Lake Ontario
Not Assessed	Western New York

Documentation:
Sources of information (e.g.: distribution models, literature, expert opinions):
While not yet established on Long Island or Staten Island; well established in Orange Co., NY. Also documented from Westchester and Putnam Cos., NY; and a few sites in northern New Jersey.
Brooklyn Botanic Garden, 2009.

If the species does not occur and is not likely to occur with any of the PRISMs, then stop here as there is no need to assess the species.

A2.2. What is the current distribution of the species in each PRISM? (obtain rank *from PRISM invasiveness ranking forms*)

	Distribution
Adirondack Park Invasive Program	Not Assessed
Capital/Mohawk	Not Assessed
Catskill Regional Invasive Species Partnership	Not Assessed
Finger Lakes	Not Assessed
Long Island Invasive Species Management Area	Restricted
Lower Hudson	Not Assessed
Saint Lawrence/Eastern Lake Ontario	Not Assessed
Western New York	Not Assessed

Documentation:
Sources of information:
Brooklyn Botanic Garden, 2009.

A2.3. Describe the potential or known suitable habitats within New York. Natural habitats include all habitats not under active human management. Managed habitats are indicated with an asterisk.

Aquatic Habitats	Wetland Habitats	Upland Habitats
☐ Salt/brackish waters	☐ Salt/brackish marshes	☐ Cultivated*
☐ Freshwater tidal	☐ Freshwater marshes	☒ Grasslands/old fields
☐ Rivers/streams	☐ Peatlands	☒ Shrublands
☐ Natural lakes and ponds	☐ Shrub swamps	☒ Forests/woodlands
☐ Vernal pools	☒ Forested wetlands/riparian	☐ Alpine
☐ Reservoirs/impoundments*	☐ Ditches*	☒ Roadsides*
	☐ Beaches and/or coastal dunes	

Other potential or known suitable habitats within New York:
Railroad, gravel pit.

Documentation:
Sources of information:
Biesboer and Eckardt 1996; Fellows, 2004; Brooklyn Botanic Garden, 2009.

B. INVASIVENESS RANKING

Questions apply to areas similar in climate and habitats to New York unless specified otherwise.

1. ECOLOGICAL IMPACT

1.1. Impact on Natural Ecosystem Processes and System-Wide Parameters (e.g. fire regime, geomorphological changes (erosion, sedimentation rates), hydrologic regime, nutrient and mineral dynamics, light availability, salinity, pH)

A.	No perceivable impact on ecosystem processes based on research studies, or the absence of impact information if a species is widespread (>10 occurrences in minimally managed areas), has been well-studied (>10 reports/publications), and has been present in the northeast for >100 years.	0
B.	Influences ecosystem processes to a minor degree (e.g., has a perceivable but mild influence on soil nutrient availability)	3
C.	Significant alteration of ecosystem processes (e.g., increases sedimentation rates along streams or coastlines, reduces open water that are important to waterfowl)	7
D.	Major, possibly irreversible, alteration or disruption of ecosystem processes (e.g., the species alters geomorphology and/or hydrology, affects fire frequency, alters soil pH, or fixes substantial levels of nitrogen in the soil making soil unlikely to support certain native plants or more likely to favor non-native species)	10
U.	Unknown	

Score: 3

Documentation:
Identify ecosystem processes impacted (or if applicable, justify choosing answer A in the absence of impact information)
Can reduce soil moisture and nutrients. Various compounds in latex presumable impacts soil chemistry but specific studies not known.
Sources of information:
Rizk, 1987; Biesboer & Eckardt, 1996; Fellows, 2004.

1.2. Impact on Natural Community Structure

A.	No perceived impact; establishes in an existing layer without influencing its structure	0
B.	Influences structure in one layer (e.g., changes the density of one layer)	3
C.	Significant impact in at least one layer (e.g., creation of a new layer or elimination of an existing layer)	7
D.	Major alteration of structure (e.g., covers canopy, eradicating most or all layers below)	10
U.	Unknown	

Score: 7

Documentation:
Identify type of impact or alteration:
Can overtake large areas of open land producing stands with up to 2000 shoots per sq. meter; forb and grass layer in natural areas may be completely displaced by leafy spurge in a few years .
Sources of information:
Biesboer & Eckardt, 1996.

1.3. Impact on Natural Community Composition

A.	No perceived impact; causes no apparent change in native populations	0
B.	Influences community composition (e.g., reduces the number of individuals in one or more native species in the community)	3
C.	Significantly alters community composition (e.g., produces a significant reduction in the	7

population size of one or more native species in the community)

D. Causes major alteration in community composition (e.g., results in the extirpation of one or several native species, reducing biodiversity or change the community composition towards species exotic to the natural community) 10

U. Unknown

Score 7

Documentation:
Identify type of impact or alteration:
Displaces native vegetation.
Sources of information:
Biesboer & Eckardt, 1996.

1.4. Impact on other species or species groups (cumulative impact of this species on the animals, fungi, microbes, and other organisms in the community it invades. Examples include reduction in nesting/foraging sites; reduction in habitat connectivity; injurious components such as spines, thorns, burrs, toxins; suppresses soil/sediment microflora; interferes with native pollinators and/or pollination of a native species; hybridizes with a native species; hosts a non-native disease which impacts a native species)

A. Negligible perceived impact 0
B. Minor impact 3
C. Moderate impact 7
D. Severe impact on other species or species groups 10
U. Unknown

Score U

Documentation:
Identify type of impact or alteration:
One study found late -season herbivory by migratory grasshopper (Melanoplus sanguinipes) nymphs resulted in reduced nymphal weights. The chemicals present in the latex presumably impact soil microflora, but speciifc studies not known.
Sources of information:
Rizk, 1987; Roberts & Olson, 1999.

Total Possible 30
Section One Total 17

2. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY

2.1. Mode and rate of reproduction (provisional thresholds, more investigation needed)

A. No reproduction by seeds or vegetative propagules (i.e. plant sterile with no sexual or asexual reproduction). 0

B. Limited reproduction (fewer than 10 viable seeds per plant AND no vegetative reproduction; if viability is not known, then maximum seed production is less than 100 seeds per plant and no vegetative reproduction) 1

C. Moderate reproduction (fewer than 100 viable seeds per plant - if viability is not known, then maximum seed production is less than 1000 seeds per plant - OR limited successful vegetative spread documented) 2

D. Abundant reproduction with vegetative asexual spread documented as one of the plants prime reproductive means OR more than 100 viable seeds per plant (if viability is not known, then maximum seed production reported to be greater than 1000 seeds per plant.) 4

U. Unknown

Score 4

Documentation:

Describe key reproductive characteristics (including seeds per plant):
The number of seeds produced per stalk can range as high as 250-200.Vegetative reproduction also occurs from both crown buds and root buds that overwinter and produce new shoots in the spring.
Sources of information:
Biesboer &Eckardt, 1996.

2.2. Innate potential for long-distance dispersal (e.g. bird dispersal, sticks to animal hair, buoyant fruits, pappus for wind-dispersal)

A.	Does not occur (no long-distance dispersal mechanisms)	0
B.	Infrequent or inefficient long-distance dispersal (occurs occasionally despite lack of adaptations)	1
C.	Moderate opportunities for long-distance dispersal (adaptations exist for long-distance dispersal, but studies report that 95% of seeds land within 100 meters of the parent plant)	2
D.	Numerous opportunities for long-distance dispersal (adaptations exist for long-distance dispersal and evidence that many seeds disperse greater than 100 meters from the parent plant)	4
U.	Unknown	

Score 4

Documentation:
Identify dispersal mechanisms:
Endozoochory: sharp-tailed grouse and deer have been documented to disperse viable seed. One study found mourning doves (Zenaida macroura), may rarely act as dispersal agents.
Hydrochory: the seeds can float and initial infestations often occur along stream or river banks where seeds have floated into appropriate habitat .
Myrmecochory: Elaiosomes (appendages) on seeds may lead to ant dispersal, there have been reports of some ant species foraging further than 100 meters from the nest (Steck et al., 2009).
Sources of information:
Blockstein et al., 1987; Pemberton & Irving, 1990; Biesboer & Eckardt, 1996; Wald et al., 2005; Steck et al., 2009.

2.3. Potential to be spread by human activities (both directly and indirectly – possible mechanisms include: commercial sales, use as forage/revegetation, spread along highways, transport on boats, contaminated compost, land and vegetation management equipment such as mowers and excavators, etc.)

A.	Does not occur	0
B.	Low (human dispersal to new areas occurs almost exclusively by direct means and is infrequent or inefficient)	1
C.	Moderate (human dispersal to new areas occurs by direct and indirect means to a moderate extent)	2
D.	High (opportunities for human dispersal to new areas by direct and indirect means are numerous, frequent, and successful)	3
U.	Unknown	

Score 2

Documentation:
Identify dispersal mechanisms:
No sources located dealing with human transportation; possibly disseminated via land management equipment. Can be spread through mowing contaminated hay.
Sources of information:
SRC pers. comm.

2.4. Characteristics that increase competitive advantage, such as shade tolerance, ability to grow on infertile soils, perennial habit, fast growth, nitrogen fixation, allelopathy, etc.

A. Possesses no characteristics that increase competitive advantage — 0
B. Possesses one characteristic that increases competitive advantage — 3
C. Possesses two or more characteristics that increase competitive advantage — 6
U. Unknown

Score: 6

Documentation:
Evidence of competitive ability:
Perennial, ability to grow on infertile soils, allelopathy. Perennial with a self-compatible reproductive system, and may be a pseudogamous apomict (Selbo & Carmichael, 1999). Seedlings have a vigorous primary root system (Raju et al., 1963); and produce an extensive root system containing abundant organic reserves (Cyr & Bewley, 1989). Tolerant of a wide range of habitats and may occur in damp or dry soils. One study found leafy spurge exhibits allelopathic characteristics (Steenhagen & Zomdahl, 1979). A high degree of genetic variability was found among North American leafy spurge populations (Rowe et al., 1997; Lym & Carlson, 2002), which may enhance ecological amplitude. Most herbivores in North America avoid leafy spurge, possibly because it contains high concentrations of terpenoids and condensed tannins (Roberts & Olson, 1999).
Sources of information:
Raju et al., 1963; Steenhagen & Zomdahl, 1979; Cyr & Bewley, 1989; Biesboer & Eckardt, 1996; Roberts & Olson, 1999; Selbo & Carmichael, 1999; Rowe et al., 1997;Lym & Carlson, 2002 .

2.5. Growth vigor

A. Does not form thickets or have a climbing or smothering growth habit — 0
B. Has climbing or smothering growth habit, forms a dense layer above shorter vegetation, forms dense thickets, or forms a dense floating mat in aquatic systems where it smothers other vegetation or organisms — 2
U. Unknown

Score: 0

Documentation:
Describe growth form:
Reported to produce stands with up to 2000 shoots per sq. meter. Not known to form thickets or smothering habit.
Sources of information:
Biesboer &Eckardt, 1996.

2.6. Germination/Regeneration

A. Requires open soil or water and disturbance for seed germination, or regeneration from vegetative propagules. — 0
B. Can germinate/regenerate in vegetated areas but in a narrow range or in special conditions — 2
C. Can germinate/regenerate in existing vegetation in a wide range of conditions — 3
U. Unknown (No studies have been completed)

Score: U

Documentation:
Describe germination requirements:
In one study germination rates as high as 87% were obtained under experimental conditions; the issue of disturbance was not addressed.
Sources of information:
Foley, 2008.

2.7. Other species in the genus invasive in New York or elsewhere

A. No — 0
B. Yes — 3
U. Unknown

Score: 3

Documentation:
Species:
Euphorbia cyparissius USDA, 2009; Weldy & Werier, 2009.

Total Possible: 19
Section Two Total: 22

3. ECOLOGICAL AMPLITUDE AND DISTRIBUTION

3.1. Density of stands in natural areas in the northeastern USA and eastern Canada (use same definition as Gleason & Cronquist which is: "The part of the United States covered extends from the Atlantic Ocean west to the western boundaries of Minnesota, Iowa, northern Missouri, and southern Illinois, south to the southern boundaries of Virginia, Kentucky, and Illinois, and south to the Missouri River in Missouri. In Canada the area covered includes Nova Scotia, Prince Edward Island, New Brunswick, and parts of Quebec and Ontario lying south of the 47th parallel of latitude")

A.	No large stands (no areas greater than 1/4 acre or 1000 square meters)	0
B.	Large dense stands present in areas with numerous invasive species already present or disturbed landscapes	2
C.	Large dense stands present in areas with few other invasive species present (i.e. ability to invade relatively pristine natural areas)	4
U.	Unknown	

Score: U

Documentation:
Identify reason for selection, or evidence of weedy history:
All large stands reported from upper Great Plains region; stand size not well documented from the Northeast.
Sources of information:
Fellows, 2004; authors' pers. obs.

3.2. Number of habitats the species may invade

A.	Not known to invade any natural habitats given at A2.3	0
B.	Known to occur in two or more of the habitats given at A2.3, with at least one a natural habitat.	1
C.	Known to occur in three or more of the habitats given at A2.3, with at least two a natural habitat.	2
D.	Known to occur in four or more of the habitats given at A2.3, with at least three a natural habitat.	4
E.	Known to occur in more than four of the habitats given at A2.3, with at least four a natural habitat.	6
U.	Unknown	

Score: 6

Documentation:
Identify type of habitats where it occurs and degree/type of impacts:
See A2.3.
Sources of information:
Biesboer and Eckardt 1996; Fellows, 2004; Brooklyn Botanic Garden, 2009

3.3. Role of disturbance in establishment

A.	Requires anthropogenic disturbances to establish.	0
B.	May occasionally establish in undisturbed areas but can readily establish in areas with natural or anthropogenic disturbances.	2

C. Can establish independent of any known natural or anthropogenic disturbances. 4
U. Unknown

Score 2

Documentation:
Identify type of disturbance:
Reported to invade disturbed and undisturbed sites, but usually is found in disturbed areas.
Sources of information:
Biesboer and Eckardt 1996; Fellows, 2004.

3.4. Climate in native range

A. Native range does not include climates similar to New York 0
B. Native range possibly includes climates similar to at least part of New York. 1
C. Native range includes climates similar to those in New York 3
U. Unknown

Score 3

Documentation:
Describe what part of the native range is similar in climate to New York:
Northern China, Korea, Mongolia, Kazakhstan.
Sources of information:
Zhengyi & Raven, 2008.

3.5. Current introduced distribution in the northeastern USA and eastern Canada (see question 3.1 for definition of geographic scope)

A. Not known from the northeastern US and adjacent Canada 0
B. Present as a non-native in one northeastern USA state and/or eastern Canadian province. 1
C. Present as a non-native in 2 or 3 northeastern USA states and/or eastern Canadian provinces. 2
D. Present as a non-native in 4–8 northeastern USA states and/or eastern Canadian provinces, and/or categorized as a problem weed (e.g., "Noxious" or "Invasive") in 1 northeastern state or eastern Canadian province. 3
E. Present as a non-native in >8 northeastern USA states and/or eastern Canadian provinces. and/or categorized as a problem weed (e.g., "Noxious" or "Invasive") in 2 northeastern states or eastern Canadian provinces. 4
U. Unknown

Score 4

Documentation:
Identify states and provinces invaded:
CT, DE, IA, IL, IN, MA, MD, ME, MI, MN, NH, NJ, NY, OH, PA, VA, VT, WI, WV; NB, NS, ON, PE, QC, Canada.

There is considerable disagreement whether the section Esula complex is a single variable species or a complex of species, including E. cyparissias. In addition, hybridization is documented between E. cyparissias and E. esula s. str. (E. x pseudoesula) (Schulz-Schaeffer & Gerhardt, 1987; Crompton et al., 1990). Furthermore, some taxonomists have recently subsumed E. cyparissias into E. esula (Zhengyi & Raven, 2008). The success of control programs, especially biocontrol, may be dependent on correct interpretation of spurge taxonomy.
Sources of information: See known introduced range in plants.usda.gov, and update with information from states and Canadian provinces.
U.S.D.A., 2009.

3.6. Current introduced distribution of the species in natural areas in the eight New York State PRISMs (Partnerships for Regional Invasive Species Management)

A. Present in none of the PRISMs — 0
B. Present in 1 PRISM — 1
C. Present in 2 PRISMs — 2
D. Present in 3 PRISMs — 3
E. Present in more than 3 PRISMs or on the Federal noxious weed lists — 4
U. Unknown

Score: 4

Documentation:
Describe distribution:
Documented from all PRISMs.
Sources of information:
Brooklyn Botanic Garden, 2009; Weldy & Werier, 2009.

Total Possible: 21
Section Three Total: 19

4. DIFFICULTY OF CONTROL

4.1. Seed banks

A. Seeds (or vegetative propagules) remain viable in soil for less than 1 year, or does not make viable seeds or persistent propagules. — 0
B. Seeds (or vegetative propagules) remain viable in soil for at least 1 to 10 years — 2
C. Seeds (or vegetative propagules) remain viable in soil for more than 10 years — 3
U. Unknown

Score: 2

Documentation:
Identify longevity of seed bank:
One study reported that seeds can remain viable in the soil for up to 8 years; but 99% of the germination occurs within the first two years. No evidence for viability over ten years.
Sources of information:
Biesboer & Eckardt 1996; Foley, 2004.

4.2. Vegetative regeneration

A. No regrowth following removal of aboveground growth — 0
B. Regrowth from ground-level meristems — 1
C. Regrowth from extensive underground system — 2
D. Any plant part is a viable propagule — 3
U. Unknown

Score: 2

Documentation:
Describe vegetative response:
Leafy spurge forms an extensive root system containing abundant organic reserves.
Sources of information:
Cyr & Bewley, 1989.

4.3. Level of effort required

A. Management is not required: e.g., species does not persist without repeated anthropogenic disturbance. — 0
B. Management is relatively easy and inexpensive: e.g. 10 or fewer person-hours of manual effort (pulling, cutting and/or digging) can eradicate a 1 acre infestation in 1 year (infestation averages 50% cover or 1 plant/100 ft^2). — 2

C. Management requires a major short-term investment: e.g. 100 or fewer person-hours/year of manual effort, or up to 10 person-hours/year using mechanical equipment (chain saws, mowers, etc.) for 2-5 years to suppress a 1 acre infestation. Eradication is difficult, but possible (infestation as above). 3

D. Management requires a major investment: e.g. more than 100 person-hours/year of manual effort, or more than 10 person hours/year using mechanical equipment, or the use of herbicide, grazing animals, fire, etc. for more than 5 years to suppress a 1 acre infestation. Eradication may be impossible (infestation as above). 4

U. Unknown

Score 4

Documentation:

Identify types of control methods and time-term required:
There is considerable disagreement whether leafy spurge is a single variable species or a complex of species; the success of control programs, especially biocontrol, may be dependent on correct interpretation of spurge taxonomy (Crompton et al., 1990).

Chemical Control:
Chemical control, except for continuous tillage or grazing in agricultural situations, is the best method for elimination of leafy spurge. Many herbicides have been used to control leafy spurge with varying degrees of success. These include picloram, 2,4-D, dicamba, glyphosate, and others; picloram may be the most effective in controlling spurge. Two other chemicals that show promise in spurge control and which may be available in the future are flouroxypyr and sulfomenturon.

Mechanical:
Repeated mowing or hand cutting may also be used to control seed production, but must be used in conjunction with herbicides for adequate control of stand expansion.
One study found a 2day rotational high-density sheep grazing strategy may provide greater long-term effectiveness in controlling leafy spurge infestations (Taylor et al., 2005); but observations elsewhere concluded that once the sheep were removed ,the spurge would quickly return.

BioControl:
Research is ongoing at a number of locations on at least 15 insects as possible biocontrol agents for spurge in the United States including six species of flea beetles, Aphthona spp. (Coleoptera: Chrysomelidae), a root-boring moth, Chamaesphecia hungarica (Lepidoptera: Sesiidae), a root-boring beetle, Oberea erythrocephala (Coleoptera: Cerambycidae), and a gall midge, Spurgia esulae (Diptera: Cecidomyiidae) (Hansen et al., 1997).

The black flea beetles (Aphthona lacertosa and A. czwalinae) in particular have been shown to cause reductions in leafy spurge stem counts in the northern Great Plains, while the brown flea beetle (A. nigriscutis) has persisted and spread, but has not been found to be as effective at controlling leafy spurge. Some dgree of control was reported by Mico & Shay, 2002. Other studies have found that the ability of black flea beetles to control leafy spurge in any given year, however, has been variable (Larson et al., 2008). One possible reason for the observed variation in the efficacy of Aphthona spp. may be attributed to multiple genotypes of leafy spurge (Rowe et al., 1997; Lym & Carlson, 2002).

The feasibility of using the spurge hawkmoth (H. euphorbiae L., Lepidoptera: Sphingidae) as a biological control agent on leafy spurge has had mixed results (Forwood & McCarty, 1980; Batra, 1983).

Spurgia capitigena (Bremi) (Dipt., Cecidomyiidae), has been undergoing evaluation for the biological control of Euphorbia esula L. in North America (Sobhian et al., 2000).

The beetle Thamnurgus eaphorbiae Kuster, is currently undergoing evaluation as another potential bio-control of leafy spurge (Campobasso et al., 2004).

Some of the more promising agents for control of spurge are: stem and root borers, such as the cerambycid Oberea erythrocephala, and the clear-winged moth Chamaesphecia tenthrediniformis; the gall midge Bayeria capitigena, which prevents flowering of spurge; and the rust fungus Uromyces scutellatus, which devastates shoots by causing systemic infections.

Skinner et al., 2006, concluded that phenology models should be developed regionally to provide useful predictions of peak emergence of these biocontrol spp.

Fire:
Fire would not be likely to provide adequate control of spurge if used alone because its effect would be on top growth and seeds, and established plants would quickly resprout.

Integrated:
A study in Idaho found the combination of 1 or 2 years of sheep grazing and imazapic did not enhance the control of E. esula. However, 2 years of carefully timed sheep grazing followed with an imazapic application resulted in sustained productivity of plant biomass in the pasture. Because 2 years of sheep grazing prevented an increase in the E. esula seed bank, managers may have a better opportunity to establish desired vegetation in sagebrush steppe ecosystems after removing E. esula with imazapic (Seefeldt et al., 2007).

Effects of herbicides on leafy spurge abundance and on dynamics of flea beetles (Aphthona spp.) used to control leafy spurge were evaluated over three field seasons following herbicide application in North Dakota. Flea beetles were less abundant on plots with a history of herbicide treatment. These results suggest that the most effective component of IPM for leafy spurge at this site is biological control. All herbicide effects we observed were short-lived, but the increased negative correlation between flea beetle relative abundances implies that herbicide application may have temporarily disrupted an effective biological control program at this site (Larson et al., 2007).

Nelson & Lym, 2004 and Lym, 2005, found incorporation of Aphthona spp. with herbicides has resulted in more rapid and complete leafy spurge control than either method used alone. Also, the insect population often increased rapidly following herbicide treatment, especially in areas where Aphthona spp. were established for several years but had been ineffective. Incorporation of Aphthona spp. with sheep or goat grazing has resulted in a larger decline in leafy spurge production than insects alone and in weed density than grazing alone. Controlled burns can aid establishment of biological control agents in marginally suitable environments, but timing of the fire must be coordinated to the insect's life-cycle to ensure survival. Integration of biological control agents with revegetation programs required the agent to be the last method introduced because the cultivation and herbicide treatments necessary to establish desirable grasses and forbs were destructive to the insect. In a practical application, herbicides were combined with Aphthona spp. to help the insect establish and control leafy spurge. Several experimental designs can be used to evaluate biological control agents with cultural, mechanical, and chemical control methods or with additional biological agents.

Combinations of the biological control agent, Aphthona beetles, the herbicide imazapic (105 g/ha), and interseeded native grass species were evaluated for leafy spurge management. Leafy spurge stem control was successfully maintained for 3 yr by Aphthona and grass competition without repetition of the imazapic treatment; however, in the fourth yr, a failure of biological control agents to establish resulted in the resurgence of leafy spurge (Joshi, 2008).

There have also been some reports indicating that fire used in conjunction with herbicides gives better control than herbicide application alone.

The use of remote sensing for detecting and mapping leafy spurge infestations in certain circumstances has been demonstrated (Everitt, et al. 1995; Casady et al., 2005).

Monitoring and repeat control measures are generally considered necessary for at least ten years following initiation of active management.

Sources of information:
Forwood & McCarty, 1980; Batra, 1983; Crompton et al., 1990; Everitt, et al. 1995; Biesboer & Eckardt, 1996; Hansen et al., 1997; Rowe et al., 1997; Sobhian et al., 2000; Lym & Carlson, 2002; Mico & Shay, 2002; Campobasso et al., 2004; Nelson & Lym, 2004; Lym, 2005; Taylor et al., 2005; Skinner et al., 2006; Seefeldt et al., 2007; Larson et al., 2007; Joshi, 2008; Larson et al., 2008;

Total Possible	10
Section Four Total	8

Total for 4 sections Possible	83
Total for 4 sections	63

C. STATUS OF CULTIVARS AND HYBRIDS:

At the present time (May 2008) there is no protocol or criteria for assessing the invasiveness of cultivars independent of the species to which they belong. Such a protocol is needed, and individuals with the appropriate expertise should address this issue in the future. Such a protocol will likely require data on cultivar fertility and identification in both experimental and natural settings.

Hybrids (crosses between different parent species) should be assessed individually and separately from the parent species wherever taxonomically possible, since their invasiveness may differ from that of the parent species. An exception should be made if the taxonomy of the species and hybrids are uncertain, and species and hybrids can not be clearly distinguished in the field. In such cases it is not feasible to distinguish species and hybrids, and they can only be assessed as a single unit.

Some cultivars of the species known to be available:

References for species assessment:

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