Ranking Invasive Exotic Plant Species in Virginia

prepared by

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Executive Summary

This report addresses a concern voiced by the American Seed Trade Association (ASTA) to the Department of Conservation and Recreation (DCR) that 11 species on the DCR List of Invasive Alien Plant Species in Virginia should be removed. The 11 species are redtop (*Agrostis gigantea*), crown vetch (*Coronilla varia*), bermudagrass (*Cynodon dactylon*), orchardgrass (*Dactylis glomerata*), weeping lovegrass (*Eragrostis curvula*), tall fescue (*Lolium pratense*, formerly *Festuca pratensis*), birdsfoot trefoil (*Lotus corniculatus*), white sweet clover (*Melilotus alba*), yellow sweet clover (*Melilotus officinalis*), timothy (*Phleum pratense*), and Canada bluegrass (*Poa compressa*).

The current List of Invasive Alien Plant Species identifies 115 species that are known, or have the potential, to threaten rare plant and animal species, native forests and grasslands, and other natural communities. The list was first published by DCR in cooperation with the Virginia Native Plant Society in 1993. This list carries no regulatory or statutory authority and is entirely advisory in nature. All DCR publications on invasive species are intended to provide information on an issue that has been of growing concern in the natural resource conservation community over the past 15 to 20 years. The list is intended to assist land managers in making informed decisions regarding plant materials used in various projects and the potential consequences of using certain species. Economic factors are not appropriate for consideration since the list informs users about their options; it does not regulate their decisions.

This report describes three methods DCR uses to assess the invasive nature of plant species in general. In particular, the invasiveness of the 11 species recently questioned by ASTA are closely examined.

First, current scientific literature and other sources were reviewed to gather information on the biology, ecology, invasiveness, and management of each species. This information was used to complete a Plant Species Invasiveness Rank Form for each species. The Rank Form presents a set of criteria framed as questions with weighted scores designed to determine the relative invasiveness of a species. Ten species were determined to be invasive by this process. This method did not find sufficient evidence to classify bermudagrass as invasive. As a result of this approach to invasiveness ranking, three species increased their rank, four species lowered their rank, and four species ranks remained the same.

Second, data regarding a suite of plant characteristics obtained from the USDA Natural Resources Conservation Service PLANTS Database were used to develop a model to predict invasiveness of a plant species. Discriminant analysis generated a model that correctly predicted the invasiveness of 32 exotic species and, when applied to the 11 species in question, classified eight as invasive. These eight species are redtop, bermudagrass, orchardgrass, weeping lovegrass, tall fescue, white sweetclover, yellow sweetclover, and timothy.

Third, field data from approximately 2,000 vegetation study plots across Virginia were used for a unique perspective on the invasiveness of various exotic plant species. A disproportionate percentage of currently listed exotic species are represented in these plots and a highly significant statistical relationship was found between frequency of species in plots and their invasiveness rank on the DCR List of Invasive Alien Plant Species in Virginia.

We conclude from this three-part study of the invasive nature of the 11 species questioned by ASTA that there is credible evidence for continuing to classify 10 of the 11 species as invasive.

Although the problems posed by invasive exotic species to native species and natural communities were first identified by scientists over forty years ago, most research into this area began to be published in the last fifteen years. It is important that research scientists, resource managers, economic stakeholders, and policymakers remain in cordial and constructive dialog regarding the complex issues this subject raises.

I. Introduction

A. Purpose of the Study

This report addresses a request by the American Seed Trade Association (ASTA) that the Department of Conservation and Recreation (DCR) remove 11 species from the DCR List of Invasive Alien Plant Species in Virginia (DCR 1999). The 11 species are redtop (*Agrostis gigantea*), crown vetch (*Coronilla varia*), bermudagrass (*Cynodon dactylon*), orchardgrass (*Dactylis glomerata*), weeping lovegrass (*Eragrostis curvula*), tall fescue (*Lolium pratense*, formerly *Festuca pratensis*), birdsfoot trefoil (*Lotus corniculatus*), white sweet clover (*Melilotus alba*), yellow sweet clover (*Melilotus officinalis*), timothy (*Phleum pratense*), and Canada bluegrass (*Poa compressa*).

Each of these 11 species has a variety of cultural uses, including soil erosion control, livestock forage, wildlife habitat management, turfgrass, and ornamental planting. Some forage species, such as orchardgrass and timothy, have been in use in Virginia since the 18th century. Other species, such as weeping lovegrass, are recent additions to the Virginia landscape. DCR recognizes that these species will be used for these purposes into the future. However, invasive species can and do move into natural areas and cause damage to native plants, animals, and communities. Therefore, great caution is advised with regard to their use in or adjacent to natural areas.

All 11 species in question are considered by organizations and agencies throughout the U.S. to exhibit invasive tendencies that threaten rare native plants and natural communities (TN-EPPC 1996; SAMAB 2001; USDA NRCS 2001). DCR re-examined information used to identify these 11 species as invasive and implemented refined criteria for ranking species invasiveness. New analyses were conducted to examine evidence not available when the List of Invasive Alien Plant Species was first developed. This fresh look at an old issue adds considerably to our understanding of invasive species in Virginia and the characteristics these species share.

B. Mission of the Virginia Natural Heritage Program

DCR's Division of Natural Heritage (DNH) is responsible by statutory authority for documenting, protecting, and managing *natural heritage resources*, defined as "the habitats of rare, threatened, or endangered plant and animal species, rare or state-significant communities, and other natural features" (section 10.1: 209-217, *Code of Virginia*). DCR maintains database information on the status, distribution, and ecology of rare native species and all natural communities; protects and manages these resources through a system of natural area preserves; and provides information and technical advice to other agencies, organizations, and individuals. Addressing the threat to natural heritage resources from exotic invasive plant species is an important part of this work.

C. Threats from Invasive Exotic Plant Species

During the past two decades, invasion of native ecosystems by exotic (also referred to as alien or non-native) species has become recognized by scientists and land managers as one of two major causes of the loss of native biodiversity (Pimm and Gilpin 1989; U.S. Congress 1993; Luken and Thieret 1997; Meffe and Carroll 1997; Scott and Wilcove 1998; Stein et al. 2000). Habitat loss or degradation is widely acknowledged as the leading cause of loss of biodiversity. However, the threat to biodiversity posed by invasive exotic species is not widely known or appreciated by the public. The exceptions may be the states of Florida and Hawaii, where invasive exotic plants and animals have led to large-scale economic and environmental losses and large expenditures by public agencies to address the problems associated with invasive species (U.S. Congress 1993; Simberloff et al. 1997; Cox 1999).

Invasive exotic plants threaten native species and natural communities on three broad and interconnected levels: (1) alteration of ecosystem processes, (2) change in community structure, and (3) change in community composition (Elton 1958; Cronk and Fuller 1995; Cox 1999; Hobbs and Huenneke 1992; Lodge 1993; Randall 1997; Simberloff et al. 1997; Walker and Smith 1997; Woods 1997).

Alteration of ecosystem processes can be caused by alteration of historical fire regimes, erosion and sedimentation rates, hydrological regimes, or nutrient regimes (D'Antonio and Vitousek 1992; Walker and Smith 1997). Purple loosestrife (*Lythrum salicaria*) illustrates this effect of invasive plants. An exotic introduction to North America for ornamental uses, purple loosestrife has invaded thousands of acres of wetlands in the Northeast. The plant grows in high density and creates substrate buildup around its roots that creates a drier site and allows the plant to invade open water (Bender 2000). The resultant changes in substrate and hydrology negatively impact native wetlands and the plants and animals that inhabit these communities.

Invasive plants can drastically alter the structure of communities. Changes in community structure result from the addition of a vegetative layer or an increase in the density of a layer. A layer could be eliminated, for example, if an invading species casts dense shade. The classic example is kudzu (*Pueraria montana*). Kudzu creates a new and highly dense layer over existing layers, even overtopping tree canopies. Using this strategy, kudzu can outcompete other plants for sunlight, with a marked reduction of biodiversity in lower layers of the site (Woods 1997).

When an invasive plant becomes a new component of an existing vegetation layer, native species are displaced. Native species must compete at new levels for nutrients, light, water, pollinators, and seed dispersal pathways (i.e., animals that transport seed to new sites). For example, Japanese stilt grass (*Microstegium vimineum*) invades wetlands and forests with moist soils, forming dense, monotypic stands and reducing diversity in the ground-layer. This ground-layer change also leads to changes in the shrub and tree layers by reducing seedling recruitment of woody species (Woods 1997).

D. About the DCR List of Invasive Alien Plant Species in Virginia

The List of Invasive Alien Plant Species in Virginia is the result of a cooperative project between the Virginia Native Plant Society (VNPS) and DCR. The list was developed as an educational tool to inform DCR and other land managers and concerned citizens about potentially troublesome exotic species. The list has no regulatory authority.
The primary list was drafted by representatives from DCR and VNPS in 1991. In 1993, a draft list was presented for review to representatives of numerous public agencies and private organizations, including Virginia Department of Agriculture and Consumer Services, Department of Transportation, Department of Game and Inland Fisheries, Virginia Tech Department of Horticulture, Virginia Nurserymen's Association, Virginia Agricultural Extension Service, National Wildlife Federation, The Nature Conservancy, and private plant nursery owners. The list was also presented for review at a 1994 Invasive Alien Plant Conference sponsored by DCR and VNPS, which was attended by over 100 private citizens, and industry representatives, and agency staff.

First published in 1993, the list was reformatted and expanded in 1996 to include invasiveness ranks and plant range and habitat requirement information. Review drafts were sent to representatives of agencies and organizations listed above. In 1999, further design refinements to the appearance were made but the content was not changed.

The list provides information to assist land managers in (1) setting priorities for managing invasive species already established at a site, and (2) making decisions about plant materials to be used in various projects and the potential consequences of using certain species. Plants that appear on the list are known to spread from where they are planted to areas where they are not wanted. Such unintended spread causes harm, such as loss of desirable native plant and animal habitat. Given the non-regulatory, educational nature of the list, cost-benefit analysis was deemed not appropriate and was not performed. However, such analyses may be an appropriate step in developing laws that regulate the use of certain plants or animals.

E. Study Components

The recent study consists of three primary components. First, a review was made of pertinent scientific literature and other sources of information on the biology, ecology, invasiveness, and management of each of the 11 species. This information was used to complete Plant Species Invasiveness Rank Forms for each species. Forms consist of a set of criteria with weighted scores designed to help determine the relative invasiveness of a species based on a wide body of biological, physical, and natural history information.

Second, the assessment of invasiveness was evaluated by compiling extensive autecological data on a range of native, non-invasive exotic, and invasive exotic plant species. Characters were chosen that influence or potentially influence invasiveness. Cluster analysis and discriminant analysis were performed to identify, respectively, (a) suites of species that share certain characteristics, and (b) those factors that are most

strongly associated with invasiveness. The cluster analysis sought to provide support for the first component of this study by showing that groups of species segregated by invasive rank. The intent of the discriminant analysis was to develop a model to predict invasiveness and apply it to the classification of the 11 species in question. Both multivariate techniques represent an objective and powerful basis for classifying exotic plant species as invasive or non-invasive.

Third, compositional data from 1,994 vegetation plot samples were examined for frequency of occurrence of exotic species. DCR ecologists have collected these data to document occurrences of natural communities and to describe examples of rare and significant vegetation types. Because sample plots are placed, to the extent possible, in habitats largely free from human disturbance, they provide a conservative estimate of the occurrence of exotic species in the Virginia landscape. These data were also used to explore the relationship between frequency of occurrence and DCR invasiveness rank for exotic species. This analysis represents one of the first examinations of the frequency of exotic species in native vegetation for a data set of this size and at the statewide scale.

II. Plant Invasiveness Ranking Criteria

A. Invasiveness Rank Form

Many lists of invasive exotic plant species have been developed in recent years and more are being developed (e.g., Harmon 1997; USDA Forest Service 1998; CA-EPPC 1999; PCA 2000; FL-EPPC 2001). Criteria for listing and scale of focus vary from list to list. Many have recognized the need for standardized, scientifically sound criteria for ranking invasiveness of plant species at local, state, and national levels (Hobbs and Humphries 1995; Heibert 1997; Simberloff 1997; ASTA 1999; National Invasive Species Council 2001; Randall et al 2001; Van Driesche and Van Driesche 2001). Such criteria are needed to guide decisions and actions of policymakers and land managers.

One of the most highly developed methods for ranking invasive plant species has come from the National Park Service (Hiebert and Stubbendieck 1993; Heibert 2001). Its focus, however, is prioritizing species for management within a park or at a particular site. Nevertheless, this system lays the groundwork for ranking systems of broader scope, including a national invasive species ranking system under development by the Association for Biodiversity Information (ABI).

ABI ranking criteria (Randall et al. 2001) have received several rounds of revision following reviews by resource managers, botanists, and ecologists and are currently being subjected to further testing (Benton, pers. comm.). The ABI criteria have been adapted by DCR for specific use in Virginia and are the criteria used in the current study of 11 species questioned by ASTA. Some criteria pertaining to U.S. distribution and invasiveness were retained because Virginia does not exist in isolation, and plant material is easily transported from one part of the country to another. Furthermore, if a plant has invasive tendencies at one location, it is likely to be invasive elsewhere (Panetta 1993; Hobbs and Humphries 1995; Reichard and Hamilton 1997).

Ranking criteria were standardized and organized into a Plant Species Invasiveness Rank Form. Invasiveness was determined by completing a form for each species under review. Rank forms present a series of multiple-choice questions in four components. Answers to questions were converted to weighted scores to tally subranks for each area. The subranks were converted to weighted scores to tally an overall rank for the species, called a Plant Species Invasiveness Rank. Scores are weighted to place greater emphasis on those criteria that most strongly reflect species impact on native plant and animal habitat and biological characteristics common to invasive plants. Less emphasis is placed on distribution, abundance, and difficulty of control. Species were ranked in one of four categories of invasiveness: High, Medium, Low, or Insignificant.

For each question, comments and supporting references were provided. References included published research articles or other pertinent literature, Internet resources or databases, and personal communications from field biologists or land managers. All references were listed with complete bibliographic information for each Rank Form.

B. Ranking Criteria Components

Four components used in ranking species invasiveness represent aspects of the species biology, ecology, and potential for management: (1) impacts on native species, habitats, and ecosystems, (2) biological characteristics and dispersal ability, (3) distribution and abundance in Virginia and the U.S., and (4) difficulty of control.

The first component examines impacts of a species on native plants, habitat, and ecosystems. Impacts by invasive species on native plants include interspecific competition for limiting resources such as light, water, or nutrients (Bratton 1982; Walker and Smith 1997). Impacts on habitat include changes in community structure (Bratton 1982; Woods 1997). Ecosystem processes are impacted by such factors as an invasive species ability to alter site hydrology or change the propensity of a site to burn, thus altering the natural fire regime (Bratton 1982; D'Antonio and Vitousek 1992; Walker and Smith 1997).

Secondly, biological characteristics help predict whether a species might become invasive. Many well-known invasive species share certain traits in common that give them a competitive advantage over native species. These traits include rapid growth to reproductive maturity, prolific seed production, rapid vegetative spread, freedom from insect or disease controls, and opportunistic growth habit (Elton 1958; Lodge 1993; Randall and Marinelli 1996; Rejmánek 1996). The best predictor may be whether the species is known to be invasive in another part of the world (Hobbs and Humphries 1995; Randall and Marinelli 1996). Evidence also suggests that repeated or large-scale introduction of a species into a new range by humans increases its potential for invasiveness (Randall and Marinelli 1996).

Distribution and abundance indicates presence of a species in a given landscape and suggests potential for that species to disperse to new sites. Propagules from nearby populations of an invasive species may become established in an un-invaded site when conditions are favorable, particularly following disturbance from storms, fire, or human activities that increase soil disturbance. However, invasions can occur even into completely undisturbed sites. Prevalence in the landscape also influences the potential for control of a species at a site. Land managers may work to eradicate a species from a preserve only to have the site re-infested from off-site populations (Luken 1997). Species range may be a factor of intentional dispersal by humans, such as planting, but may also be due to unique dispersal mechanisms of a species.

Finally, difficulty of control indicates what resources (time and money) are required to control an invasive species. Feasibility of control and degree of impact are the two primary factors used to prioritize invasive plant populations for management action (Heibert 2001). Readily available information regarding control methods for a species assists land managers in determining feasibility of control. Prioritizing invasive plant populations is an important step in adaptive management of natural areas (Schwartz and Randall 1995).

C. Results of the Ranking Process

Table 1 presents updated ranks for the 11 species examined for this study. As a result of this review of invasiveness ranks, three species increased their rank: white sweetclover, yellow sweetclover, and timothy. Four species lowered their rank: redtop, crown vetch, bermudagrass, and weeping lovegrass. Four species ranks remained the same: orchardgrass, tall fescue, Canada bluegrass, and birdsfoot trefoil. Completed ranking forms for all 11 species are presented in Appendix B.

Table 1. Ranking Criteria Scores for the Eleven Species under Review

Scientific Name	Common Name	Impact	Biology & Ecology	Distribution & Abundance in Natural Areas	Difficulty of Control	New Invasiveness Rank	Former Invasiveness Rank (1999)
Agrostis gigantea	Redtop	Medium	Low	Low	Medium	Low	Medium
Coronilla varia	Crown Vetch	Low	Medium	Medium	Medium	Low	Medium
Cynodon dactylon	Bermudagrass	Insignificant	Medium	Low	Medium	Insignificant	Medium
Dactylis glomerata	Orchardgrass	Low	Medium	Low	Medium	Low	Low
Eragrostis curvula	Weeping Lovegrass	Low	Medium	Insignificant	Medium	Low	Medium
Lolium pratense (*Festuca pratensis*)	Tall Fescue	Medium	Medium	Low	High	Medium	Medium
Lotus corniculatus	Birdsfoot Trefoil	Medium	Low	Insignificant	Medium	Low	Low
Melilotus alba	White Sweet Clover	High	High	Insignificant	High	High	Medium
Melilotus officinalis	Yellow Sweet Clover	High	High	Insignificant	High	High	Medium
Phleum pratensis	Timothy	Medium	Medium	Low	High	Medium	Low
Poa compressa	Canada Bluegrass	Medium	High	Low	High	Medium	Medium

Weighted average/point system

SUBRANK:		**SCORE:**
I.	Impact	H = 4, M = 3, L = 2, I = 0
II.	Biology	H = 3, M = 2, L = 1, I = 0
III.	Distribution	H = 1, M = 0, L = 0, I = 0
IV.	Control	H = 2, M = 1, L = 0, I = 0

These scores are tallied to yield overall Plant Species Invasiveness Rank. Highest possible score = 10

Overall ranking scale:

I.	Insignificant:	total score = 0-3	Species represents an insignificant threat to natural communities
L.	Low:	total score = 4-6	Species represents low threat to natural communities
M.	Medium:	total score = 7-8	Species represents moderate threat to natural communities
H.	High:	total score = 9-10	Species represents high threat to natural communities

III. Multivariate Analysis of Biological Characters in Invasive and Non-invasive Species

A. Data Source

USDA NRCS PLANTS Database Version 3.1 (http://plants.usda.gov) provides a wide array of information on plants found in the United States, including native and exotic species. Among its many offerings are standardized plant characteristics data for 2500 species. The data set contains 88 plant attributes including nativity, growth form, growth requirements, bloom period, seedling vigor, and suitability/use traits (USDA NRCS 2001).

DCR staff saw an opportunity to use these data to perform multivariate analysis in an attempt to identify a pattern of invasiveness as expressed by these characteristics. In other words, the question "Do invasive plants posses a set of characteristics that set them apart from non-invasive plants?" might be answered by statistical analysis of the NRCS data.

Species were selected from the PLANTS Database based on the following criteria: (1) the species was found in Virginia, (2) species were chosen for even representation between native and exotic. Among the natives, species were chosen to represent a range of rarity in Virginia using Natural Heritage "S" ranks (see Appendix C). For the exotic species, taxa widely recognized as either invasive or non-invasive were selected. See Appendix B for List of Invasive Alien Plant Species in Virginia. The 11 target species were also included. Because seven of the these species were grasses and four were legumes, and since the overwhelming majority of taxa meeting the criteria above belonged to one of these two plant families, it was decided to further limit the selected species to grass and legume species. Seventy-one species were selected for this study.

The NRCS data set's 88 attributes were reduced to 43 that were considered likely or possibly to have some association with invasiveness. Table 2 lists these retained characters, which comprise nine binary nominal (categorical) variables, seven multistate nominal variables, 18 ordinal variables, and nine ratio (continuous) variables. To avoid negative values, the unit of measurement in the minimum temperature category was converted to degrees Kelvin.

Seven species selected had no data for one or more of four attributes. DCR staff supplied missing data or provided estimates for these data. The species and the characters lacking were: *Leersia lenticularis* (foliage porosity summer, foliage porosity winter, seed per pound), *Arundo donax* (seed per pound), *Lespedeza bicolor* (foliage porosity summer, foliage porosity winter), *Cinna latifolia* (seed per pound), *Chasmanthium laxum* (seed per pound), *Lolium perenne* (seed per pound), *Dichanthelium clandestinum* (seed per pound). For the ratio seed per pound variable, only relative rank (see **Cluster Analysis**, *Method*, below) was estimated.

Table 2. Variables used in multivariate character analysis of invasive and non-invasive species.

Binary (Nominal) Variables	**Values**
shape and orientation	originally multistate – converted to horizontal/erect
growth form	originally multistate – converted to local/spreading
resprout ability	yes/no
allelopathic	yes/no
fire resistant	yes/no
fruit/seed period begin	originally multistate – converted to early/late
fruit/seed period end	originally multistate – converted to early/late
fruit/seed persistence	yes/no
propagated by bare root	yes/no
propagated by seed	yes/no
adapted to fine textured soils	yes/no
adapted to coarse textured soils	yes/no
cold stratification required	yes/no
active growth period – season (3)	spring, summer, fall

Ordinal Variables	**Values**
lifespan	short/moderate/long
foliage texture	fine/medium/coarse
foliage porosity – summer	porous/moderate/dense
foliage porosity – winter	porous/moderate/dense
active growth period – duration	original multistate – converted to one/two/three+ seasons
growth rate	slow/moderate/rapid
nitrogen fixation	none/low/medium/high
toxicity	none/slight/moderate
bloom period	originally multistate – converted to very early/early/medium/late
fruit/seed abundance	low/medium/high
seedling vigor	low/medium/high
seed spread rate	slow/moderate/rapid
vegetative spread rate	slow/moderate/rapid
fertility requirement	low/medium/high
moisture use	low/medium/high
anaerobic tolerance	none/low/medium/high
$CaCO_3$ tolerance	none/low/medium/high
drought tolerance	low/medium/high
fire tolerance	none/low/medium/high
shade tolerance	intolerant/intermediate/tolerant

Ratio (Continuous) Variables	**Transformation**
***Note*:** Ratio variables were also square root transformed to four-rank variables.	
mature height	ordinal
seed per pound	logarithm
minimum pH	none
maximum pH	none
minimum root depth	logarithm
minimum precipitation	none
maximum precipitation	logarithm
minimum frost-free days	square root
minimum temperature	converted to Kelvin units, then logarithm

New Synthetic Variables	Equality
pH range	maximum pH – minimum pH
precipitation range	maximum precipitation - minimum precipitation

B. Cluster Analysis

Method. – In an effort to identify distinct groups of species that share a suite of characteristics, hierarchical cluster analysis was performed on this reduced data set. Of particular interest was whether native and exotic, invasive and non-invasive, and strongly and weakly invasive species would segregate with respect to the assembled biological characters. Cluster analysis comprises a family of multivariate techniques that seek to aggregate cases into groups based on overall similarity in a set of measured characters. Clustering algorithms are driven by a distance function, which measures the dissimilarity between all pairs of cases, and a linkage method, which computes the dissimilarity between pairs of clusters and thus determines linkage decisions. Certain dissimilarity measures are appropriate only for certain types of data. Because this heterogeneous data set neither suggested nor lent itself to a single multivariate analysis in which each character receives equal weight and contributes equally to a multivariate function, three modifications were performed prior to analysis.

(1) A data set containing exclusively binary variables was assembled by creating dummy pseudovariables for each character. Because the largest number of levels for an ordinal character was four, each ordinal variable was converted to three dummy variables to permit unique coding of each value. For example, a species with low fire tolerance (the second of four levels) was coded with dummy variables (called low, medium, and high) having the values 1, 0, and 0, whereas a species with high tolerance was coded as 1, 1, and 1. Two dummy variables were defined for ordinal characters with three levels, and binary characters were coded as single 0/1 dummy variables. Multistage categorical characters were first converted to binary or ordinal variables (Table 2), and a single character describing active growth period was converted to three dummy variables, each corresponding to a different season. Ratio characters were converted to ranks and thence to four-rank ordinal variables. Cut points were determined by the normal probability function such that the four ranges would have equal probability distributions if the underlying variable were normally distributed (Sokal and Rohlf 1995). This approach was deemed less arbitrary than defining quartiles based on the median because of a much lower chance of encountering values that equaled the cut points.

(a) first range	$< (Y - 0.674s)$
(b) second range	$> (Y - 0.674s)$ AND $<$
(a) third range	$> Y$ AND $< (Y + 0.674s)$
(a) fourth range	$> (Y + 0.674s)$

where Y is an estimate of the mean ì and s is an estimate of the standard deviation ó. Because the original characters are represented by differing numbers of dummy variables (i.e., binary characters are represented by one dummy variable, three-rank ordinal characters by two, and four-rank ordinal and ratio characters by three), additional replicate dummy variables were created to equalize the contribution of each original character to the modified data set. Hence, six identical pseudovariables were created for each binary character, three identical pseudovariables for each of the two unique dummy variables for three-rank ordinal characters, and two identical pseudovariables for each of

the three unique dummy variables for the four-rank ordinal and ratio characters. Thus, this data set contained six binary pseudovariables for each original character. This set was subjected to cluster analysis using centroid linkage and the Jaccard simple matching coefficient. This distance measure was chosen in order to give both double "presence" and double "absence" matches equal weight, since the binary coding scheme employed here did not reflect the true presence or absence of a given character.

(2) In the second modification, all variables were rescaled to a minimum value of 0 and a maximum value of 1. Binary characters were coded as 0 or 1, and multistate nominal categories were converted to ordinal or binary variables, as in modification (1). Ordinal variables were assigned values of 0, 1, 2, or 3, depending on the number of categories. Three binary variables coding for active growth period were included. Before rescaling, mature height and minimum frost-free days were square-root transformed and seed per pound, minimum root depth, maximum precipitation, and minimum temperature were natural log-transformed to normalize their distributions. This data set was used in cluster analysis with Ward's linkage method and Euclidian distance. Equilibrating the scale of each variable was necessary to achieve equality in the contribution that each character made to the distance function.

Because seed per pound data were missing for four species (see **Data Source**, above), and since this data set required precise values and not simply ranks that could be estimated with some confidence, two separate analyses were performed with this data set. For one analysis this character was dropped for all species; in the other the four species with missing data were removed.

(3) Principle components analysis (PCA) was performed to eliminate redundant and relatively invariant variables and to identify those sets of characters most strongly associated with one another. Data were assembled as in modification (2), including transformations to ratio variables, except that variables were not rescaled but instead standardized to zero mean and unit variance. PCA was conducted using the correlation matrix, since variances and covariances computed from binary variables are meaningless. To determine the number of extracted factors to retain, eigenvalues were compared to a null model consisting of decreasing values of the broken stick model (Frontier 1976, Legendre and Legendre 1998). Given a stick of unit length broken into p pieces of random length, the proportional length of the jth piece is equal to

$$\frac{1}{p}\sum_{x=j}^{p}\frac{1}{x}$$

An eigenvalue was retained if its value exceeded that of the corresponding value of the broken stick model – that is, if a given eigenvalue explained more variance than the null model predicted. Again, two separate analyses were performed, one in which seed per pound was dropped for all species and another in which four species with missing data for this character were removed. Following this procedure, 12 and 8 eigenvalues, respectively, were retained from these two analyses as used as the new variables in a cluster analysis with Ward's linkage method and Euclidian distance.

All cluster analyses were performed in SPSS v. 10.0.5 (SPSS 1999).

Results. – Procedures using different data sets produced widely varying results and few groups of species consistently emerged. Cluster analysis using centroid linkage and the Jaccard coefficient produced a conspicuous bifurcating pattern in the resulting dendrogram and nearly equally sized clusters, which may have been an artifact of the combination of linkage method, distance measure, and binary nature of the data. Analysis based on extracted principal components yielded the most readily identifiable clusters, but results differed markedly between the analysis with the seed per pound character removed and that without the four species with missing data for this variable. In all analyses neither invasive and non-invasive species nor native and exotic species segregated using the full set of characters. In hindsight this result is not surprising, since the large character set comprised numerous factors that may exhibit no association with invasiveness. Even if a fraction of the included characters differed strongly and consistently between invasive and non-invasive species, this pattern could easily be obscured by complex and multilateral variation in the remaining characters that bore no systematic relationship to invasiveness. Because the heterogeneous nature of the original data set did not suggest an obvious strategy for cluster analysis or procedure for standardizing the data, no single analysis can be considered optimal and specific results are not presented further.

C. Predictive Modeling of Invasiveness

Method. – Discriminant analysis (DA) was performed to identify those characters that mostly strongly differed between invasive and non-invasive species and to develop a model that could predict whether a given target species is likely to be invasive. DA (also known as discriminant function analysis) identifies a linear combination of explanatory (dependent) variables that most strongly discriminates between or among values of a single categorical response (independent) variable, or classification criterion, which is defined *a priori*. In the case of only two groups, a single combination, or discriminant function, is computed to explain differences between the groups. Here the goal of discriminant analysis was twofold: (1) to identify the factors that could best distinguish between groups, and (2) to apply the discriminant function model to the 11 target species to classify them as invasive or non-invasive. This second procedure provides an evaluation of the prior assessment of the invasiveness of these species.

The same data set of 71 species and 43 characters was used for this analysis. Data were prepared as in modification (3) for cluster analysis, above, except that variables were not standardized and PCA was not performed first. Minimum and maximum pH and minimum and maximum precipitation were replaced by single variables representing the range of values for each pair. Precipitation range was square-root transformed to normalize its distribution. Seed per pound was converted to a ranked variable, with values for four species with missing data estimated from published information on seed size and volume or from values of similar species.

The 28 native species in the data set were held passive in DA. That is, they were not used to construct the discriminant function, since the intent of this analysis was to predict whether a given exotic species is invasive. The 11 target exotic species were also not used to build the model, but were instead used to test its effectiveness at classification. Thus a model of invasiveness based on 32 exotic species, 25 of which are considered by DCR not to be invasive and seven of which are ranked as invasive, was constructed and then applied to the 11 target species (Table 3). (The highly skewed ratio of non-invasive to invasive taxa in the data set used to construct the model was, unfortunately, unavoidable, as information could not be obtained on additional invasive exotic species.) The model was cross-validated using a jackknife procedure, whereby each case (species) was successively removed and a discriminant function computed, which was then used to classify the deleted case.

Initial DA revealed that six variables had constant values for either the invasive or the non-invasive group. Because this lack of intragroup variance could bias the results by inflating the apparent success of classification, and since there was no biological basis for assuming that such a pattern would hold for a larger data set, these variables were removed in order to construct a more conservative model. These variables were allelopathy, fire resistance, propagated by seed, cold stratification, growth orientation, and resprout ability. A stepwise procedure was used to select the final model. Additions or removals of variables to and from the model were determined by critical values of an *F* statistic that tests the significance of the change in Wilks' lambda. Although this procedure provides no guarantee of generating an optimal model, it was the appropriate choice for this data set, which contained too many characters to permit testing every possible combination and too complex to warrant the *a priori* selection of a certain set of variables or the inclusion of the full complement. DA was performed in SPSS v. 10.0.5 (SPSS 1999).

Table 3. Frequency distribution of species used in discriminant analysis by status, invasive rank, and plant family.

Species Status	Invasive Rank	Target Species		Non-Target Species		TOTAL
		grasses	legumes	grasses	legumes	
Native				19	9	28
Non-Invasive Exotic				17	8	25
Invasive Exotic	A			1	1	2
	B	5	3	3	1	12
	C	2	1	1		4
TOTAL		7	4	41	19	71

Results. – The stepwise procedure selected five characters for the final discriminant function: height, summer leaf porosity, a dummy variable indicating active growth during spring, seed per pound (ordinal rank), and pH range (Table 4). *Z* scores > 1.0 indicates probable invasiveness. All 32 non-target species were correctly classified using the model, and only two (*Arundo donax* and *Vulpia myuros*) were incorrectly classified in

jackknifed cross-validation trials. Such a 94% success rate is unusually high. When the discriminant function was applied to the 11 target species, all of which are considered by DCR to be invasive, eight were classified as such. *Coronilla varia*, *Lotus corniculatus* and *Poa compressa* were predicted to be non-invasive. All three of these species had *Z* scores close to the threshold of 1.0.

The five characters included in the discriminant function can all be considered to have an association with traits conferring invasive ability. This analysis reveals that invasive plants tend to be taller, to have denser foliage during the summer, to have active growth periods that begin in summer rather than spring, to produce more copious seed, and to tolerate a wider range of soil pH. Abundant seed production is generally considered a trait strongly associated with the competitive success of invasive species (Elton 1958, Rejmánek 1996). Greater height may confer a competitive advantage for light, and less porous foliage may permit greater photosynthetic ability during the optimal growing season. A delay in active growth period may allow invasive species to exploit a phenological window after other species have already completed their annual growth and possibly to gain an advantage preceding the next growing season. Tolerance to a wide range of soil pH may indicate broad habitat requirements and the ability to colonize under a range of site conditions. Standardized canonical discriminant function coefficients indicate that rank of seed per pound contributed most strongly to the model, followed by spring growth and plant height. The weakest contributions came from pH range and summer leaf porosity.

Rejmánek and Richardson (1996) used DA to identify the characteristics associated with invasiveness in pine species. These authors chose 12 invasive and 12 non-invasive species, for which quantitative data were available on 10 life-history attributes. Jackknifed procedures correctly classified all 24 species. Further cross-validation involved 500 runs for which six species from each group were randomly chosen, a discriminant model constructed, and the model applied to the remaining species. Using this method 20 of the species were correctly classified in > 90% of the runs. The three variables included in the discriminant function model were mean seed mass (square root transformed), minimum juvenile period (square root transformed), and mean interval between large seed crops. That the characters associated with invasiveness in Rejmánek and Richardson's (1996) study differ from those identified in the present analysis – in particular, large values of seed per pound tautologically imply small seed mass – should not be surprising, since life-history traits generally differ considerably between woody and herbaceous plants. For opportunistic herbs, abundant seed crops may facilitate dispersal by wind and increase the likelihood of saturating suitable sites for germination. Larger seed size in woody plants, on the other hand, conveys a competitive advantage for young seedlings by providing a greater supply of nutrient reserves. This advantage may be critical to woody plants competing with other large seeded woody plants, in which initial growth of roots often greatly exceeds that of above-ground shoots (Harper 1977). When applied to 40 highly invasive woody species from 40 additional genera, the model of Rejmánek and Richardson (1996) correctly classified 38 as invasive. Similar tests of the model developed in the present study must await the accumulation of additional data on invasive herbaceous species.

Table 4. Discriminant analysis of 71 native, non-invasive exotic, and invasive exotic plant species in Virginia.

Species	S Rank	Invasive Rank	Z Score
Eragrostis curvula*	SE	B	6.79
Lespedeza cuneata	SE	A	4.20
Miscanthus sinensis	SE	C	4.08
Festuca pratensis*	SE	B	3.11
Agrostis gigantea*	SE	B	2.92
Sorghum halepense	SE	A	2.80
Lespedeza bicolor	SE	B	2.73
Dactylis glomerata*	SE	C	2.68
Phleum pratense*	SE	C	2.66
Holcus lanatus	SE	B	2.44
Arundo donax**	SE	B	1.66
Poa trivialis	SE	B	1.62
Melilotus alba*	SE	B	1.38
Melilotus officinalis*	SE	B	1.38
Cynodon dactylon*	SE	B	1.06
Paspalum dilatatum	SE		0.72
Vulpia myuros**	SE		0.56
Poa compressa*	SE	B	**0.54**
Cytisus scoparius	SE		0.18
Sorghum bicolor ssp. drummondii	SE		0.13
Echinochloa colona	SE		0.02
Setaria italica	SE		-0.05
Medicago sativa	SE		-0.07
Lolium perenne ssp. multiflorum	SE		-0.14
Panicum miliaceum	SE		-0.21
Trifolium repens	SE		-0.48
Coronilla varia*	SE	B	**-0.50**
Lotus corniculatus*	SE	C	**-0.55**
Triticum aestivalis	SE		-0.59
Crotalaria spectabilis	SE		-0.71
Poa bulbosa	SE		-0.78
Buchloe dactyloides	SE		-0.80
Bromus inermis	SE		-0.83
Bromus hordeaceus	SE		-0.91
Polypogon monspeliensis	SE		-0.91
Hordeum vulgare	SE		-0.92
Glycyrrhiza lepidota	SE		-1.04
Glycine max	SE		-1.35
Secale cereale	SE		-1.52
Avena sativa	SE		-1.59
Bromus catharticus	SE		-1.59
Kummerowia stipulacea	SE		-3.32
Kummerowia striata	SE		-3.32

Species	S Rank	Z Score
Alopecurus carolinianus	S3S4	0.99
Amorpha fruticosa	S3	0.27
Andropogon gerardii 'Niagara'	S5	3.16
Andropogon virginicus	S5	4.00
Apios americana	S5	-5.07
Astragalus canadensis	S4	-4.07
Baptisia tinctoria	S5	1.63
Bouteloua curtipendula	S4	4.64
Bromus kalmii	S1	-1.73
Chamaecrista fasciculata	S5	-3.84
Chasmanthium laxum	S5	-1.16
Cinna latifolia	S3	2.38
Desmodium paniculatum	S5	-0.91
Dichanthelium aciculare	S4S5	1.43
Dichanthelium clandestinum	S5	1.80
Elymus trachycaulus	S2	1.27
Elymus virginicus	S5	-1.34
Hierochloe odorata	S1	-2.85
Leersia lenticularis	S4	0.87
Lespedeza capitata	S5	3.03
Lespedeza hirta	S4	3.13
Muhlenbergia cuspidata	S2	-0.27
Panicum virgatum	S5	6.25
Paspalum distichum	S1	-1.30
Sorghastrum nutans	S5	5.28
Tridens strictus	S1	2.96
Uniola paniculata	S3	-1.93
Vicia americana	S1S2	-4.18

A discriminant function was developed from a set of 36 characters and 32 exotic species, 25 of which were classified a priori as non-invasive and seven as invasive. The function that best discriminates between invasive and non-invasive taxa includes plant height (in ft), H; rank (on a three-part scale) of summer leaf porosity, SLP; a dummy variable coding for active growth in the spring, SPR; rank (on a four-point scale) of seed per pound, SVR; and pH range, PHR. The discriminant function $Z = 2.165\ H + 0.843SLR - 2.667SPR + 1.120SVR + 1.023PHR - 8.065$; $\div^2 = 33.034$; $p < 0.0001$. See text for explanation of S-ranks and invasive ranks. (*) Target taxa used to test the effectiveness of the model. (**) *Z* scores for species incorrectly classified in jackknifed cross-validation procedure. *Z* scores for target species incorrectly classified in test of model are shown in **bold**.

IV. Patterns of Occurrence of Exotic Species in Vegetation Sample Plots

DCR ecologists are currently developing a comprehensive classification of the natural communities of Virginia (Fleming et al. 2001). This long-term endeavor entails identification of each distinct, repeating assemblage of natural vegetation in the state; assessing the conservation status of each type; and documenting outstanding examples of all vegetation types and occurrences of rare communities. To support this classification nearly 2500 vegetation plots have been sampled to date to provide quantitative data on the composition and structure of vegetation and on local site conditions. Compositional data from 1994 of these plots were compiled and examined for the frequency of occurrence of exotic species. These plots span all physiographic provinces in the state, include both terrestrial and wetland habitats, and comprise a wide range of ecological community types. Since plot placement is targeted locally to capture homogeneous vegetation and at a coarser scale to document examples of noteworthy communities, these data provide an imperfect tool for detecting patterns of distribution of exotic species statewide. Moreover, the dispersion of plots across the state exhibits a pronounced clumped pattern, which reflects intensive, focused sampling in a small number of local landscapes. Nevertheless, since plot selection has been subjectively biased toward relatively pristine vegetation that generally lacks exotic species, examination of the collective flora from these plot data serves as a conservative test of patterns of occurrence of exotics. Hence, any patterns that this analysis reveals may actually underestimate the frequency of occurrence of exotics in Virginia vegetation and the ability of exotics to invade intact vegetation.

A total of 1983 unique taxa occur in at least one of the 1994 plots. Although this number includes numerous overlapping infraspecific taxa, owing to inconsistencies in taxonomic resolution and identification, it represents 48.6% of the 4084 plant taxa (including both species and overlapping infraspecific taxa) recognized in Virginia (DCR, unpubl. data). A substantially lower percentage of the exotic flora have been captured in these plots. Of the 810 exotic species in the Virginia flora, 139, or 17.2%, occur in at least one vegetation plot. These 139 taxa represent only 7.0% of the total species sampled.

Many of these occurrences may constitute chance events and not represent characteristic constituents of the communities sampled. Indeed 390 (19.7%) of the total taxa were sampled in only one of the 1,994 plots. Restricting the analysis to species that occur in a minimum percentage of the total plots may reveal more meaningful and real patterns. Only 643 taxa, or 32.4% of the total sampled species, occur in $\geq$ 1% of the plots (i.e., at least 20 plots). Of these 16, or 2.5%, of the species that occur in $\geq$ 1% of the plots, are exotic (Table 5). All of these species are considered by DCR to be invasive. This number represents 0.76% of all the species sampled in vegetation plots. Of the 810 exotic species in the Virginia flora, 1.9% occur in $\geq$ 1% of vegetation plots.

A substantially greater percentage of invasive exotic species than of all exotics occur in vegetation plots. Of the 115 exotics that DCR considers invasive, 59 (51.3%) occur in at least one plot. This number includes six of the 11 target species: *Agrostis gigantea*, *Coronilla varia*, *Dactylis glomerata*, *Festuca pratensis*, *Lotus corniculatus* and

Table 5. Frequency of Exotic Species in Vegetation Sample Plots

SPECIES	Frequency (total plots=1994)	Percent	DCR-DNH Invasive Rank (1999)
Lonicera japonica	249	12.49	A
Murdannia keisak	146	7.32	A
Alliaria petiolata	84	4.21	A
Microstegium vimineum	80	4.01	A
Ailanthus altissima	71	3.56	A
Polygonum cespitosum var. longisetum	46	2.31	B
Rosa multiflora	43	2.16	C
Prunus avium	38	1.91	
Celastrus orbiculatus	37	1.86	A
Elaeagnus umbellata var. parvifolia	32	1.60	A
Stellaria media	28	1.40	B
Taraxacum officinale	27	1.35	
Festuca pratensis	25	1.25	B
Rumex acetosella	23	1.15	B
Poa trivialis	20	1.00	B
Rubus phoenicolasius	17	0.85	A
Barbarea vulgaris	16	0.80	
Glechoma hederacea	15	0.75	B
Lysimachia nummularia	15	0.75	B
Ligustrum sinense	14	0.70	A
Verbascum thapsus	14	0.70	
Veronica hederifolia	13	0.65	B
Allium vineale	13	0.65	B
Lespedeza cuneata	12	0.60	A
Hieracium caespitosum	11	0.55	
Berberis thunbergii	9	0.45	B
Holcus lanatus	9	0.45	B
Rumex obtusifolius	9	0.45	
Anthoxanthum odoratum	8	0.40	
Setaria viridis	8	0.40	
Hydrilla verticillata	7	0.35	A
Arthraxon hispidus	7	0.35	B
Agrostis stolonifera	7	0.35	
Cardamine hirsuta	7	0.35	
Duchesnea indica	7	0.35	
Leucanthemum vulgare	7	0.35	
Iris pseudacorus	6	0.30	B
Ligustrum obtusifolium	6	0.30	B
Daucus carota	6	0.30	
Veronica arvensis	6	0.30	
Coronilla varia	5	0.25	B
Humulus japonicus	5	0.25	B
Conium maculatum	5	0.25	C
Mentha arvensis	5	0.25	

Table 5. Frequency of Exotic Species in Vegetation Sample Plots

SPECIES	Frequency (total plots=1994)	Percent	DCR-DNH Invasive Rank (1999)
Morus alba	5	0.25	
Ranunculus bulbosus	5	0.25	
Arctium minus	5	0.25	
Myriophyllum spicatum	4	0.20	A
Rumex crispus	4	0.20	B
Perilla frutescens	4	0.20	C
Chamaesyce humistrata	4	0.20	
Mollugo verticillata	4	0.20	
Cerastium fontanum ssp. vulgare	4	0.20	
Hesperis matronalis	4	0.20	
Ammannia coccinea	4	0.20	
Bromus commutatus	4	0.20	
Dianthus armeria	4	0.20	
Digitaria sanguinalis	4	0.20	
Hypericum perforatum	4	0.20	
Polygonum persicaria	4	0.20	
Setaria glauca	4	0.20	
Lonicera morrowii	3	0.15	A
Hedera helix	3	0.15	B
Lapsana communis L.	3	0.15	C
Agrostis capillaris	3	0.15	
Saponaria officinalis	3	0.15	
Dioscorea oppositifolia	3	0.15	
Kummerowia striata	3	0.15	
Plantago lanceolata	3	0.15	
Cerastium glomeratum	3	0.15	
Chenopodium ambrosioides var. ambrosioides	3	0.15	
Centaurea biebersteinii	2	0.10	A
Agrostis gigantea	2	0.10	B
Artemisia vulgaris var. vulgaris	2	0.10	B
Cirsium vulgare	2	0.10	B
Ipomoea purpurea	2	0.10	B
Dactylis glomerata	2	0.10	C
Spirodela punctata	2	0.10	
Hieracium pilosella	2	0.10	
Plantago aristata	2	0.10	
Rorippa nasturtium-aquaticum	2	0.10	
Rorippa sylvestris	2	0.10	
Trifolium pratense	2	0.10	
Asparagus officinalis	2	0.10	
Atriplex patula	2	0.10	
Carduus acanthoides	2	0.10	
Clematis terniflora	2	0.10	
Kummerowia stipulacea	2	0.10	

Table 5. Frequency of Exotic Species in Vegetation Sample Plots

SPECIES	Frequency (total plots=1994)	Percent	DCR-DNH Invasive Rank (1999)
Lonicera standishii	1	0.05	A
Myriophyllum aquaticum	1	0.05	A
Polygonum perfoliatum	1	0.05	A
Euonymus fortunei	1	0.05	B
Acer platanoides	1	0.05	B
Carduus nutans	1	0.05	B
Convolvulus arvensis	1	0.05	B
Ipomoea hederacea	1	0.05	B
Lespedeza bicolor	1	0.05	B
Raphanus raphanistrum	1	0.05	B
Albizia julibrissin	1	0.05	C
Paulownia tomentosa	1	0.05	
Prunus mahaleb	1	0.05	
Rhodotypos scandens	1	0.05	
Eragrostis pilosa	1	0.05	
Aira caryophyllea	1	0.05	
Anagallis arvensis	1	0.05	
Cleome hassleriana	1	0.05	
Magnolia grandiflora	1	0.05	
Amaranthus spinosus	1	0.05	
Artemisia annua	1	0.05	
Barbarea verna	1	0.05	
Bromus inermis	1	0.05	
Bromus sterilis	1	0.05	
Bromus tectorum	1	0.05	
Catalpa speciosa	1	0.05	
Draba verna	1	0.05	
Echinochloa crus-galli var. crus-galli	1	0.05	
Eleusine indica	1	0.05	
Eryngium prostratum	1	0.05	
Erysimum cheiranthoides	1	0.05	
Fimbristylis annua	1	0.05	
Juncus inflexus	1	0.05	
Leonurus marrubiastrum	1	0.05	
Lycopus europaeus	1	0.05	
Medicago lupulina	1	0.05	
Mentha x piperita	1	0.05	
Muscari botryoides	1	0.05	
Nepeta cataria	1	0.05	
Ornithogalum nutans	1	0.05	
Ornithogalum umbellatum	1	0.05	
Rumex conglomeratus	1	0.05	
Sedum sarmentosum	1	0.05	
Sida spinosa	1	0.05	

Table 5. Frequency of Exotic Species in Vegetation Sample Plots

SPECIES	Frequency (total plots=1994)	Percent	DCR-DNH Invasive Rank (1999)
Silene vulgaris	1	0.05	
Stellaria graminea var. graminea	1	0.05	
Teesdalia nudicaulis	1	0.05	
Trifolium campestre	1	0.05	
Trifolium repens	1	0.05	
Veronica serpyllifolia	1	0.05	
Vicia sativa ssp. sativa	1	0.05	

Poa compressa. 16 invasives occur in ≥ 1% of the vegetation plots, including *Festuca* and *Poa* among the target species. There is a strong correlation between frequency of occurrence and invasive rank; that is, highly invasive species occur more frequently. Invasive rank was converted to an ordinal scale (A=1, B=2, C=3), and Pearson product-moment correlations were computed between frequency of occurrence for all exotic species ($r = -0.331$, $n=112$, $p<0.001$) and for only those exotics that occur in ≥ 1% of plots ($r = -0.407$, $n=59$, $p<0.005$). In addition, many more species ranked highly invasive are captured in plots than species ranked with low invasiveness (Table 6).

Table 6. Occurrence of invasive exotic plant species in 1,994 vegetation sample plots in Virginia.

Invasive Rank	# Species in Virginia Flora	# Species in Vegetation Plots	Percentage
A - high	32	19	59.4
B - medium	54	32	59.3
C - low	26	8	30.8
I - insignificant	692	80	11.6

In summary, a considerably smaller percentage of the exotic flora in Virginia has been captured in vegetation sample plots than the percentage of the total flora in the state, as would be expected since the plots are targeted to pristine habitat. Those exotics that do occur in plots, however, tend to be species that DCR considers invasive. This pattern is especially strong among species that occur in ≥ 1% of plots. A strong relationship exists between DCR invasive rank and the proportion of plots in which a species occurs. Moreover, plots capture a much higher percentage of exotic species considered to constitute a high or medium threat to natural communities than a percentage of exotics considered a low threat.

V. Conclusions

The threats posed by invasive exotic plant species are widely acknowledged by scientists, land managers, policymakers, and others (U.S. Congress 1993; Luken and Thieret 1997; ASTA 1999; Stein et al. 2000; USDA NRCS 2001). The DCR List of Invasive Alien Plant Species has been developed as a tool to raise awareness of the threat of invasive plants and provide information about species that have been identified as invasive. This study reviewed 11 species using revised ranking criteria. It also developed a predictive model to classify species as invasive or noninvasive and made use of extensive field data collect by DCR ecologists.

Based on the combination of literature and information review, multivariate analysis, and analysis of vegetation sample plot data, the 10 of the11 species under review were found to be of significant threat or potential threat to natural heritage resources in Virginia. Based upon this detailed analysis, these 10 species will remain on the advisory DCR List of Invasive Alien Plant Species in Virginia. Bermudagrass, however, will be removed from the list. As new information becomes available, these and other species should be reviewed to assess their ranking. It is expected that the ranking process itself will be refined as knowledge of invasive species and their impacts increases.

Although the problems posed by invasive exotic species to native species and natural communities were first identified by scientists over forty years ago (Elton 1958), most research into this area began to be published in the last fifteen years. It is important that research scientists, resource managers, commercial stakeholders, and policymakers remain in cordial and constructive dialog regarding the complex issues this subject raises.

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Appendix A.: Written Communications between American Seed Trade Association and Department of Conservation and Recreation

HOGAN & HARTSON
L.L.P.

NOV 0 9 2000

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555 THIRTEENTH STREET, NW
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November 6, 2000

Thomas L. Smith
Division Director, Natural Heritage Division
Virginia Department of Conservation and Recreation
217 Governor Street
Richmond, VA 23219

Dear Mr. Smith:

On behalf of American Seed Trade Association (ASTA), I am writing concerning the list of invasive alien plant species published by the Natural Heritage Division (the Division) of the Department of Conservation and Recreation (DCR). ASTA is the leading national trade association representing the interests of over 900 companies involved in seed production and distribution, plant breeding, and related industries.

ASTA recognizes that bona fide invasive alien plant species can cause substantial economic and environmental damage. Land management measures designed to prevent the introduction and spread of such species are warranted and have ASTA's full support. As the Natural Heritage Division makes clear on its website, however, many alien plant species provide substantial economic benefits (e.g., as forage plants, in gardens). Distinguishing truly invasive alien species from beneficial non-native species requires careful investigation and full consideration of a wide range of issues.

Unfortunately, ASTA's understanding of the Division's procedure for listing invasive alien plant species suggests that this thorough and careful analysis is not being done. DCR staff have advised ASTA representatives that the Division develops the list informally, in conjunction with the Virginia Native Plant Society. Species are added based primarily on individual recommendations. ASTA understands further that species may be, and frequently are, included without supporting scientific information or cost/benefit analyses. Moreover, no formal publication of nominations to the list or opportunity for public comment is provided.

As a result of this informal, non-public process, ASTA believes many beneficial plant species have been erroneously added to the list. These include birdsfoot trefoil, canada bluegrass, crownvetch, orchardgrass, red top, tall fescue, timothy, weeping lovegrass, white sweet clover, and yellow sweet clover. These species are not properly classified as invasive alien plant species under the definition subscribed to by the Natural Heritage Division (and published on its website) or that established by the President in his recent Executive Order (EO 13112, February 3, 1999) establishing an Invasive Species Council.

The continued inclusion of these species on the Natural Heritage Division's list is distorting planting decisions by Virginia state and private organizations. Land managers are refusing to plant these highly useful, beneficial species, citing their presence on the list. This refusal to plant directly affects the seed industry, substantially lowering revenues for numerous seed producers.

Because of the influence of the Natural Heritage Division's list, and its ability to affect planting decisions throughout Virginia and beyond, the list must reflect a thorough consideration and analysis of all scientific, environmental, and economic factors relevant to any particular species. Moreover, as a state government entity, the Division and DCR must be careful to ensure that publication of the invasive alien species list does not exceed DCR's authority and that due process in the listing process, including affording stakeholders an opportunity to be heard, is provided.

To ensure that due process and a full, science-based assessment of the relevant facts and evidence is conducted, ASTA would like the opportunity to meet with Natural Heritage Division staff to discuss the listing of birdsfoot trefoil, crownvetch, and the other species enumerated above, and to provide specific information relevant to each. ASTA is confident that, after meeting with ASTA representatives and reviewing this information, the Division will conclude that it has improperly classified these species as invasive alien plant species.

ASTA's Invasive Species Committee is prepared to meet with Division representatives at your earliest convenience. Please contact us as soon as possible to arrange a mutually convenient time.

Thank you for your cooperation. We look forward to hearing from you soon.

Sincerely,

Gary Jay Kushner /eym

Gary Jay Kushner
Counsel to American Seed Trade Association

James S. Gilmore, III
Governor

John Paul Woodley, Jr.
Secretary of Natural Resources

David G. Brickley
Director

COMMONWEALTH of VIRGINIA

DEPARTMENT OF CONSERVATION AND RECREATION

217 Governor Street, 3rd Floor
TDD (804) 786-2121 Richmond, Virginia 23219 (804) 786-7951 FAX (804) 371-2674
http://www.state.va.us/~dcr/vaher.html

February 1, 2001

Gary Jay Kushner
Hogan & Hartson
Columbia Square
555 Thirteenth Street, NW
Washington, DC 20004-1109

Dear Mr. Kushner:

Senior Assistant Attorney General Fisher, Chris Ludwig, and I enjoyed meeting with you and representatives of the American Seed Trade Association last month to discuss the *Invasive Alien Plant Species in Virginia* list. The Department of Conservation and Recreation (DCR) always welcomes the opportunity to discuss our programs, and we appreciate the time and effort on your part to travel to Richmond.

As we discussed at the December meeting, DCR is currently making some revisions to the text of the *Invasive Alien Plant Species in Virginia* list to further clarify the nonregulatory nature of the list. We have discussed this issue with the Department of Agriculture and Consumer Services and are in agreement on the position.

At our December meeting ASTA offered to provide the Department of Conservation and Recreation with information on economic effects and invasive tendencies for the ten species listed in your letter of November 6, 2000: birdsfoot trefoil, Canada bluegrass, crown-vetch, orchard grass, redtop, tall fescue, timothy, weeping lovegrass, white sweet clover, and yellow sweet clover. We look forward to receiving this information and will give it our close attention.

At your request, the Department is taking another look at the adaptive strategies, known distribution, and invasive tendencies of these ten species plus Bermuda grass, so that all current data is incorporated, thus giving the most objective ranking with regards to their potential threat to natural habitats.

Sincerely,

Thomas L. Smith
Natural Heritage Division Director

Cc: Frederick Fisher, Senior Assistant Attorney General
Dean Urmston, Executive Vice President, ASTA
J. Carlton Courter III, VA Commissioner of Agriculture

Appendix B.: DCR List of Invasive Alien Plant Species in Virginia

Invasive Alien Plant Species of Virginia

Department of Conservation and Recreation
Division of Natural Heritage
217 Governor Street
Richmond, Virginia 23219
(804) 786-7951
http://www.state.va.us/dnh/

Virginia Native Plant Society
Blandy Experimental Farm
400 Blandy Farm Lane, Unit 2
Boyce, Virginia 22620
(540) 837-1600
http://www.vnps.org

June 1999

This list was developed in a cooperative project between the Virginia Department of Conservation and Recreation's Division of Natural Heritage and the Virginia Native Plant Society

Key

A = High	M = Mountains	F = Full sun	H = Hydric
B = Medium	P = Piedmont	P = Partial sun	M = Mesic
C = Low	C = Coastal	S = Shade	X = Xeric

COMMON NAME	SCIENTIFIC NAME	INVASIVENESS			REGION			LIGHT			MOISTURE		
		A	B	C	M	P	C	F	P	S	H	M	X
TREES													
Black pine	*Pinus thunbergii*			●			●	●	●			●	
China-berry	*Melia azedarach*		●			●	●	●	●			●	
Mimosa	*Albizia julibrissin*			●	●	●	●	●	●			●	
Norway maple	*Acer platanoides*		●		●	●	●	●	●			●	
Sawtooth oak	*Quercus acutissima*			●	●			●				●	
Siberian elm	*Ulmus pumila*			●		●		●	●			●	
Tree-of-heaven	*Ailanthus altissima*	●			●	●	●	●	●			●	
White mulberry	*Morus alba*			●	●	●	●	●	●			●	
White poplar	*Populus alba*		●		●	●	●	●	●			●	
VINES													
Balloon vine	*Cardiospermum halicababum*		●				●	●				●	
Chinese wisteria	*Wisteria sinensis*		●			●	●		●	●		●	
English ivy	*Hedera helix*		●			●	●	●	●	●		●	
Fiveleaf akebia	*Akebia quinata*		●			●	●	●	●	●		●	
Japanese honeysuckle	*Lonicera japonica*	●			●	●	●	●	●	●		●	
Japanese hops	*Humulus japonicus*		●		●	●	●	●	●	●	●	●	
Japanese wisteria	*Wisteria floribunda*			●			●		●	●		●	
Kudzu vine	*Pueraria lobata* (*P. montana*)	●			●	●	●	●	●	●		●	
Oriental bittersweet	*Celastrus orbiculatus*	●			●	●	●		●	●		●	
Periwinkle	*Vinca minor* & *V. major*			●	●	●	●	●	●	●		●	
Porcelain-berry	*Ampelopsis brevipedunculata*	●				●		●	●	●		●	

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		A	B	C	M	P	C	F	P	S	H	M	X
SHRUBS													
Amur honeysuckle	*Lonicera maackii*		●		●	●			●			●	
Autumn olive	*Elaeagnus umbellata*	●			●	●	●	●	●			●	
Bell's honeysuckle	*Lonicera x bella*			●	●	●	●	●	●			●	
Blunt-leaved privet	*Ligustrum obtusifolium*		●			●	●			●		●	
Chinese privet	*Ligustrum sinense*	●			●	●	●		●	●		●	
Japanese barberry	*Berberis thunbergii*		●		●	●	●	●	●	●		●	
Japanese spirea	*Spiraea japonica*		●		●	●			●	●	●	●	
Linden viburnum	*Viburnum dilatatum*			●		●		●	●			●	
Morrow's honeysuckle	*Lonicera morrowii*	●			●	●		●	●	●		●	
Multiflora rose	*Rosa multiflora*	●			●	●	●	●	●			●	
Russian olive	*Elaeagnus angustifolia*			●	●	●	●	●	●			●	
Standish's honeysuckle	*Lonicera standishii*	●			●	●			●	●		●	
Sweet breath of spring	*Lonicera fragrantissima*			●		●		●	●			●	
Tartarian honeysuckle	*Lonicera tatarica*		●		●	●		●	●			●	
Thorny elaeagnus	*Elaeagnus pungens*			●		●	●		●			●	
Wineberry	*Rubus phoenicolasius*	●			●	●	●		●	●		●	
Winged burning bush	*Euonymus alatus*	●				●			●	●		●	
Wintercreeper	*Euonymus fortunei*		●				●		●	●	●	●	

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		A	B	C	M	P	C	F	P	S	H	M	X
HERBACEOUS PLANTS													
Alligator weed	*Alternanthera philoxeroides*	●					●	●	●		●		
Aneilima	*Murdannia keisak*	●				●	●	●	●		●		
Asiatic sand sedge	*Carex kobomugi*	●					●	●	●				●
Beefsteak plant	*Perilla frutescens*			●	●	●	●		●	●		●	
Bermuda grass	*Cynodon dactylon*		●		●	●	●	●				●	
Birdsfoot trefoil	*Lotus corniculatus*			●	●	●	●	●	●			●	●
Brazilian water-weed	*Egeria densa*		●		●	●	●	●	●		●		
Bristled knotweed	*Polygonum cespitosum*		●		●	●	●	●	●	●	●	●	
Brown knapweed	*Centaurea jacea*		●		●	●		●	●			●	●
Bugleweed	*Ajuga reptans*			●	●	●	●	●	●			●	●
Bull-thistle	*Cirsium vulgare*		●		●	●	●	●				●	
Canada bluegrass	*Poa compressa*		●		●	●	●	●	●	●		●	●
Canada thistle	*Cirsium arvense*	●			●	●	●	●				●	
Chinese lespedeza	*Lespedeza cuneata*	●			●	●		●				●	
Chinese yam	*Dioscorea batatas*	●			●	●	●		●	●		●	
Cogon grass	*Imperata cylindrica*	●					●		●	●		●	
Common chickweed	*Stellaria media*		●		●	●	●	●	●	●		●	
Common cocklebur	*Xanthium strumarium*		●		●	●	●	●	●			●	●
Common dayflower	*Commelina communis*			●	●	●	●	●	●			●	
Common morning-glory	*Ipomoea purpurea*		●		●	●	●	●				●	
Common reed	*Phragmites australis*	●				●	●	●	●		●	●	
Common teasel	*Dipsacus sylvestris*		●		●	●	●	●			●	●	
Crown-vetch	*Coronilla varia*		●		●	●	●	●				●	●
Curled dock	*Rumex crispus*		●		●	●		●				●	●
Cut-leaf teasel	*Dipsacus laciniatus*		●		●			●				●	
European water-milfoil	*Myriophyllum spicatum*	●			●	●	●	●			●		
Fennel	*Foeniculum vulgare*		●			●	●	●			●	●	●
Field-bindweed	*Convovulus arvensis*		●		●	●	●	●	●			●	
Garlic mustard	*Alliaria petiolata*	●			●	●		●	●	●		●	

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		A	B	C	M	P	C	F	P	S	H	M	X
Giant foxtail	*Setaria faberi*		●			●	●	●	●			●	
Giant reed	*Arundo donax*		●			●	●	●	●		●	●	
Gill-over-the-ground	*Glechoma hederacea*		●		●	●	●		●	●		●	
Golden bamboo	*Phyllostachys aurea*		●			●	●	●	●			●	
Hydrilla	*Hydrilla verticillata*	●					●	●	●		●		
Ivy-leaved morning-glory	*Ipomoea hederacea*		●		●	●	●	●	●		●	●	
Ivy-leaved speedwell	*Veronica herderaefolia*		●		●	●	●	●	●	●		●	
Japanese knotweed	*Polygonum cuspidatum*	●			●	●	●	●	●			●	
Japanese stilt grass	*Microstegium vimineum*	●			●	●	●	●	●	●	●	●	
Johnson-grass	*Sorghum halapense*	●			●	●	●	●	●			●	
Jointed charlock	*Raphanus raphanistrum*		●		●	●	●	●				●	
Jointed grass	*Arthraxon hispidus*		●		●	●	●	●	●	●	●	●	
Leafy spurge	*Euphorbia esula*			●	●	●			●	●		●	
Lesser celandine	*Ranunculus ficaria*	●					●		●	●		●	
Mile-a-minute	*Polygonum perfoliatum*	●				●		●	●	●		●	
Moneywort	*Lysimachia nummularia*		●		●	●	●	●	●	●	●	●	
Mugwort	*Artemisia vulgaris*		●		●	●	●	●	●			●	●
Musk thistle	*Carduus nutans*		●		●	●	●	●				●	
Nipplewort	*Lapsana communis*			●	●			●	●			●	
Oatgrass	*Arrhenatherum elatius*			●	●	●	●	●	●			●	
Orchard grass	*Dactylis glomerata*			●	●	●	●	●	●			●	
Parrot's feather	*Myriophyllum aquaticum*	●			●	●	●	●			●		
Poison hemlock	*Conium maculatum*			●	●	●	●	●	●			●	
Purple loosestrife	*Lythrum salicaria & L. virgatum*	●			●	●	●	●			●	●	
Quack grass	*Agropyron repans*		●		●	●	●	●	●			●	
Red morning-glory	*Ipomoea coccinea*			●	●	●	●	●				●	
Red sorrel	*Rumex acetosella*		●		●	●	●	●	●			●	
Redtop	*Agrostis gigantea*		●		●	●	●	●	●			●	
Rhode Island bent-grass	*Agrostis tenuis*		●		●	●		●	●			●	
Rough bluegrass	*Poa trivialis*		●		●	●	●	●	●	●	●	●	
Short-fringed knapweed	*Centaurea dubia*	●			●			●	●			●	●

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COMMON NAME	SCIENTIFIC NAME	INVASIVENESS			REGION			LIGHT			MOISTURE		
		A	B	C	M	P	C	F	P	S	H	M	X
Shrubby bushclover	*Lespedeza bicolor*		●		●	●	●	●	●			●	
Sickle pod	*Cassia obtusifolia*		●			●	●	●	●			●	●
Silvergrass	*Miscanthus sinensis*			●	●	●	●	●	●			●	
Spotted knapweed	*Centaurea maculosa*	●			●	●	●	●	●				●
Tall fescue	*Festuca elatior* (*F. pratensis*)		●		●	●	●	●	●			●	
Timothy	*Phleum pratense*			●	●	●	●	●	●			●	
Velvet-grass	*Holcus lanatus*		●		●	●	●	●	●		●	●	
Water chestnut	*Trapa natans*			●			●	●			●	●	
Weeping lovegrass	*Eragrostis curvula*		●		●	●	●	●				●	●
White sweet clover	*Melilotus alba*		●		●	●	●	●	●			●	
Wild onion	*Allium vineale*		●		●	●	●	●	●			●	
Wild parsnip	*Pastinaca sativa*			●	●	●	●	●	●			●	
Yellow flag	*Iris pseudacorus*		●		●	●	●	●	●		●		
Yellow sweet clover	*Melilotus officinalis*		●		●	●	●	●	●			●	

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C = Low	C = Coastal	S = Shade	X = Xeric

COMMON NAME	SCIENTIFIC NAME	INVASIVENESS			REGION			LIGHT			MOISTURE		
		A	B	C	M	P	C	F	P	S	H	M	X

About the List
This advisory list is published by Virginia Department of Conservation and Recreation (VDCR) to inform land managers of potential risks associated with certain plant species know to exhibit invasive behavior in some situations. It should also be noted the list is not regulatory in nature, and thus does not prohibit the use of the listed plant species.

VDCR Natural Heritage and Virginia Native Plant Society use detailed criteria to assess the invasiveness of a plant. Factors used to rank each species include: culmulative impacts on natural areas; potential to disperse and invade natural landscapes; distribution and abundance; difficulty to manage; and impacts on other species. The list is periodically reviewed and updated by land managers, nurserymen, landscape architects, horticulturalists, botantists, wildlife biologists, and other conservation partners.

Invasiveness Ranking
Each species on the list is assessed according to its cumulative effects on natural areas and native plant habitats where it typically occurs.

The A-ranked species exhibit the most invasive tendancies in natural areas and native plant habitats. they may disrupt ecosystem processes and cause ma

The B-ranked species exhibit moderate invasiveness in natural areas. They may have minor influence on ecosystem processes, alter plant community com threatening all species found in the community. These species usually require a minor disturbance to become established.

The C-ranked species generally do not affect ecosystem processes but may alter plant community composition by outcompeting one or more native plant species. They often establish in severely disturbed areas. The disturbance may be natural or human origin, such as icestorm damage, windthrow, or road construction. These species spread slowly or not at all from disturbed sites.

Regions
For purposes of this list, the state has been divided into three regions. Coastal Plain and Piedmont follow conventional boundaries. Blue Ridge, Ridge and Valley, and Cumberland Plateau and grouped together into one region called Mountain.

Habitat Requirements
The categories for light and soil requirements are very broad and are meant only to give general indication of habitat adaptations for these plants.

Appendix C.: Plant Invasiveness Rank Forms

PLANT SPECIES INVASIVENESS RANK FORM

SUMMARY SPECIES DATA

Scientific Name: ***Agrostis gigantea***

Synonyms:
Common Name(s): **Redtop**
Native Range: **Europe**

AUTHOR INFORMATION

Author: Kevin Heffernan

Author's affiliation: Virginia Department of Conservation and Recreation

Mailing address: 217 Governor St., Richmond, VA 23219

RANKING CRITERIA

SECTION I. IMPACT ON NATIVE SPECIES, HABITATS AND ECOSYSTEMS

Where possible assess the *cumulative* (e.g., over a period of several decades) impact of the species on the natural areas and other wildlands where it typically occurs. Impacts will be re-assessed as more is learned and as the species moves into new areas.

A. Ability to Invade Natural Systems
Choose one answer that best describes the ability of this species to invade natural systems:

I. Not known to spread into natural areas on its own (e.g., species may persist from former cultivation)
L. Establishes only in areas where major disturbance has occurred in last 20 years (e.g., post-hurricane sites, highway corridors)
M Often establishes in mid- to late-successional natural areas where minor disturbances may occur (e.g., tree falls, hiking trails, streambank erosion), but no major disturbance in last 20-75 years
H. Often establishes in intact or otherwise healthy natural areas with no major disturbance for at least 75 yrs

Comments: Redtop is established by seeding, but may also colonize areas disturbed by flooding or fire (USDAFS 2001). In 2000 vegetation classification plots, redtop appeared in less than 1% of the plots (Heffernan et al. 2001).

B. Impact on Ecosystem Processes

Species that alter processes such as fire occurrence or frequency, erosion and sedimentation rates, hydrological regimes, or nutrient regimes often have the greatest long-term impacts on ecosystems. Some non-native invaders can completely transform natural systems so that they can no longer support native species.

Choose one answer that best describes the impact of this species on ecological processes:

I. No perceivable impact on ecosystem processes

L. Influences ecosystem processes (e.g., has perceivable but mild influence on soil nutrient availability)

M. Significant alteration in ecosystem processes (e.g., increases sedimentation rates along coastlines, reducing open water areas that are important for waterfowl)

H. Major, possibly irreversible, alteration or disruption of ecosystem processes (e.g., the species drains water from open water or wetland systems through rapid transpiration, making these areas more fire prone and unable to support native wetland species; species fixes nitrogen in the soil making soil unlikely to support certain native plants)

Comments:

C. Impact on Natural Community Structure

Choose one answer that best describes this species' impact on community structure:

I. No impact; establishes in an existing layer without influencing its structure

L. Influences structure in one layer (e.g., changes density of a layer)

M. Significant impact on at least one layer (e.g., creation of a new layer, elimination of an existing layer)

H. Major alteration of structure (e.g., covers canopy, eradicating most or all layers below)

Comments: Redtop establishes at a site following disturbance such as flood or fire. It is a colonizing species and does not alter an established community or vegetation layer (USDAFS 2001).

D. Impact on Natural Community Composition

Choose one answer that best describes this species' impact on community composition:

I. No impact; causes no perceivable change in native populations

L. Influences community composition (e.g., reduces the number of individuals in one or more native populations by reducing recruitment)

M. Significantly alters community composition (e.g., produces a significant reduction in the population size of one or more native species in the community)

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

Comments: Redtop is reported to occur in pure stands and in stands with other graminoids (USDAFS 2001). Native species and other exotic plant species, such as sweet clover (*Melilotus officinalis*), are reported to invade older redtop stands (USDAFS 2001).

E. Conservation Significance of the Natural Area(s) and Native Species Threatened
Many exotic plants occur primarily in disturbed, low quality habitats that are dominated by other exotic species. Exotic plants have a greater impact if they (a) directly or indirectly threaten native species or communities that are considered rare or vulnerable (e.g., Federally listed or ranked G1-G3 by The Nature Conservancy and Natural Heritage Network), or (b) threaten outstanding, high quality occurrences of common community types.

Choose one answer that best describes the overall conservation significance of native species or communities impacted by this exotic species:

I. Insignificant (e.g., found in human-disturbed habitats and is not known to impact any vulnerable or high quality native species or communities)
L. Low significance (e.g., usually inhabits common, unthreatened habitats and rarely impacts vulnerable or high quality species or communities)
M. Moderately significant (e.g., may occasionally threaten vulnerable or high quality species or communities)
H. Highly significant (e.g., known to inhabit one or more vulnerable or high quality communities and/or often threatens rare native species)

Comments: Redtop requires disturbance to become established at a site (USDAFS 2001). Natural and human-caused disturbances may allow redtop to become established in natural areas. Human-caused disturbances that may directly affect some natural areas are those associated with prescribed fire, roads, trails, and parking lots.

- **Impact Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Subrank Guidance
Minimum ranking information: to determine Impact Subrank, you must answer both categories A and B as well as at least one other category in this section.
If H in A and B, Subrank = High
If H in A or B, and M or H in at least one other category (A-E), Subrank = High
If M in A and B, and H in at least one other category, Subrank = High
If M in A or B, and M or H in at least one other category, Subrank = Medium
If L in A or B, and H in at least one other category, Subrank = Medium
If M in at least one category, Subrank = Low
All others, Subrank = Insignificant

SECTION II. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY

A. Biological Characteristics: Reproduction, Competitive Ability, and Dispersal

The following are some biological characteristics of invasive species. Check those that apply to this species and note any other weedy or invasive traits this species possesses in the space for comments below.

Reproduction:

- ☐ Reproduces readily both vegetatively and by seed
- ☐ If reproduction is by seed, produces over 1,000 seeds per plant annually
- ☐ Reproduces more than once per year
- ☒ Rapid growth to reproductive maturity
- ☒ Seeds remain viable in soil for 2 or more years
- ☒ Has quickly spreading rhizomes that may root at nodes
- ☐ Resprouts readily when cut, grazed or burned
- ☐ Other (please discuss in comments)

Competitive ability:

- ☐ Highly successful competitor for limiting resources
- ☐ Tolerance of a wide range of conditions or tolerance of stressful conditions
- ☐ Ability to germinate in vegetated areas under a wide range of conditions
- ☐ Allelopathic
- ☐ Known to hybridize with native species
- ☐ Lack of natural predators or control agents in the United States
- ☐ Other (please discuss in comments)

Dispersal ability:

- ☐ Rapid local proliferation of seeds
- ☒ Long-distance dispersal ability (e.g., bird dispersed seed, small seeds carried by water)
- ☐ Other (please discuss in comments)

Choose one answer that best describes the biological characteristics of this species:

I. Not aggressive (e.g., has none of the above characteristics or only one or two to a very small extent)
L. Somewhat aggressive (e.g., has only one or two of the above and to a small extent)
M. Moderately aggressive (e.g., has two or more of the above characteristics, but has only one or two to a great extent)
H. Extremely aggressive (e.g., has three or more of the above characteristics and has them to a great extent)

Comments: Source: USDAFS (2001) and USDA NRCS (2000). Using a suite of plant characteristics and data from NRCS PLANTS Database, a predictive model classified this species as invasive (Heffernan et al 2001).

B. Other regions invaded

Is this species known to be invasive beyond its native range in other areas outside the United States? **NO**
If yes, briefly list the other countries or regions invaded:

C. Dispersal Ability and Speed of Spread

1. Speed of spread (increase in range) once reported as escaped
Choose one answer that best describes the speed of spread:

I. Does not spread
L. Slow -- doubling time (new local reports) > 50 years
M. Moderate -- doubling time (new local reports) 10-50 years
H. Rapid -- doubling time (new local reports) < 10 years

Comments (if possible, comment on the maximum speed of spread): No data.

2. Current trend in total range within the United States
Choose one answer that best describes the current trend:

I. Declining or Historical
L. Stable
M. Increasing
H. Increasing rapidly

Comments:

3. Potential to be spread by human activity
Is this species frequently spread or does it have has high potential to be spread by human activity (e.g., species is sold commercially for use in agriculture or ornamental horticulture; species takes advantage of transportation corridors such as highways; species is aquatic and is transported by boats or boat trailers)? **YES**

Comments: This species is widely used as forage for livestock and for streambank stabilization. It has also been used to revegetate abandon mine sites (USDAFS 2001).

- **Biology/Dispersal Ability Subrank** (enter Insignificant, Low, Medium or High)**:**

LOW

Subrank Guidance
Minimum ranking information: to determine this Subrank, you must answer at least 4 of the 5 questions above.
Use the following scoring system: 3 points for H, 2 for M, 1 for L; 2 for Yes. Highest possible score = 13
If total score is 9-13, Subrank = High
If total score is 6-8, Subrank = Medium
If total score is 3-5, Subrank = Low
If total score is 0-2, Subrank = Insignificant

SECTION III. DISTRIBUTION AND ABUNDANCE IN VIRGINIA AND THE UNITED STATES

A. Approximate number of distinct natural areas or other wildlands infested in Virginia.
Choose one answer that best matches the number of sites infested:

(Treat one site as the rough equivalent of one preserve, park, BLM district, wildlife refuge, wilderness area, etc.)

I. < 5 (few; scattered)
L. 6 to 10 sites
M. 11 to 30 sites
H. Greater than 30 sites
Enter approximate date of information (year): 2001

Comments: (Include Virginia range information from *Atlas of Virginia Flora*.) Redtop was reported as occurring at one state park and two natural area preserves (Caljouw 1994). It occurs in 81 Virginia localities and all physiographic provinces (Harvill et al 1992).

B. Extent of the species U.S. range in which it has been identified as a problem by land managers
Some non-native species are not invasive everywhere they occur in U.S. but only in certain regions or habitats. For instance, Tamarisks are severe riparian and wetland pests from California to Texas and north at least to Kansas, but while they escape occasionally in the eastern United States, they have not been reported as a problem east of the Mississippi.

This species has been identified by land managers as a problem in approximately what portion of its U.S. range?
Choose one answer that best describes the extent of range in which considered to be a problem:

I. 0 to 5%
L. 6 to 20%
M. 20 to 50%
H. Greater than 50%

Comments (Include U.S. range information. If the species is a threat to only certain types of natural communities, please specify):
Redtop occurs in 45 states (Kartesz 1999) and is listed as a weed in Stubbendieck et al. (1994) and Whitson et al. (1996).

C. Potential cover of the species in strata where it occurs
Choose one answer that best describes the potential cover:

I. Infrequent (less than 10%)
L. Fair coverage but less than half (10 - 50%)
M. Dominant (50 - 90%)
H. Monospecific stand (90 - 100%)

Comments: May occur in pure stands or with sedges (Carex spp., spikerushes (Eleocharis spp.), and other grasses (FEIS 2000).

- **Distribution and Abundance Subrank** (enter Insignificant, Low, Medium or High)**:**

LOW

Subrank Guidance
Minimum ranking information: to determine this Subrank, you must answer A. and at least 1 other question in this section.
If H in A, and M or H in at least one other category, Subrank = High
If H in A, and L or I in all other categories, Subrank = Medium
If M in A, and H in at least one other category, Subrank = High
If M in A, and M in at least one other category, Subrank = Medium
If M in A, and L or I in all other categories, Subrank = Medium
If L in A, and H in at least one other category, Subrank = Medium
If L in A, and M in at least one other category, Subrank = Low
If I in A, and H in at least one other category, Subrank = Low
All others, Subrank = Insignificant

SECTION IV. MANAGEMENT POTENTIAL

Given the current state of knowledge regarding management methods, how difficult is it to control this species?

I. Management is not required (e.g., species does not persist without repeated disturbance)
L. Management is relatively easy and inexpensive; requires a minor investment in human and financial resources
M. Management requires a major short-term investment of human and financial resources, or a moderate long-term investment
H. Management requires a major, long-term investment of human and financial resources

- **Management Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Comments (Comment on both the difficulty of control and on the extent of knowledge that exists regarding the management of this species. Please keep comments brief -- do not go into detail on control methods):

Redtop can be controlled with the herbicide atrazine (USDAFS 2001), a product commonly used to control cool season grasses. Management Subrank of MEDIUM was selected here as a conservative estimate of the effort required to control a grass species with pesticide on a natural area preserve.

SECTION V. OVERALL RANKING PROCEDURE FOR PLANT SPECIES INVASIVENESS RANK

The Plant Species Invasiveness Rank is a rating of the overall significance of the threat caused by this species to native species and native plant habitat in Virginia, based on the four subranks below.

- **SUBRANKS**

I.	**Impact subrank:**	**INSIGNIFICANT**
II.	**Biology and dispersal ability subrank:**	**LOW**
III.	**Distribution and abundance subrank:**	**HIGH**
IV.	**Management subrank**:	**MEDIUM**

The Plant Species Invasiveness Rank is based on the four subranks. Please assign scores to the subranks as follows:

Weighted average/point system

SUBRANK:		**SCORE:**
I.	Impact	H = 4, M = 3, L = 2, I = 0
II.	Biology	H = 3, M = 2, L = 1, I = 0
III.	Distribution	H = 1, M = 0, L = 0, I = 0
IV.	Management	H = 2, M = 1, L = 0, I = 0

Add up these scores to get overall Plant Species Invasiveness Rank. Highest possible score = 10

Overall ranking scale:

I.	Insignificant:	total score = 0-3	Species represents an insignificant threat to natural communities
L.	Low:	total score = 4-6	Species represents low threat to natural communities
M.	Medium:	total score = 7-8	Species represents moderate threat to natural communities
H.	High:	total score = 9-10	Species represents high threat to natural communities

Examples: A species with the significance category of "I" may be exotic but poses little or no threat to natural communities. A species with the significance category of "H" poses a serious threat to native species and communities in Virginia.

- **PLANT SPECIES INVASIVENESS RANK**
  (Enter Insignificant, Low, Medium or High)**: LOW**

SECTION VI. REFERENCES

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PLANT SPECIES INVASIVENESS RANK FORM

SUMMARY SPECIES DATA

Scientific Name: ***Coronilla varia***

Synonyms: **Securigera varia**
Common Name(s): **Crown Vetch**
Native Range: **Europe, Northern Africa, and Southwest Asia.**

AUTHOR INFORMATION

Author: **Kevin Heffernan**

Author's affiliation: **Virginia Department of Conservation and Recreation, Division of Natural Heritage**

Mailing address: **217 Governor St., Richmond, VA 23219**

Edition date (mm/dd/yyyy): **04/16/2001**

RANKING CRITERIA

SECTION I. IMPACT ON NATIVE SPECIES, HABITATS AND ECOSYSTEMS

Where possible assess the *cumulative* (e.g., over a period of several decades) impact of the species on the natural areas and other wildlands where it typically occurs. Impacts will be re-assessed as more is learned and as the species moves into new areas.

A. Ability to Invade Natural Systems
Choose one answer that best describes the ability of this species to invade natural systems:

I. Not known to spread into natural areas on its own (e.g., species may persist from former cultivation)
L. Establishes only in areas where major disturbance has occurred in last 20 years (e.g., post-hurricane sites, highway corridors)
M Often establishes in mid- to late-successional natural areas where minor disturbances may occur (e.g., tree falls, hiking trails, streambank erosion), but no major disturbance in last 20-75 years
H. Often establishes in intact or otherwise healthy natural areas with no major disturbance for at least 75 yrs

Comments: Crown vetch can spread into undisturbed sites via rhizomes and by seed (Hoffman and Kearns 1997); seed may remain dormant in the soil for over 15 years (WIDNR 1998). Walton (pers. comm.) found crown vetch invading a significant shale barren community that supports the state rare yellow nailwort (*Paronychia virginica*).

B. Impact on Ecosystem Processes

Species that alter processes such as fire occurrence or frequency, erosion and sedimentation rates, hydrological regimes, or nutrient regimes often have the greatest long-term impacts on ecosystems. Some non-native invaders can completely transform natural systems so that they can no longer support native species.

Choose one answer that best describes the impact of this species on ecological processes:

I. No perceivable impact on ecosystem processes

L. Influences ecosystem processes (e.g., has perceivable but mild influence on soil nutrient availability)

M. Significant alteration in ecosystem processes (e.g., increases sedimentation rates along coastlines, reducing open water areas that are important for waterfowl)

H. Major, possibly irreversible, alteration or disruption of ecosystem processes (e.g., the species drains water from open water or wetland systems through rapid transpiration, making these areas more fire prone and unable to support native wetland species; species fixes nitrogen in the soil making soil unlikely to support certain native plants)

Comments: Crown vetch possesses high nitrogen-fixing ability that increases soil nitrogen (USDA NRCS 2000). Increased soil fertility can increase competition between plants adapted to low fertility habitat and species that require higher soil fertility conditions (Ramakrishnan and Vitousek. 1989, Vitousek and Walker 1989, Vitousek 1990).

C. Impact on Natural Community Structure

Choose one answer that best describes this species' impact on community structure:

I. No impact; establishes in an existing layer without influencing its structure

L. Influences structure in one layer (e.g., changes density of a layer)

M. Significant impact on at least one layer (e.g., creation of a new layer, elimination of an existing layer)

H. Major alteration of structure (e.g., covers canopy, eradicating most or all layers below)

Comments: Crown vetch forms dense monospecific groundcover layer (USDA NRCS 2001).

D. Impact on Natural Community Composition

Choose one answer that best describes this species' impact on community composition:

I. No impact; causes no perceivable change in native populations

L. Influences community composition (e.g., reduces the number of individuals in one or more native populations by reducing recruitment)

M. Significantly alters community composition (e.g., produces a significant reduction in the population size of one or more native species in the community)

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

Comments: Crown vetch forms dense monospecific groundcover layer, thus reducing the abundance and presence of other species in the groundcover layer. Few species can compete with crown vetch once it is established (USDA NRCS 2001).

E. Conservation Significance of the Natural Area(s) and Native Species Threatened
Many exotic plants occur primarily in disturbed, low quality habitats that are dominated by other exotic species. Exotic plants have a greater impact if they (a) directly or indirectly threaten native species or communities that are considered rare or vulnerable (e.g., Federally listed or ranked G1-G3 by The Nature Conservancy and Natural Heritage Network), or (b) threaten outstanding, high quality occurrences of common community types.

Choose one answer that best describes the overall conservation significance of native species or communities impacted by this exotic species:

I. Insignificant (e.g., found in human-disturbed habitats and is not known to impact any vulnerable or high quality native species or communities)
L. Low significance (e.g., usually inhabits common, unthreatened habitats and rarely impacts vulnerable or high quality species or communities)
M. Moderately significant (e.g., may occasionally threaten vulnerable or high quality species or communities)
H. Highly significant (e.g., known to inhabit one or more vulnerable or high quality communities and/or often threatens rare native species)

Comments: The threat of invasion by crown vetch comes from sites where it is established on roads, trails, fire breaks, power lines. In Wisconsin, crownvetch is reported to have invaded remnant prairies, woodland edges, and streambanks and gravel bars (WIDNR 1999). Some rare plant species in Virginia are found in road rights-of-way and are threatened by crown vetch, e.g. Kankakee mallow (*Iliamna remota*), which is directly threatened by crown vetch at several sites (Heffernan 2000).

- **Impact Subrank** (enter Insignificant, Low, Medium or High)**:**

LOW

Subrank Guidance
Minimum ranking information: to determine Impact Subrank, you must answer both categories A and B as well as at least one other category in this section.
If H in A and B, Subrank = High
If H in A or B, and M or H in at least one other category (A-E), Subrank = High
If M in A and B, and H in at least one other category, Subrank = High
If M in A or B, and M or H in at least one other category, Subrank = Medium
If L in A or B, and H in at least one other category, Subrank = Medium
If M in at least one category, Subrank = Low
All others, Subrank = Insignificant

SECTION II. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY

A. Biological Characteristics: Reproduction, Competitive Ability, and Dispersal

The following are some biological characteristics of invasive species. Check those that apply to this species and note any other weedy or invasive traits this species possesses in the space for comments below.

Reproduction:
- ☒ Reproduces readily both vegetatively and by seed
- ☐ If reproduction is by seed, produces over 1,000 seeds per plant annually
- ☐ Reproduces more than once per year
- ☐ Rapid growth to reproductive maturity
- ☒ Seeds remain viable in soil for 2 or more years
- ☒ Has quickly spreading rhizomes that may root at nodes
- ☒ Resprouts readily when cut, grazed or burned
- ☐ Other (please discuss in comments)

Competitive ability:
- ☒ Highly successful competitor for limiting resources
- ☒ Tolerance of a wide range of conditions or tolerance of stressful conditions
- ☐ Ability to germinate in vegetated areas under a wide range of conditions
- ☐ Allelopathic
- ☐ Known to hybridize with native species
- ☐ Lack of natural predators or control agents in the United States
- ☐ Other (please discuss in comments)

Dispersal ability:
- ☐ Rapid local proliferation of seeds
- ☐ Long-distance dispersal ability (e.g., bird dispersed seed, **small seeds** carried by water)
- ☐ Other (please discuss in comments)

Choose one answer that best describes the biological characteristics of this species:

I. Not aggressive (e.g., has none of the above characteristics or only one or two to a very small extent)
L. Somewhat aggressive (e.g., has only one or two of the above and to a small extent)
M. Moderately aggressive (e.g., has two or more of the above characteristics, but has only one or two to a great extent)
H. Extremely aggressive (e.g., has three or more of the above characteristics and has them to a great extent)

Comments: USDA NRCS (2000), Randall and Marinelli (1996), and Heim (1990).

B. Other regions invaded

Is this species known to be invasive beyond its native range in other areas outside the United States? **NO**
If yes, briefly list the other countries or regions invaded:

C. Dispersal Ability and Speed of Spread

1. Speed of spread (increase in range) once reported as escaped
Choose one answer that best describes the speed of spread:

I. Does not spread
L. Slow -- doubling time (new local reports) > 50 years
M. Moderate -- doubling time (new local reports) 10-50 years
H. Rapid -- doubling time (new local reports) < 10 years

Comments (if possible, comment on the maximum speed of spread): No data.

2. Current trend in total range within the United States
Choose one answer that best describes the current trend:

I. Declining or Historical
L. Stable
M. Increasing
H. Increasing rapidly

Comments: Crown vetch is a very popular species for erosion control, livestock, and wildlife plantings. This species has become widely established since its introduction in the 1950's (USDA NRCS 2000).

3. Potential to be spread by human activity
Is this species frequently spread or does it have has high potential to be spread by human activity (e.g., species is sold commercially for use in agriculture or ornamental horticulture; species takes advantage of transportation corridors such as highways; species is aquatic and is transported by boats or boat trailers)? **YES**

Comments: See comment in Section II. 2.

- **Biology/Dispersal Ability Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Subrank Guidance
Minimum ranking information: to determine this Subrank, you must answer at least 4 of the 5 questions above.
Use the following scoring system: 3 points for H, 2 for M, 1 for L; 2 for Yes. Highest possible score = 13
If total score is 9-13, Subrank = High
If total score is 6-8, Subrank = Medium
If total score is 3-5, Subrank = Low
If total score is 0-2, Subrank = Insignificant

SECTION III. DISTRIBUTION AND ABUNDANCE IN VIRGINIA AND THE UNITED STATES

A. Approximate number of distinct natural areas or other wildlands infested in Virginia.
Choose one answer that best matches the number of sites infested:

(Treat one site as the rough equivalent of one preserve, park, BLM district, wildlife refuge, wilderness area, etc.)
I. < 5 (few; scattered)
L. 6 to 10 sites
M. 11 to 30 sites
H. Greater than 30 sites
Enter approximate date of information (year):

Comments: (Include Virginia range information from *Atlas of Virginia Flora*.) Walton (pers. comm.) found crown vetch invading a significant shale barren community that supports the state rare yellow nailwort (*Paronychia virginica*). This species was found at four state parks and three natural area preserves (Caljouw 1994). Crown vetch was reported from 53 Virginia counties (Harvill 1992).

B. Extent of the species U.S. range in which it has been identified as a problem by land managers
Some non-native species are not invasive everywhere they occur in U.S. but only in certain regions or habitats. For instance, Tamarisks are severe riparian and wetland pests from California to Texas and north at least to Kansas, but while they escape occasionally in the eastern United States, they have not been reported as a problem east of the Mississippi.

This species has been identified by land managers as a problem in approximately what portion of its U.S. range?
Choose one answer that best describes the extent of range in which considered to be a problem:

I. 0 to 5%
L. 6 to 20%
M. 20 to 50%
H. Greater than 50%

Comments (Include U.S. range information. If the species is a threat to only certain types of natural communities, please specify): Crown vetch is present in 45 continental US states, Hawaii, and five Canadian provinces (Kartesz 1999, USDA NRCS 2000). The Wisconsin Department of Natural Resources identifies crown vetch as an invasive plant that threatens remnant prairie habitat (WIDNR 1999). The Tennessee Exotic Pest Plant Council list crown vetch as an invasive plant (SEEPC 2001). Crownvetch is also reported as a problem in the Northeast and Midwest (Randall and Marinelli 1996).

C. Potential cover of the species in strata where it occurs
Choose one answer that best describes the potential cover:
I. Infrequent (less than 10%)
L. Fair coverage but less than half (10 - 50%)
M. Dominant (50 - 90%)
H. Monospecific stand (90 - 100%)

Comments: USDA NRCS (2001) and Randall and Marinelli (1996).

- **Distribution and Abundance Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Subrank Guidance

Minimum ranking information: to determine this Subrank, you must answer A. and at least 1 other question in this section.

If H in A, and M or H in at least one other category, Subrank = High

If H in A, and L or I in all other categories, Subrank = Medium

If M in A, and H in at least one other category, Subrank = High

If M in A, and M in at least one other category, Subrank = Medium

If M in A, and L or I in all other categories, Subrank = Medium

If L in A, and H in at least one other category, Subrank = Medium

If L in A, and M in at least one other category, Subrank = Low

If I in A, and H in at least one other category, Subrank = Low

All others, Subrank = Insignificant

SECTION IV. MANAGEMENT POTENTIAL

Given the current state of knowledge regarding management methods, how difficult is it to control this species?

I. Management is not required (e.g., species does not persist without repeated disturbance)

L. Management is relatively easy and inexpensive; requires a minor investment in human and financial resources

M. Management requires a major short-term investment of human and financial resources, or a moderate long-term investment

H. Management requires a major, long-term investment of human and financial resources

- **Management Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Comments (Comment on both the difficulty of control and on the extent of knowledge that exists regarding the management of this species. Please keep comments brief -- do not go into detail on control methods):

Any of several control methods recommended require repeated treatments over several years for control of crown vetch (Heim 1990).

SECTION V. OVERALL RANKING PROCEDURE FOR PLANT SPECIES INVASIVENESS RANK

The Plant Species Invasiveness Rank is a rating of the overall significance of the threat caused by this species to native species and native plant habitat in Virginia, based on the four subranks below.

- **SUBRANKS**

I.	**Impact subrank:**	**LOW**
II.	**Biology and dispersal ability subrank:**	**MEDIUM**
III.	**Distribution and abundance subrank:**	**HIGH**
IV.	**Management subrank**:	**MEDIUM**

The Plant Species Invasiveness Rank is based on the four subranks. Please assign scores to the subranks as follows:

Weighted average/point system

SUBRANK:		**SCORE:**
I.	Impact	H = 4, M = 3, L = 2, I = 0
II.	Biology	H = 3, M = 2, L = 1, I = 0
III.	Distribution	H = 1, M = 0, L = 0, I = 0
IV.	Management	H = 2, M = 1, L = 0, I = 0

Add up these scores to get overall Plant Species Invasiveness Rank. Highest possible score = 10

Overall ranking scale:

I.	Insignificant:	total score = 0-3	Species represents an insignificant threat to natural communities
L.	Low:	total score = 4-6	Species represents low threat to natural communities
M.	Medium:	total score = 7-8	Species represents moderate threat to natural communities
H.	High:	total score = 9-10	Species represents high threat to natural communities

Examples: A species with the significance category of "I" may be exotic but poses little or no threat to natural communities. A species with the significance category of "H" poses a serious threat to native species and communities in Virginia.

- **PLANT SPECIES INVASIVENESS RANK**

  (Enter Insignificant, Low, Medium or High)**: LOW**

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PLANT SPECIES INVASIVENESS RANK FORM

SUMMARY SPECIES DATA

Scientific Name: ***Cynodon dactylon***

Synonyms:
Common Name(s): **Bermudagrass**
Native Range: **Africa**

AUTHOR INFORMATION

Author: **Kevin Heffernan**

Author's affiliation: **Virginia Department of Conservation and Recreation, Division of Natural Heritage**

Mailing address: **217 Governor St., Richmond, VA 23219**

Edition date: **04/19/01**

RANKING CRITERIA

SECTION I. IMPACT ON NATIVE SPECIES, HABITATS AND ECOSYSTEMS

Where possible assess the *cumulative* (e.g., over a period of several decades) impact of the species on the natural areas and other wildlands where it typically occurs. Impacts will be re-assessed as more is learned and as the species moves into new areas.

A. Ability to Invade Natural Systems
Choose one answer (I-H) below that best describes the ability of this species to invade natural systems:

I. Not known to spread into natural areas on its own (e.g., species may persist from former cultivation)
L. Establishes only in areas where major disturbance has occurred in last 20 years (e.g., post-hurricane sites, highway corridors)
M Often establishes in mid- to late-successional natural areas where minor disturbances may occur (e.g., tree falls, hiking trails, streambank erosion), but no major disturbance in last 20-75 years
H. Often establishes in intact or otherwise healthy natural areas with no major disturbance for at least 75 yrs

Comments: Bermudagrass requires disturbance such as grazing, flooding, or fire for establishment and maintenance of habitat (Newman 1992).

B. Impact on Ecosystem Processes

Species that alter processes such as fire occurrence or frequency, erosion and sedimentation rates, hydrological regimes, or nutrient regimes often have the greatest long-term impacts on ecosystems. Some non-native invaders can completely transform natural systems so that they can no longer support native species.

Choose one answer that best describes the impact of this species on ecological processes:

I. No perceivable impact on ecosystem processes

L. Influences ecosystem processes (e.g., has perceivable but mild influence on soil nutrient availability)

M. Significant alteration in ecosystem processes (e.g., increases sedimentation rates along coastlines, reducing open water areas that are important for waterfowl)

H. Major, possibly irreversible, alteration or disruption of ecosystem processes (e.g., the species drains water from open water or wetland systems through rapid transpiration, making these areas more fire prone and unable to support native wetland species; species fixes nitrogen in the soil making soil unlikely to support certain native plants)

Comments: Bermudagrass is a rapid colonizer of disturbed sites. Its rapid colonization and allelopathic properties may allow Bermudagrass to prevent establishment of native species and alter the coarse of succession (USDAFS 2001, Newman 1992).

C. Impact on Natural Community Structure

Choose one answer that best describes this species' impact on community structure:

I. No impact; establishes in an existing layer without influencing its structure

L. Influences structure in one layer (e.g., changes density of a layer)

M. Significant impact on at least one layer (e.g., creation of a new layer, elimination of an existing layer)

H. Major alteration of structure (e.g., covers canopy, eradicating most or all layers below)

Comments: Generally, bermudagrass does not invade established plant communities. However, it does rapidly colonize disturbed sites (USDA FS 2001, Newman 1992).

D. Impact on Natural Community Composition

Choose one answer that best describes this species' impact on community composition:

I. No impact; causes no perceivable change in native populations

L. Influences community composition (e.g., reduces the number of individuals in one or more native populations by reducing recruitment)

M. Significantly alters community composition (e.g., produces a significant reduction in the population size of one or more native species in the community)

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

Comments: Bermudagrass does not invade established plant communities but may retard the recruitment of native species by rapid growth and allelopathic properties (USDA FS 2001, Newman 1992).

E. Conservation Significance of the Natural Area(s) and Native Species Threatened
Many exotic plants occur primarily in disturbed, low quality habitats that are dominated by other exotic species. Exotic plants have a greater impact if they (a) directly or indirectly threaten native species or communities that are considered rare or vulnerable (e.g., Federally listed or ranked G1-G3 by The Nature Conservancy and Natural Heritage Network), or (b) threaten outstanding, high quality occurrences of common community types.

Choose one answer that best describes the overall conservation significance of native species or communities impacted by this exotic species:

I. Insignificant (e.g., found in human-disturbed habitats and is not known to impact any vulnerable or high quality native species or communities)
L. Low significance (e.g., usually inhabits common, unthreatened habitats and rarely impacts vulnerable or high quality species or communities)
M. Moderately significant (e.g., may occasionally threaten vulnerable or high quality species or communities)
H. Highly significant (e.g., known to inhabit one or more vulnerable or high quality communities and/or often threatens rare native species)

Comments: Bermudagrass requires extreme disturbance and does not invade natural communities (Newman 1992).

- **Impact Subrank** (enter Insignificant, Low, Medium or High)**:**

INSIGNIFICANT

Subrank Guidance
Minimum ranking information: to determine Impact Subrank, you must answer both categories A and B as well as at least one other category in this section.
If H in A and B, Subrank = High
If H in A or B, and M or H in at least one other category (A-E), Subrank = High
If M in A and B, and H in at least one other category, Subrank = High
If M in A or B, and M or H in at least one other category, Subrank = Medium
If L in A or B, and H in at least one other category, Subrank = Medium
If M in at least one category, Subrank = Low
All others, Subrank = Insignificant

SECTION II. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY

A. Biological Characteristics: Reproduction, Competitive Ability, and Dispersal

The following are some biological characteristics of invasive species. Check those that apply to this species and note any other weedy or invasive traits this species possesses in the space for comments below.

Reproduction:
- ☒ Reproduces readily both vegetatively and by seed
- ☐ If reproduction is by seed, produces over 1,000 seeds per plant annually
- ☐ Reproduces more than once per year
- ☒ Rapid growth to reproductive maturity
- ☐ Seeds remain viable in soil for 2 or more years
- ☒ Has quickly spreading rhizomes that may root at nodes
- ☒ Resprouts readily when cut, grazed or burned
- ☐ Other (please discuss in comments)

Competitive ability:
- ☐ Highly successful competitor for limiting resources
- ☒ Tolerance of a wide range of conditions or tolerance of stressful conditions
- ☐ Ability to germinate in vegetated areas under a wide range of conditions
- ☒ Allelopathic
- ☐ Known to hybridize with native species
- ☐ Lack of natural predators or control agents in the United States
- ☐ Other (please discuss in comments)

Dispersal ability:
- ☐ Rapid local proliferation of seeds
- ☒ Long-distance dispersal ability (e.g., bird dispersed seed, small seeds carried by water)
- ☐ Other (please discuss in comments)

Choose one answer that best describes the biological characteristics of this species:

I. Not aggressive (e.g., has none of the above characteristics or only one or two to a very small extent)
L. Somewhat aggressive (e.g., has only one or two of the above and to a small extent)
M. Moderately aggressive (e.g., has two or more of the above characteristics, but has only one or two to a great extent)
H. Extremely aggressive (e.g., has three or more of the above characteristics and has them to a great extent)

Comments: Source: USDA FS (2001) and Newman (1992).

B. Other regions invaded

Is this species known to be invasive beyond its native range in other areas outside the United States? **NO**
If yes, briefly list the other countries or regions invaded:

C. Dispersal Ability and Speed of Spread

1. Speed of spread (increase in range) once reported as escaped
Choose one answer that best describes the speed of spread:

I. Does not spread
L. Slow -- doubling time (new local reports) > 50 years
M. Moderate -- doubling time (new local reports) 10-50 years
H. Rapid -- doubling time (new local reports) < 10 years

Comments (if possible, comment on the maximum speed of spread): No data.

2. Current trend in total range within the United States
Choose one answer that best describes the current trend:

I. Declining or Historical
L. Stable
M. Increasing
H. Increasing rapidly

Comments:

3. Potential to be spread by human activity
Is this species frequently spread or does it have has high potential to be spread by human activity (e.g., species is sold commercially for use in agriculture or ornamental horticulture; species takes advantage of transportation corridors such as highways; species is aquatic and is transported by boats or boat trailers)? **YES**

Comments: Bermudagrass is used for forage, revegetation of surface mine spoils, streambank stabilization, and turf grass for lawns, athletic fields, and golf courses (USDA FS 2001).

- **Biology/Dispersal Ability Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Subrank Guidance
Minimum ranking information: to determine this Subrank, you must answer at least 4 of the 5 questions above.
Use the following scoring system: 3 points for H, 2 for M, 1 for L; 2 for Yes. Highest possible score = 13
If total score is 9-13, Subrank = High
If total score is 6-8, Subrank = Medium
If total score is 3-5, Subrank = Low
If total score is 0-2, Subrank = Insignificant

SECTION III. DISTRIBUTION AND ABUNDANCE IN VIRGINIA AND THE UNITED STATES

A. Approximate number of distinct natural areas or other wildlands infested in Virginia.
Choose one answer that best matches the number of sites infested:

(Treat one site as the rough equivalent of one preserve, park, BLM district, wildlife refuge, wilderness area, etc.)
I. < 5 (few; scattered)
L. 6 to 10 sites
M. 11 to 30 sites
H. Greater than 30 sites
Enter approximate date of information (year):

Comments: (Include Virginia range information from *Atlas of Virginia Flora*.) Bermudagrass was found at three state parks and two natural area preserves (Caljouw 1994). Bermudagrass was reported from 84 Virginia localities (Harvill 1992).

B. Extent of the species U.S. range in which it has been identified as a problem by land managers
Some non-native species are not invasive everywhere they occur in U.S. but only in certain regions or habitats. For instance, Tamarisks are severe riparian and wetland pests from California to Texas and north at least to Kansas, but while they escape occasionally in the eastern United States, they have not been reported as a problem east of the Mississippi.

This species has been identified by land managers as a problem in approximately what portion of its U.S. range?
Choose one answer that best describes the extent of range in which considered to be a problem:

I. 0 to 5%
L. 6 to 20%
M. 20 to 50%
H. Greater than 50%

Comments (Include U.S. range information. If the species is a threat to only certain types of natural communities, please specify): Bermudagrass is reported from 41 states (Kartesz 1999). Bermudagrass invades highly disturbed sites (Newman 1992). This species is reported as a troublesome weed globally and throughout the United States (USDA NRCS 2000, Wilken and Hannah 1998). It is listed as a noxious weed in CA and UT and as noxious-weed seed in AL, AR, FL, GA, LA, MD, NC, NJ, SC, and TX (CDFA 1998, USDA ARS 2001).

C. Potential cover of the species in strata where it occurs
Choose one answer that best describes the potential cover:

I. Infrequent (less than 10%)
L. Fair coverage but less than half (10 - 50%)
M. Dominant (50 - 90%)
H. Monospecific stand (90 - 100%)

Comments: (USDA FS 2001)

- **Distribution and Abundance Subrank** (enter Insignificant, Low, Medium or High)**:**

LOW

Subrank Guidance
Minimum ranking information: to determine this Subrank, you must answer A. and at least 1 other question in this section.
If H in A, and M or H in at least one other category, Subrank = High
If H in A, and L or I in all other categories, Subrank = Medium
If M in A, and H in at least one other category, Subrank = High
If M in A, and M in at least one other category, Subrank = Medium
If M in A, and L or I in all other categories, Subrank = Medium
If L in A, and H in at least one other category, Subrank = Medium
If L in A, and M in at least one other category, Subrank = Low
If I in A, and H in at least one other category, Subrank = Low
All others, Subrank = Insignificant

SECTION IV. MANAGEMENT POTENTIAL

Given the current state of knowledge regarding management methods, how difficult is it to control this species?

I. Management is not required (e.g., species does not persist without repeated disturbance)
L. Management is relatively easy and inexpensive; requires a minor investment in human and financial resources
M. Management requires a major short-term investment of human and financial resources, or a moderate long-term investment
H. Management requires a major, long-term investment of human and financial resources

- **Management Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Comments (Comment on both the difficulty of control and on the extent of knowledge that exists regarding the management of this species. Please keep comments brief -- do not go into detail on control methods): A variety of methods have been used to control Bermudagrass. Control is difficult because of this species ability to resprout from stolons and rhizomes and its high seed production (USDA FS 2001, Newman 1992, Elmore and Cudney 2000).

SECTION V. OVERALL RANKING PROCEDURE FOR PLANT SPECIES INVASIVENESS RANK

The Plant Species Invasiveness Rank is a rating of the overall significance of the threat caused by this species to native species and native plant habitat in Virginia, based on the four subranks below.

- **SUBRANKS**

I.	**Impact subrank:**	**INSIGNIFICANT**
II.	**Biology and dispersal ability subrank:**	**MEDIUM**
III.	**Distribution and abundance subrank:**	**HIGH**
IV.	**Management subrank**:	**MEDIUM**

The Plant Species Invasiveness Rank is based on the four subranks. Please assign scores to the subranks as follows:

Weighted average/point system

SUBRANK:		**SCORE:**
I.	Impact	H = 4, M = 3, L = 2, I = 0
II.	Biology	H = 3, M = 2, L = 1, I = 0
III.	Distribution	H = 1, M = 0, L = 0, I = 0
IV.	Management	H = 2, M = 1, L = 0, I = 0

Add up these scores to get overall Plant Species Invasiveness Rank. Highest possible score = 10

Overall ranking scale:

I.	Insignificant:	total score = 0-3	Species represents an insignificant threat to natural communities
L.	Low:	total score = 4-6	Species represents low threat to natural communities
M.	Medium:	total score = 7-8	Species represents moderate threat to natural communities
H.	High:	total score = 9-10	Species represents high threat to natural communities

Examples: A species with the significance category of "I" may be exotic but poses little or no threat to natural communities. A species with the significance category of "H" poses a serious threat to native species and communities in the United States.

- **PLANT SPECIES INVASIVENESS RANK**
  (Enter Insignificant, Low, Medium or High)**: INSIGNIFICANT**

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PLANT SPECIES INVASIVENESS (IPP) RANK FORM

SUMMARY SPECIES DATA

Scientific Name: ***Dactylis glomerata***

Synonyms:
Common Name(s): **Orchardgrass**
Native Range: **Europe**

AUTHOR INFORMATION

Author: **Kevin Heffernan**

Author's affiliation: **Virginia Department of Conservation and Recreation, Division of Natural Heritage**

Mailing address: **217 Governor St., Richmond, VA 23219**

Edition date (mm/dd/yyyy): **04/20/2001**

RANKING CRITERIA

SECTION I. IMPACT ON NATIVE SPECIES, HABITATS AND ECOSYSTEMS

Where possible assess the *cumulative* (e.g., over a period of several decades) impact of the species on the natural areas and other wildlands where it typically occurs. Impacts will be re-assessed as more is learned and as the species moves into new areas.

A. Ability to Invade Natural Systems
Choose one answer (I-H) below that best describes the ability of this species to invade natural systems:

I. Not known to spread into natural areas on its own (e.g., species may persist from former cultivation)

L. Establishes only in areas where major disturbance has occurred in last 20 years (e.g., post-hurricane sites, highway corridors)

M Often establishes in mid- to late-successional natural areas where minor disturbances may occur (e.g., tree falls, hiking trails, streambank erosion), but no major disturbance in last 20-75 years

H. Often establishes in intact or otherwise healthy natural areas with no major disturbance for at least 75 yrs

Comments: Although widely considered a weed species, (Stubbendieck et al. 1994), orchardgrass is not reported to invade natural areas. It is mostly restricted to areas where it was planted or disturbed sites such as roadsides (Rutledge and McLendon 1998, USDA FS 2001, Uva et al. 1997). This species was found in less than 1% of approximately 2000 vegetation sample plots located in Virginia natural areas (Heffernan et al. 2001).

B. Impact on Ecosystem Processes

Species that alter processes such as fire occurrence or frequency, erosion and sedimentation rates, hydrological regimes, or nutrient regimes often have the greatest long-term impacts on ecosystems. Some non-native invaders can completely transform natural systems so that they can no longer support native species.

Choose one answer that best describes the impact of this species on ecological processes:

I. No perceivable impact on ecosystem processes

L. Influences ecosystem processes (e.g., has perceivable but mild influence on soil nutrient availability)

M. Significant alteration in ecosystem processes (e.g., increases sedimentation rates along coastlines, reducing open water areas that are important for waterfowl)

H. Major, possibly irreversible, alteration or disruption of ecosystem processes (e.g., the species drains water from open water or wetland systems through rapid transpiration, making these areas more fire prone and unable to support native wetland species; species fixes nitrogen in the soil making soil unlikely to support certain native plants)

Comments: Orchardgrass is a highly competitive species that has been planted to keep out other weed species in agricultural fields and powerline rights-of-way (Haubensak and Smyth 1999) and can persist on a site for up to twenty years (USDA FS 2001).

C. Impact on Natural Community Structure

Choose one answer that best describes this species' impact on community structure:

I. No impact; establishes in an existing layer without influencing its structure

L. Influences structure in one layer (e.g., changes density of a layer)

M. Significant impact on at least one layer (e.g., creation of a new layer, elimination of an existing layer)

H. Major alteration of structure (e.g., covers canopy, eradicating most or all layers below)

Comments: No references were found regarding orchardgrass invading natural areas.

D. Impact on Natural Community Composition

Choose one answer that best describes this species' impact on community composition:

I. No impact; causes no perceivable change in native populations

L. Influences community composition (e.g., reduces the number of individuals in one or more native populations by reducing recruitment)

M. Significantly alters community composition (e.g., produces a significant reduction in the population size of one or more native species in the community)

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

Comments: Outcompetes other herb layer species, even other weed species (Haubensak and Smyth 1999). It is identified as a codominant species is at least two plant community types in Oregon and California. Orchardgrass may persist at a site for more than twenty years (USDA-USFS 2001).

E. Conservation Significance of the Natural Area(s) and Native Species Threatened
Many exotic plants occur primarily in disturbed, low quality habitats that are dominated by other exotic species. Exotic plants have a greater impact if they (a) directly or indirectly threaten native species or communities that are considered rare or vulnerable (e.g., Federally listed or ranked G1-G3 by The Nature Conservancy and Natural Heritage Network), or (b) threaten outstanding, high quality occurrences of common community types.

Choose one answer that best describes the overall conservation significance of native species or communities impacted by this exotic species:

I. Insignificant (e.g., found in human-disturbed habitats and is not known to impact any vulnerable or high quality native species or communities)
L. Low significance (e.g., usually inhabits common, unthreatened habitats and rarely impacts vulnerable or high quality species or communities)
M. Moderately significant (e.g., may occasionally threaten vulnerable or high quality species or communities)
H. Highly significant (e.g., known to inhabit one or more vulnerable or high quality communities and/or often threatens rare native species)

Comments: No references were found regarding orchardgrass impacting vulnerable or high quality native species or communities.

- **Impact Subrank** (enter Insignificant, Low, Medium or High)**:**

LOW

Subrank Guidance
Minimum ranking information: to determine Impact Subrank, you must answer both categories A and B as well as at least one other category in this section.
If H in A and B, Subrank = High
If H in A or B, and M or H in at least one other category (A-E), Subrank = High
If M in A and B, and H in at least one other category, Subrank = High
If M in A or B, and M or H in at least one other category, Subrank = Medium
If L in A or B, and H in at least one other category, Subrank = Medium
If M in at least one category, Subrank = Low
All others, Subrank = Insignificant

SECTION II. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY

A. Biological Characteristics: Reproduction, Competitive Ability, and Dispersal

The following are some biological characteristics of invasive species. Check those that apply to this species and note any other weedy or invasive traits this species possesses in the space for comments below.

Reproduction:

- ☐ Reproduces readily both vegetatively and by seed
- ☒ If reproduction is by seed, produces over 1,000 seeds per plant annually
- ☐ Reproduces more than once per year
- ☐ Rapid growth to reproductive maturity
- ☐ Seeds remain viable in soil for 2 or more years
- ☐ Has quickly spreading rhizomes that may root at nodes
- ☒ Resprouts readily when cut, grazed or burned
- ☐ Other (please discuss in comments)

Competitive ability:

- ☒ Highly successful competitor for limiting resources
- ☒ Tolerance of a wide range of conditions or tolerance of stressful conditions
- ☐ Ability to germinate in vegetated areas under a wide range of conditions
- ☐ Allelopathic
- ☒ Known to hybridize with native species
- ☐ Lack of natural predators or control agents in the United States
- ☐ Other (please discuss in comments)

Dispersal ability:

- ☐ Rapid local proliferation of seeds
- ☐ Long-distance dispersal ability (e.g., bird dispersed seed, small seeds carried by water)
- ☐ Other (please discuss in comments)

Choose one answer that best describes the biological characteristics of this species:

I. Not aggressive (e.g., has none of the above characteristics or only one or two to a very small extent)
L. Somewhat aggressive (e.g., has only one or two of the above and to a small extent)
M. Moderately aggressive (e.g., has two or more of the above characteristics, but has only one or two to a great extent)
H. Extremely aggressive (e.g., has three or more of the above characteristics and has them to a great extent)

Comments: Sources: USDA FS (2001), USDA NRCS (2000), Haubensak and Smyth (1999), Rutledge and McLendon (1998), Uva et al. (1997), Lumaret (1990). Using a suite of plant characteristics and data from NRCS PLANTS Database, a predictive model classified this species as invasive (Heffernan et al 2001).

B. Other regions invaded

Is this species known to be invasive beyond its native range in other areas outside the United States? **NO**
If yes, briefly list the other countries or regions invaded: Commercial varieties of orchardgrass has become invasive in Galicia, Spain, where it has invaded and/or hybridized with native *Dactylis* populations (Lumaret 1990). However, there are no native *Dactylis* populations in Virginia. Therefore, hybridization is not a threat.

C. Dispersal Ability and Speed of Spread

1. Speed of spread (increase in range) once reported as escaped
Choose one answer that best describes the speed of spread:

I. Does not spread
L. Slow -- doubling time (new local reports) > 50 years
M. Moderate -- doubling time (new local reports) 10-50 years
H. Rapid -- doubling time (new local reports) < 10 years

Comments (if possible, comment on the maximum speed of spread): Orchardgrass does not appear to spread readily on its own (Rutledge and McLendon 1998).

2. Current trend in total range within the United States
Choose one answer that best describes the current trend:

I. Declining or Historical
L. Stable
M. Increasing
H. Increasing rapidly

Comments: Introduced to North America during the 18th-Century, orchardgrass is widely used for livestock forage, erosion control, and wildlife plantings throughout the United States (USDA NRCS 2000).

3. Potential to be spread by human activity
Is this species frequently spread or does it have has high potential to be spread by human activity (e.g., species is sold commercially for use in agriculture or ornamental horticulture; species takes advantage of transportation corridors such as highways; species is aquatic and is transported by boats or boat trailers)? **YES**

Comments: Orchardgrass is primarily used for forage production and is considered highly palatable to all classes of livestock. It is also used for soil stabilization and in grass-legume mixes for wildlife habitat (USDA NRCS 2000).

- **Biology/Dispersal Ability Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Subrank Guidance
Minimum ranking information: to determine this Subrank, you must answer at least 4 of the 5 questions above.
Use the following scoring system: 3 points for H, 2 for M, 1 for L; 2 for Yes. Highest possible score = 13
If total score is 9-13, Subrank = High
If total score is 6-8, Subrank = Medium
If total score is 3-5, Subrank = Low
If total score is 0-2, Subrank = Insignificant

SECTION III. DISTRIBUTION AND ABUNDANCE IN THE UNITED STATES

A. Approximate number of distinct natural areas or other wildlands infested in Virginia.
Choose one answer that best matches the number of sites infested:

(Treat one site as the rough equivalent of one preserve, park, BLM district, wildlife refuge, wilderness area, etc.)
I. < 5 (few; scattered)
L. 6 to 10 sites
M. 11 to 30 sites
H. Greater than 30 sites
Enter approximate date of information (year): 1994

Comments: A survey of DCR State Parks and Natural Area Preserves reported three parks and three preserves with orchardgrass (Caljouw 1994). Orchardgrass occurs 92 localities in Virginia (Harvill et al. 1992)

B. Extent of the species U.S. range in which it has been identified as a problem by land managers
Some non-native species are not invasive everywhere they occur in U.S. but only in certain regions or habitats. For instance, Tamarisks are severe riparian and wetland pests from California to Texas and north at least to Kansas, but while they escape occasionally in the eastern United States, they have not been reported as a problem east of the Mississippi.

This species has been identified by land managers as a problem in approximately what portion of its U.S. range?
Choose one answer that best describes the extent of range in which considered to be a problem:

I. 0 to 5%
L. 6 to 20%
M. 20 to 50%
H. Greater than 50%

Comments (Include U.S. range information. If the species is a threat to only certain types of natural communities, please specify): Orchardgrass is found in all fifty states (USDA NRCS 2000, Kartesz 1999). This species is identified as a weed in the Northeast and Great Plains (Uva et al 1997, Stubbendieck et al 1994). Orchardgrass is listed as a noxious weed seed in Delaware, Maryland, New Jersey, Pennsylvania, and Virginia (USDA ARS 2001).

C. Potential cover of the species in strata where it occurs
Choose one answer that best describes the potential cover:

I. Infrequent (less than 10%)
L. Fair coverage but less than half (10 - 50%)
M. Dominant (50 - 90%)
H. Monospecific stand (90 - 100%)

Comments: Orchardgrass develops in distinct clumps and does not spread vegetatively. It is usually planted with legumes. In naturalized communities it is co-dominant with other grasses and sedges (USDA FS 2001).

- **Distribution and Abundance Subrank** (enter Insignificant, Low, Medium or High)**:**

LOW

Subrank Guidance

Minimum ranking information: to determine this Subrank, you must answer A. and at least 1 other question in this section.

If H in A, and M or H in at least one other category, Subrank = High

If H in A, and L or I in all other categories, Subrank = Medium

If M in A, and H in at least one other category, Subrank = High

If M in A, and M in at least one other category, Subrank = Medium

If M in A, and L or I in all other categories, Subrank = Medium

If L in A, and H in at least one other category, Subrank = Medium

If L in A, and M in at least one other category, Subrank = Low

If I in A, and H in at least one other category, Subrank = Low

All others, Subrank = Insignificant

SECTION IV. MANAGEMENT POTENTIAL

Given the current state of knowledge regarding management methods, how difficult is it to control this species?

I. Management is not required (e.g., species does not persist without repeated disturbance)

L. Management is relatively easy and inexpensive; requires a minor investment in human and financial resources

M. Management requires a major short-term investment of human and financial resources, or a moderate long-term investment

H. Management requires a major, long-term investment of human and financial resources

- **Management Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Comments (Comment on both the difficulty of control and on the extent of knowledge that exists regarding the management of this species. Please keep comments brief -- do not go into detail on control methods): No literature specific to the control of orchardgrass was found. Control would likely require a moderate long-term investment due to orchardgrass seedling vigor (USDA NRCS 2000).

SECTION V. OVERALL RANKING PROCEDURE FOR PLANT SPECIES INVASIVENESS RANK

The Plant Species Invasiveness Rank is a rating of the overall significance of the threat caused by this species to native species and native plant habitat in the United States, based on the four subranks below.

- **SUBRANKS**

I.	**Impact subrank:**	**LOW**
II.	**Biology and dispersal ability subrank:**	**MEDIUM**
III.	**Distribution and abundance subrank:**	**HIGH**
IV.	**Management subrank**:	**MEDIUM**

The Plant Species Invasiveness Rank is based on the four subranks. Please assign scores to the subranks as follows:

Weighted average/point system

SUBRANK:		**SCORE:**
I.	Impact	H = 4, M = 3, L = 2, I = 0
II.	Biology	H = 3, M = 2, L = 1, I = 0
III.	Distribution	H = 1, M = 0, L = 0, I = 0
IV.	Management	H = 2, M = 1, L = 0, I = 0

Add up these scores to get overall Plant Species Invasiveness Rank. Highest possible score = 10

Overall ranking scale:

I.	Insignificant:	total score = 0-3	Species represents an insignificant threat to natural communities
L.	Low:	total score = 4-6	Species represents low threat to natural communities
M.	Medium:	total score = 7-8	Species represents moderate threat to natural communities
H.	High:	total score = 9-10	Species represents high threat to natural communities

Examples: A species with the significance category of "I" may be exotic but poses little or no threat to natural communities. A species with the significance category of "H" poses a serious threat to native species and communities in Virginia.

- **PLANT SPECIES INVASIVENESS RANK**

  (Enter Insignificant, Low, Medium or High)**: LOW**

SECTION VI. REFERENCES

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PLANT SPECIES INVASIVENESS RANK FORM

SUMMARY SPECIES DATA

Scientific Name: ***Eragrostis curvula***

Synonyms:
Common Name(s): **Weeping Lovegrass**
Native Range: **Africa**

AUTHOR INFORMATION

Author: **Kevin Heffernan**

Author's affiliation: **Virginia Department of Conservation and Recreation, Division of Natural Heritage**

Mailing address: **217 Governor St., Richmond, VA 23219**

Edition date (mm/dd/yyyy): **4/23/01**

RANKING CRITERIA

SECTION I. IMPACT ON NATIVE SPECIES, HABITATS AND ECOSYSTEMS

Where possible assess the *cumulative* (e.g., over a period of several decades) impact of the species on the natural areas and other wildlands where it typically occurs. Impacts will be re-assessed as more is learned and as the species moves into new areas.

A. Ability to Invade Natural Systems
Choose one answer (I-H) below that best describes the ability of this species to invade natural systems:

I. Not known to spread into natural areas on its own (e.g., species may persist from former cultivation)

L. Establishes only in areas where major disturbance has occurred in last 20 years (e.g., post-hurricane sites, highway corridors)

M Often establishes in mid- to late-successional natural areas where minor disturbances may occur (e.g., tree falls, hiking trails, streambank erosion), but no major disturbance in last 20-75 years

H. Often establishes in intact or otherwise healthy natural areas with no major disturbance for at least 75 yrs

Comments: Except for one anecdotal report (Scott, pers. comm.), weeping lovegrass is not reported to spread from were it is planted.

B. Impact on Ecosystem Processes

Species that alter processes such as fire occurrence or frequency, erosion and sedimentation rates, hydrological regimes, or nutrient regimes often have the greatest long-term impacts on ecosystems. Some non-native invaders can completely transform natural systems so that they can no longer support native species.

Choose one answer that best describes the impact of this species on ecological processes:

I. No perceivable impact on ecosystem processes

L. Influences ecosystem processes (e.g., has perceivable but mild influence on soil nutrient availability)

M. Significant alteration in ecosystem processes (e.g., increases sedimentation rates along coastlines, reducing open water areas that are important for waterfowl)

H. Major, possibly irreversible, alteration or disruption of ecosystem processes (e.g., the species drains water from open water or wetland systems through rapid transpiration, making these areas more fire prone and unable to support native wetland species; species fixes nitrogen in the soil making soil unlikely to support certain native plants)

Comments: No reports of ecosystem alteration.

C. Impact on Natural Community Structure

Choose one answer that best describes this species' impact on community structure:

I. No impact; establishes in an existing layer without influencing its structure

L. Influences structure in one layer (e.g., changes density of a layer)

M. Significant impact on at least one layer (e.g., creation of a new layer, elimination of an existing layer)

H. Major alteration of structure (e.g., covers canopy, eradicating most or all layers below)

Comments: Weeping lovegrass does not alter community structure. However, where it is planted, it may stop succession of native species (Bock et al. 1986).

D. Impact on Natural Community Composition

Choose one answer that best describes this species' impact on community composition:

I. No impact; causes no perceivable change in native populations

L. Influences community composition (e.g., reduces the number of individuals in one or more native populations by reducing recruitment)

M. Significantly alters community composition (e.g., produces a significant reduction in the population size of one or more native species in the community)

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

Comments: Bock et al. (1986) found that Arizona sites planted in the 1940s and 1950s with weeping lovegrass and Loehmann's lovegrass were still dominated by these species in 1984. Nearby unseeded areas supported mixtures of native grasses, herbs, and shrubs. This finding contrasts other reports that state weeping lovegrass does not persistent at a site (USDA FS 2001, USDA NRCS 2000). Further, Bock et al (1986) found that species richness for plants and animals was much lower in the lovegrass sites than neighboring sites dominated by native vegetation. This suggests that weeping lovegrass may be a poor choice for revegetating sites where the long-term goal is to establish native vegetation.

E. Conservation Significance of the Natural Area(s) and Native Species Threatened
Many exotic plants occur primarily in disturbed, low quality habitats that are dominated by other exotic species. Exotic plants have a greater impact if they (a) directly or indirectly threaten native species or communities that are considered rare or vulnerable (e.g., Federally listed or ranked G1-G3 by The Nature Conservancy and Natural Heritage Network), or (b) threaten outstanding, high quality occurrences of common community types.

Choose one answer that best describes the overall conservation significance of native species or communities impacted by this exotic species:

I. Insignificant (e.g., found in human-disturbed habitats and is not known to impact any vulnerable or high quality native species or communities)
L. Low significance (e.g., usually inhabits common, unthreatened habitats and rarely impacts vulnerable or high quality species or communities)
M. Moderately significant (e.g., may occasionally threaten vulnerable or high quality species or communities)
H. Highly significant (e.g., known to inhabit one or more vulnerable or high quality communities and/or often threatens rare native species)

Comments: No reports of weeping lovegrass directly impacting native species or communities.

- **Impact Subrank** (enter Insignificant, Low, Medium or High)**:**

LOW

Subrank Guidance
Minimum ranking information: to determine Impact Subrank, you must answer both categories A and B as well as at least one other category in this section.
If H in A and B, Subrank = High
If H in A or B, and M or H in at least one other category (A-E), Subrank = High
If M in A and B, and H in at least one other category, Subrank = High
If M in A or B, and M or H in at least one other category, Subrank = Medium
If L in A or B, and H in at least one other category, Subrank = Medium
If M in at least one category, Subrank = Low
All others, Subrank = Insignificant

SECTION II. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY

A. Biological Characteristics: Reproduction, Competitive Ability, and Dispersal

The following are some biological characteristics of invasive species. Check those that apply to this species and note any other weedy or invasive traits this species possesses in the space for comments below.

Reproduction:

- ☐ Reproduces readily both vegetatively and by seed
- ☐ If reproduction is by seed, produces over 1,000 seeds per plant annually
- ☐ Reproduces more than once per year
- ☐ Rapid growth to reproductive maturity
- ☐ Seeds remain viable in soil for 2 or more years
- ☐ Has quickly spreading rhizomes that may root at nodes
- ☒ Resprouts readily when cut, grazed or burned
- ☐ Other (please discuss in comments)

Competitive ability:

- ☐ Highly successful competitor for limiting resources
- ☒ Tolerance of a wide range of conditions or tolerance of stressful conditions
- ☐ Ability to germinate in vegetated areas under a wide range of conditions
- ☐ Allelopathic
- ☐ Known to hybridize with native species
- ☐ Lack of natural predators or control agents in the United States
- ☐ Other (please discuss in comments)

Dispersal ability:

- ☐ Rapid local proliferation of seeds
- ☐ Long-distance dispersal ability (e.g., bird dispersed seed, small seeds carried by water)
- ☐ Other (please discuss in comments)

Choose one answer that best describes the biological characteristics of this species:

I. Not aggressive (e.g., has none of the above characteristics or only one or two to a very small extent)
L. Somewhat aggressive (e.g., has only one or two of the above and to a small extent)
M. Moderately aggressive (e.g., has two or more of the above characteristics, but has only one or two to a great extent)
H. Extremely aggressive (e.g., has three or more of the above characteristics and has them to a great extent)

Comments: Source: USDA FS (2001). Using a suite of plant characteristics and data from NRCS PLANTS Database, a predictive model classified this species as invasive (Heffernan et al 2001).

B. Other regions invaded

Is this species known to be invasive beyond its native range in other areas outside the United States? **YES**
If yes, briefly list the other countries or regions invaded: Weeping lovegrass is a Regionally Prohibited Weed and Regionally Controlled Weed in various regions of the State of Victoria, Australia (State of Victoria 1999).

C. Dispersal Ability and Speed of Spread

1. Speed of spread (increase in range) once reported as escaped
Choose one answer that best describes the speed of spread:

I. Does not spread
L. Slow -- doubling time (new local reports) > 50 years
M. Moderate -- doubling time (new local reports) 10-50 years
H. Rapid -- doubling time (new local reports) < 10 years

Comments (if possible, comment on the maximum speed of spread): No published reports of weeping lovegrass escaping cultivation.

2. Current trend in total range within the United States
Choose one answer that best describes the current trend:

I. Declining or Historical
L. Stable
M. Increasing
H. Increasing rapidly

Comments: Weeping lovegrass has been in use since 1932, when it was first introduced to the United States (USDA FS 2001). It is widely distributed throughout the Southern United States, the Northeast, and Northwest (USDA NRCS 2000).

3. Potential to be spread by human activity
Is this species frequently spread or does it have has high potential to be spread by human activity (e.g., species is sold commercially for use in agriculture or ornamental horticulture; species takes advantage of transportation corridors such as highways; species is aquatic and is transported by boats or boat trailers)? **YES**

Comments: Weeping lovegrass is widely used for erosion control (USDA NRCS 2000). It is also planted as forage for livestock, and is a popular ornamental grass (USDA FS 2001).

- **Biology/Dispersal Ability Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Subrank Guidance
Minimum ranking information: to determine this Subrank, you must answer at least 4 of the 5 questions above.
Use the following scoring system: 3 points for H, 2 for M, 1 for L; 2 for Yes. Highest possible score = 13
If total score is 9-13, Subrank = High
If total score is 6-8, Subrank = Medium
If total score is 3-5, Subrank = Low
If total score is 0-2, Subrank = Insignificant

SECTION III. DISTRIBUTION AND ABUNDANCE IN VIRGINIA AND THE UNITED STATES

A. Approximate number of distinct natural areas or other wildlands infested in Virginia.
Choose one answer that best matches the number of sites infested:

(Treat one site as the rough equivalent of one preserve, park, BLM district, wildlife refuge, wilderness area, etc.)

I. < 5 (few; scattered)
L. 6 to 10 sites
M. 11 to 30 sites
H. Greater than 30 sites
Enter approximate date of information (year): 2001

Comments: (Include Virginia range information from *Atlas of Virginia Flora*.) A 1994 survey of invasive species on DCR state parks and natural area preserves found weeping lovegrass at two state parks (Caljouw 1994). This species is reported from 28 counties in Virginia (Harvill 1992).

B. Extent of the species U.S. range in which it has been identified as a problem by land managers
Some non-native species are not invasive everywhere they occur in U.S. but only in certain regions or habitats. For instance, Tamarisks are severe riparian and wetland pests from California to Texas and north at least to Kansas, but while they escape occasionally in the eastern United States, they have not been reported as a problem east of the Mississippi.

This species has been identified by land managers as a problem in approximately what portion of its U.S. range?
Choose one answer that best describes the extent of range in which considered to be a problem:

I. 0 to 5%
L. 6 to 20%
M. 20 to 50%
H. Greater than 50%

Comments (Include U.S. range information. If the species is a threat to only certain types of natural communities, please specify): Weeping lovegrass is reported from 27 states (Kartesz 1999).

D. Potential cover of the species in strata where it occurs
Choose one answer that best describes the potential cover:

I. Infrequent (less than 10%)
L. Fair coverage but less than half (10 - 50%)
M. Dominant (50 - 90%)
H. Monospecific stand (90 - 100%)

Comments: Source: USDA FS (2001).

- **Distribution and Abundance Subrank** (enter Insignificant, Low, Medium or High)**:**

INSIGNIFICANT

Subrank Guidance
Minimum ranking information: to determine this Subrank, you must answer A. and at least 1 other question in this section.
If H in A, and M or H in at least one other category, Subrank = High
If H in A, and L or I in all other categories, Subrank = Medium
If M in A, and H in at least one other category, Subrank = High
If M in A, and M in at least one other category, Subrank = Medium
If M in A, and L or I in all other categories, Subrank = Medium
If L in A, and H in at least one other category, Subrank = Medium
If L in A, and M in at least one other category, Subrank = Low
If I in A, and H in at least one other category, Subrank = Low
All others, Subrank = Insignificant

SECTION IV. MANAGEMENT POTENTIAL

Given the current state of knowledge regarding management methods, how difficult is it to control this species?

I. Management is not required (e.g., species does not persist without repeated disturbance)
L. Management is relatively easy and inexpensive; requires a minor investment in human and financial resources
M. Management requires a major short-term investment of human and financial resources, or a moderate long-term investment
H. Management requires a major, long-term investment of human and financial resources

- **Management Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Comments (Comment on both the difficulty of control and on the extent of knowledge that exists regarding the management of this species. Please keep comments brief -- do not go into detail on control methods): The limited literature on controlling weeping lovegrass is published in Australian scientific journals (Campbell 1985, Campbell 1987).

SECTION V. OVERALL RANKING PROCEDURE FOR PLANT SPECIES INVASIVENESS RANK

The Plant Species Invasiveness Rank is a rating of the overall significance of the threat caused by this species to native species and native plant habitat in Virginia, based on the four subranks below.

- **SUBRANKS**

I.	**Impact subrank:**	**LOW**
II.	**Biology and dispersal ability subrank:**	**MEDIUM**
III.	**Distribution and abundance subrank:**	**HIGH**
IV.	**Management subrank**:	**MEDIUM**

The Plant Species Invasiveness Rank is based on the four subranks. Please assign scores to the subranks as follows:

Weighted average/point system

SUBRANK:		**SCORE:**
I.	Impact	H = 4, M = 3, L = 2, I = 0
II.	Biology	H = 3, M = 2, L = 1, I = 0
III.	Distribution	H = 1, M = 0, L = 0, I = 0
IV.	Management	H = 2, M = 1, L = 0, I = 0

Add up these scores to get overall Plant Species Invasiveness Rank. Highest possible score = 10

Overall ranking scale:

I.	Insignificant:	total score = 0-3	Species represents an insignificant threat to natural communities
L.	Low:	total score = 4-6	Species represents low threat to natural communities
M.	Medium:	total score = 7-8	Species represents moderate threat to natural communities
H.	High:	total score = 9-10	Species represents high threat to natural communities

Examples: A species with the significance category of "I" may be exotic but poses little or no threat to natural communities. A species with the significance category of "H" poses a serious threat to native species and communities in Virginia.

- **PLANT SPECIES INVASIVENESS RANK**
  (Enter Insignificant, Low, Medium or High)**: LOW**

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PLANT SPECIES INVASIVENESS RANK FORM

SUMMARY SPECIES DATA

Scientific Name: ***Lolium pratense***
Synonyms: ***Festuca pratensis, F. elatior, F. arundinacea*(?)**
Common Name(s): **Tall Fescue**
Native Range: **Eurasia**

AUTHOR INFORMATION

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Edition date (mm/dd/yyyy): **04/20/2001**

RANKING CRITERIA

SECTION I. IMPACT ON NATIVE SPECIES, HABITATS AND ECOSYSTEMS

Where possible assess the *cumulative* (e.g., over a period of several decades) impact of the species on the natural areas and other wildlands where it typically occurs. Impacts will be re-assessed as more is learned and as the species moves into new areas.

A. Ability to Invade Natural Systems
Choose one answer that best describes the ability of this species to invade natural systems:

I. Not known to spread into natural areas on its own (e.g., species may persist from former cultivation)
L. Establishes only in areas where major disturbance has occurred in last 20 years (e.g., post-hurricane sites, highway corridors)
M Often establishes in mid- to late-successional natural areas where minor disturbances may occur (e.g., tree falls, hiking trails, streambank erosion), but no major disturbance in last 20-75 years
H. Often establishes in intact or otherwise healthy natural areas with no major disturbance for at least 75 years

Comments: This species is not an extremely fast spreader, although tillering is mentioned as a means of vegetative spread in some publications (Ball et al. 1993). The plant does seem capable of spread if there is a nearby source of plants/seed. The level of diversity in fields invaded by tall fescue tends to decrease over time as the highly competitive endophyte-infected plants grow in abundance and become more numerous than the un-infected plants (Clay and Holah 1999), thus shading or crowding out the native flora. Tall fescue appeared as one of the most frequently found alien plant species in sample plots for the Virginia vegetation community classification project (Heffernan et al 2001).

B. Impact on Ecosystem Processes

Species that alter processes such as fire occurrence or frequency, erosion and sedimentation rates, hydrological regimes, or nutrient regimes often have the greatest long-term impacts on ecosystems. Some non-native invaders can completely transform natural systems so that they can no longer support native species.

Choose one answer that best describes the impact of this species on ecological processes:

I. No perceivable impact on ecosystem processes

L. Influences ecosystem processes (e.g., has perceivable but mild influence on soil nutrient availability)

M. Significant alteration in ecosystem processes (e.g., increases sedimentation rates along coastlines, reducing open water areas that are important for waterfowl)

H. Major, possibly irreversible, alteration or disruption of ecosystem processes (e.g., the species drains water from open water or wetland systems through rapid transpiration, making these areas more fire prone and unable to support native wetland species; species fixes nitrogen in the soil making soil unlikely to support certain native plants)

Comments: This species apparently burns well and will not resprout from the base following fire (USDA, NRCS 2001), so it will not interfere with fire-maintained habitats such as prairies.

C. Impact on Natural Community Structure

Choose one answer that best describes the impact of this species on community structure:

I. No impact; establishes in an existing layer without influencing its structure

L. Influences structure in one layer (e.g., changes density of a layer)

M. Significant impact on at least one layer (e.g., creation of a new layer, elimination of an existing layer)

H. Major alteration of structure (e.g., covers canopy, eradicating most or all layers below)

Comments: Although shading and crowding out other herb layer species is always possible with pasture grasses, no specific references were seen to this effect.

D. Impact on Natural Community Composition

Choose one answer that best describes this species' impact on community composition:

I. No impact; causes no perceivable change in native populations

L. Influences community composition (e.g., reduces the number of individuals in one or more native populations by reducing recruitment)

M. Significantly alters community composition (e.g., produces a significant reduction in the population size of one or more native species in the community)

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

Comments: Tall fescue will invade open, natural communities and displace native species (Eidson 1997), most likely where the species has been planted near a natural area that has been subjected to some disturbance. This species is vigorous enough that it will outcompete even other pasture grasses, such as orchardgrass (*Dactylis glomerata*) and bluegrass (*Poa compressa*) (White, H.E. 1996).

E. Conservation Significance of the Natural Area(s) and Native Species Threatened
Many exotic plants occur primarily in disturbed, low quality habitats that are dominated by other exotic species. Exotic plants have a greater impact if they (a) directly or indirectly threaten native species or communities that are considered rare or vulnerable (e.g., Federally listed or ranked G1-G3 by The Nature Conservancy and Natural Heritage Network), or (b) threaten outstanding, high quality occurrences of common community types.

Choose one answer that best describes the overall conservation significance of native species or communities impacted by this exotic species:

I. Insignificant (e.g., found in human-disturbed habitats and is not known to impact any vulnerable or high quality native species or communities)
L. Low significance (e.g., usually inhabits common, unthreatened habitats and rarely impacts vulnerable or high quality species or communities)
M. Moderately significant (e.g., may occasionally threaten vulnerable or high quality species or communities)
H. Highly significant (e.g., known to inhabit one or more vulnerable or high quality communities and/or often threatens rare native species)

Comments: Tall fescue has definite potential for invading the more grass-dominated natural communities in the state, all of which are of conservation concern (Batcher 2000). This species is allelopathic and, once infected with the endophytic fungus, actually becomes a *more* aggressive competitor in the plant community for reasons that are not entirely clear (Ball et al 1993). The restoration potential for wildlands is moderately low, and even then would entail extensive herbiciding, prescribed burning, reseeding, tilling, etc., the latter two of which would be destructive to the very native species in need of protection at the site (Batcher 2000).

- **Impact Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Subrank Guidance
Minimum ranking information: to determine Impact Subrank, you must answer both categories A and B as well as at least one other category in this section.
If H in A and B, Subrank = High
If H in A or B, and M or H in at least one other category (A-E), Subrank = High
If M in A and B, and H in at least one other category, Subrank = High
If M in A or B, and M or H in at least one other category, Subrank = Medium
If L in A or B, and H in at least one other category, Subrank = Medium
If M in at least one category, Subrank = Low
All others, Subrank = Insignificant

SECTION II. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY

A. Biological Characteristics: Reproduction, Competitive Ability, and Dispersal

The following are some biological characteristics of invasive species. Check those that apply to this species and note any other weedy or invasive traits this species possesses in the space for comments below.

Reproduction:

- ☐ Reproduces readily both vegetatively and by seed
- ☒ If reproduction is by seed, produces over 1,000 seeds per plant annually
- ☐ Reproduces more than once per year
- ☐ Rapid growth to reproductive maturity
- ☒ Seeds remain viable in soil for 2 or more years
- ☐ Has quickly spreading rhizomes that may root at nodes
- ☐ Resprouts readily when cut, grazed or burned
- ☐ Other (please discuss in comments)

Competitive ability:

- ☐ Highly successful competitor for limiting resources
- ☒ Tolerance of a wide range of conditions or tolerance of stressful conditions
- ☐ Ability to germinate in vegetated areas under a wide range of conditions
- ☒ Allelopathic
- ☐ Known to hybridize with native species
- ☐ Lack of natural predators or control agents in the United States
- ☐ Other (please discuss in comments)

Dispersal ability:

- ☐ Rapid local proliferation of seeds
- ☐ Long-distance dispersal ability (e.g., bird dispersed seed, small seeds carried by water)
- ☐ Other (please discuss in comments)

Choose one answer that best describes the biological characteristics of this species:

I. Not aggressive (e.g., has none of the above characteristics or only one or two to a very small extent)
L. Somewhat aggressive (e.g., has only one or two of the above and to a small extent)
M. Moderately aggressive (e.g., has two or more of the above characteristics, but has only one or two to a great extent)
H. Extremely aggressive (e.g., has three or more of the above characteristics and has them to a great extent)

Comments: Source: USDA, NRCS (2001). Using a suite of plant characteristics and data from NRCS PLANTS Database, a predictive model classified this species as invasive (Heffernan et al 2001).

B. Other regions invaded

Is this species known to be invasive beyond its native range in other areas outside the United States? **NO**
If yes, briefly list the other countries or regions invaded:

Comments: Tall fescue is found in all but three Canadian provinces (Kartesz 1999), but no reports of invasiveness were found.

C. Dispersal Ability and Speed of Spread

1. Speed of spread (increase in range) once reported as escaped.
Choose one answer that best describes the speed of spread:

I. Does not spread
L. Slow -- doubling time (new local reports) > 50 years
M. Moderate -- doubling time (new local reports) 10-50 years
H. Rapid -- doubling time (new local reports) < 10 years

Comments (if possible, comment on the maximum speed of spread): No data.

2. Current trend in total range within the United States.
Choose one answer that best describes the current trend:

I. Declining or Historical
L. Stable
M. Increasing
H. Increasing rapidly

Comments: Tall fescue is already found in all 48 contiguous U.S. states (USDA NRCS 2001).

3. Potential to be spread by human activity
Is this species frequently spread or does it have has high potential to be spread by human activity (e.g., species is sold commercially for use in agriculture or ornamental horticulture; species takes advantage of transportation corridors such as highways; species is aquatic and is transported by boats or boat trailers)? **YES**

Comments:

- **Biology/Dispersal Ability Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Subrank Guidance
Minimum ranking information: to determine this Subrank, you must answer at least 4 of the 5 questions above.
Use the following scoring system: 3 points for H, 2 for M, 1 for L; 2 for Yes. Highest possible score = 13
If total score is 9-13, Subrank = High
If total score is 6-8, Subrank = Medium
If total score is 3-5, Subrank = Low
If total score is 0-2, Subrank = Insignificant

SECTION III. DISTRIBUTION AND ABUNDANCE IN VIRGINIA AND THE UNITED STATES

A. Approximate number of distinct natural areas or other wildlands infested in Virginia.
Choose one answer that best matches the number of sites infested:

(Treat one site as the rough equivalent of one preserve, park, BLM district, wildlife refuge, wilderness area, etc.)
I. < 5 (few; scattered)
L. 6 to 10 sites
M. 11 to 30 sites
H. Greater than 30 sites
Enter approximate date of information (year): 1992

Comments: (Include Virginia range information from *Atlas of Virginia Flora*.) In Virginia, tall fescue is reported from two state parks and four natural area preserves (Caljouw 1994). Harvill et al (1992) list this species from all but 14 Virginia counties.

B. Extent of the species U.S. range in which it has been identified as a problem by land managers
Some non-native species are not invasive everywhere they occur in U.S. but only in certain regions or habitats. For instance, Tamarisks are severe riparian and wetland pests from California to Texas and north at least to Kansas, but while they escape occasionally in the eastern United States, they have not been reported as a problem east of the Mississippi.

This species has been identified by land managers as a problem in approximately what portion of its U.S. range?
Choose one answer that best describes the extent of range in which considered to be a problem:

I. 0 to 5%
L. 6 to 20%
M. 20 to 50%
H. Greater than 50%

Comments (Include U.S. range information. If the species is a threat to only certain types of natural communities, please specify): Tall fescue is reported from all 48 continental states and Alaska (Kartesz 1999). Tall fescue is listed as an invasive species by the Tennessee Exotic Pest Plants Council (USDA NRCS 2000). It is also declared a noxious weed seed in Virginia, Delaware, Maryland, New Jersey, and Pennsylvania. The Weed Science Society list tall fescue in their weed database (WSSA 2001).Tall fescue has definite potential for invading the more grass-dominated natural communities in the state, all of which are of conservation concern (Batcher 2000). Tall fescue appeared as one of the most frequently found alien plant species in sample plots for the Virginia vegetation community classification project (Heffernan et al 2001).

D. Potential cover of the species in strata where it occurs
Choose one answer that best describes the potential cover:

I. Infrequent (less than 10%)
L. Fair coverage but less than half (10 - 50%)
M. Dominant (50 - 90%)
H. Monospecific stand (90 - 100%)

Comments: Source: Hutchinson (1990).

- **Distribution and Abundance Subrank** (enter Insignificant, Low, Medium or High)**:**

LOW

Subrank Guidance
Minimum ranking information: to determine this Subrank, you must answer A. and at least 1 other question in this section.
If H in A, and M or H in at least one other category, Subrank = High
If H in A, and L or I in all other categories, Subrank = Medium
If M in A, and H in at least one other category, Subrank = High
If M in A, and M in at least one other category, Subrank = Medium
If M in A, and L or I in all other categories, Subrank = Medium
If L in A, and H in at least one other category, Subrank = Medium
If L in A, and M in at least one other category, Subrank = Low
If I in A, and H in at least one other category, Subrank = Low
All others, Subrank = Insignificant

SECTION IV. MANAGEMENT POTENTIAL

Given the current state of knowledge regarding management methods, how difficult is it to control this species?

Choose one answer that best describes the potential for management:

I. Management is not required (e.g., species does not persist without repeated disturbance)
L. Management is relatively easy and inexpensive; requires a minor investment in human and financial resources
M. Management requires a major short-term investment of human and financial resources, or a moderate long-term investment
H. Management requires a major, long-term investment of human and financial resources

- **Management Subrank** (enter Insignificant, Low, Medium or High)**:**

HIGH

Comments (Comment on both the difficulty of control and on the extent of knowledge that exists regarding the management of this species. Please keep comments brief -- do not go into detail on control methods):

SECTION V. OVERALL RANKING PROCEDURE FOR PLANT SPECIES INVASIVENESS RANK

The Plant Species Invasiveness Rank is a rating of the overall significance of the threat caused by this species to native species and native plant habitat in the Virginia, based on the four subranks below.

- **SUBRANKS**

I.	**Impact subrank:**	**MEDIUM**
II.	**Biology and dispersal ability subrank:**	**HIGH**
III.	**Distribution and abundance subrank:**	**HIGH**
IV.	**Management subrank**:	**HIGH**

The Plant Species Invasiveness Rank is based on the four subranks. Please assign scores to the subranks as follows:

Weighted average/point system

SUBRANK:		**SCORE:**
I.	Impact	H = 4, M = 3, L = 2, I = 0
II.	Biology	H = 3, M = 2, L = 1, I = 0
III.	Distribution	H = 1, M = 0, L = 0, I = 0
IV.	Management	H = 2, M = 1, L = 0, I = 0

Add up these scores to get overall Plant Species Invasiveness Rank. Highest possible score = 10

Overall ranking scale:

I.	Insignificant:	total score = 0-3	Species represents an insignificant threat to natural communities
L.	Low:	total score = 4-6	Species represents low threat to natural communities
M.	Medium:	total score = 7-8	Species represents moderate threat to natural communities
H.	High:	total score = 9-10	Species represents high threat to natural communities

Examples: A species with the significance category of "I" may be exotic but poses little or no threat to natural communities. A species with the significance category of "H" poses a serious threat to native species and communities in Virginia.

- **PLANT SPECIES INVASIVENESS RANK**
  (Enter Insignificant, Low, Medium or High)**: MEDIUM**

SECTION VI. REFERENCES

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PLANT SPECIES INVASIVENESS RANK FORM

SUMMARY SPECIES DATA

Scientific Name: ***Lotus corniculatus***
Synonyms: ***Lotus corniculatus* var. *arvensis***
Common Name(s): **Birdsfoot Trefoil, Birdsfoot Deervetch**
Native Range: **Eurasia**

AUTHOR INFORMATION

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Edition date (mm/dd/yyyy): **04/20/2001**

RANKING CRITERIA

SECTION I. IMPACT ON NATIVE SPECIES, HABITATS AND ECOSYSTEMS

Where possible assess the *cumulative* (e.g., over a period of several decades) impact of the species on the natural areas and other wildlands where it typically occurs. Impacts will be re-assessed as more is learned and as the species moves into new areas.

A. Ability to Invade Natural Systems
Choose one answer (I-H) below that best describes the ability of this species to invade natural systems:

I. Not known to spread into natural areas on its own (e.g., species may persist from former cultivation)
L. Establishes only in areas where major disturbance has occurred in last 20 years (e.g., post-hurricane sites, highway corridors)
M Often establishes in mid- to late-successional natural areas where minor disturbances may occur (e.g., tree falls, hiking trails, streambank erosion), but no major disturbance in last 20-75 years
H. Often establishes in intact or otherwise healthy natural areas with no major disturbance for at least 75 yrs

Comments: Mostly considered to establish and spread in disturbed habitats when planted, but can invade natural areas (Uva et al. 1997, Rice and Randall 1999).

B. Impact on Ecosystem Processes

Species that alter processes such as fire occurrence or frequency, erosion and sedimentation rates, hydrological regimes, or nutrient regimes often have the greatest long-term impacts on ecosystems. Some non-native invaders can completely transform natural systems so that they can no longer support native species.

Choose one answer that best describes the impact of this species on ecological processes:

I. No perceivable impact on ecosystem processes

L. Influences ecosystem processes (e.g., has perceivable but mild influence on soil nutrient availability)

M. Significant alteration in ecosystem processes (e.g., increases sedimentation rates along coastlines, reducing open water areas that are important for waterfowl)

H. Major, possibly irreversible, alteration or disruption of ecosystem processes (e.g., the species drains water from open water or wetland systems through rapid transpiration, making these areas more fire prone and unable to support native wetland species; species fixes nitrogen in the soil making soil unlikely to support certain native plants)

Comments: Birdsfoot trefoil possesses high nitrogen-fixing ability that increases soil nitrogen (USDA NRCS 2000). Increased soil fertility can increase competition between plants adapted to low fertility habitat and species that require higher soil fertility conditions (Ramakrishnan and Vitousek. 1989, Vitousek and Walker 1989, Vitousek 1990).

C. Impact on Natural Community Structure

Choose one answer that best describes this species' impact on community structure:

I. No impact; establishes in an existing layer without influencing its structure

L. Influences structure in one layer (e.g., changes density of a layer)

M. Significant impact on at least one layer (e.g., creation of a new layer, elimination of an existing layer)

H. Major alteration of structure (e.g., covers canopy, eradicating most or all layers below)

Comments:

D. Impact on Natural Community Composition

Choose one answer that best describes this species' impact on community composition:

I. No impact; causes no perceivable change in native populations

L. Influences community composition (e.g., reduces the number of individuals in one or more native populations by reducing recruitment)

M. Significantly alters community composition (e.g., produces a significant reduction in the population size of one or more native species in the community)

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

Comments: Birdsfoot trefoil forms dense mats that choke out most other vegetation (Randall and Marinelli 1996).

E. Conservation Significance of the Natural Area(s) and Native Species Threatened
Many exotic plants occur primarily in disturbed, low quality habitats that are dominated by other exotic species. Exotic plants have a greater impact if they (a) directly or indirectly threaten native species or communities that are considered rare or vulnerable (e.g., Federally listed or ranked G1-G3 by The Nature Conservancy and Natural Heritage Network), or (b) threaten outstanding, high quality occurrences of common community types.

Choose one answer that best describes the overall conservation significance of native species or communities impacted by this exotic species:

I. Insignificant (e.g., found in human-disturbed habitats and is not known to impact any vulnerable or high quality native species or communities)
L. Low significance (e.g., usually inhabits common, unthreatened habitats and rarely impacts vulnerable or high quality species or communities)
M. Moderately significant (e.g., may occasionally threaten vulnerable or high quality species or communities)
H. Highly significant (e.g., known to inhabit one or more vulnerable or high quality communities and/or often threatens rare native species)

Comments: Seen as a problem plant in tallgrass prairies, with this species creeping into natural areas from roadsides and other disturbed or cultivated areas (Rice and Randall 1999).

- **Impact Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Subrank Guidance
Minimum ranking information: to determine Impact Subrank, you must answer both categories A and B as well as at least one other category in this section.
If H in A and B, Subrank = High
If H in A or B, and M or H in at least one other category (A-E), Subrank = High
If M in A and B, and H in at least one other category, Subrank = High
If M in A or B, and M or H in at least one other category, Subrank = Medium
If L in A or B, and H in at least one other category, Subrank = Medium
If M in at least one category, Subrank = Low
All others, Subrank = Insignificant

SECTION II. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY

A. Biological Characteristics: Reproduction, Competitive Ability, and Dispersal

The following are some biological characteristics of invasive species. Check those that apply to this species and note any other weedy or invasive traits this species possesses in the space for comments below.

Reproduction:

- ☐ Reproduces readily both vegetatively and by seed
- ☐ If reproduction is by seed, produces over 1,000 seeds per plant annually
- ☐ Reproduces more than once per year
- ☐ Rapid growth to reproductive maturity
- ☐ Seeds remain viable in soil for 2 or more years
- ☐ Has quickly spreading rhizomes that may root at nodes
- ☒ Resprouts readily when cut, grazed or burned
- ☒ Other (please discuss in comments)

Competitive ability:

- ☐ Highly successful competitor for limiting resources
- ☐ Tolerance of a wide range of conditions or tolerance of stressful conditions
- ☐ Ability to germinate in vegetated areas under a wide range of conditions
- ☐ Allelopathic
- ☐ Known to hybridize with native species
- ☐ Lack of natural predators or control agents in the United States
- ☐ Other (please discuss in comments)

Dispersal ability:

- ☐ Rapid local proliferation of seeds
- ☐ Long-distance dispersal ability (e.g., bird dispersed seed, small seeds carried by water)
- ☐ Other (please discuss in comments)

Choose one answer that best describes the biological characteristics of this species:

I. Not aggressive (e.g., has none of the above characteristics or only one or two to a very small extent)
L. Somewhat aggressive (e.g., has only one or two of the above and to a small extent)
M. Moderately aggressive (e.g., has two or more of the above characteristics, but has only one or two to a great extent)
H. Extremely aggressive (e.g., has three or more of the above characteristics and has them to a great extent)

Comments: Small seed size noted as a factor contributing to the invasiveness of this species (USDA, NRCS 2000).

B. Other regions invaded

Is this species known to be invasive beyond its native range in other areas outside the United States? **NO**
If yes, briefly list the other countries or regions invaded:

This species is found in eight Canadian provinces (Kartesz 1999), but no reports of invasiveness their were found.

C. Dispersal Ability and Speed of Spread

1. Speed of spread (increase in range) once reported as escaped
Choose one answer that best describes the speed of spread:

I. Does not spread
L. Slow -- doubling time (new local reports) > 50 years
M. Moderate -- doubling time (new local reports) 10-50 years
H. Rapid -- doubling time (new local reports) < 10 years

Comments (if possible, comment on the maximum speed of spread):

2. Current trend in total range within the United States
Choose one answer that best describes the current trend:

I. Declining or Historical
L. Stable
M. Increasing
H. Increasing rapidly

Comments: No data.

3. Potential to be spread by human activity
Is this species frequently spread or does it have has high potential to be spread by human activity (e.g., species is sold commercially for use in agriculture or ornamental horticulture; species takes advantage of transportation corridors such as highways; species is aquatic and is transported by boats or boat trailers)? **YES**

Comments: This species is commonly planted for forage, nitrogen building, wildlife cover, and erosion control (USDA, NRCS, 2000).

- **Biology/Dispersal Ability Subrank** (enter Insignificant, Low, Medium or High)**:**

LOW

Subrank Guidance
Minimum ranking information: to determine this Subrank, you must answer at least 4 of the 5 questions above.
Use the following scoring system: 3 points for H, 2 for M, 1 for L; 2 for Yes. Highest possible score = 13
If total score is 9-13, Subrank = High
If total score is 6-8, Subrank = Medium
If total score is 3-5, Subrank = Low
If total score is 0-2, Subrank = Insignificant

SECTION III. DISTRIBUTION AND ABUNDANCE IN VIRGINIA AND THE UNITED STATES

A. Approximate number of distinct natural areas or other wildlands infested in Virginia.
Choose one answer that best matches the number of sites infested:

(Treat one site as the rough equivalent of one preserve, park, BLM district, wildlife refuge, wilderness area, etc.)

I. < 5 (few; scattered)
L. 6 to 10 sites
M. 11 to 30 sites
H. Greater than 30 sites
Enter approximate date of information (year): 1992

Comments: No reports of birdsfoot trefoil in state parks or natural areas in Virginia (Caljouw 1994). Harvill et al (1992) list this species from 28 Virginia counties.

B. Extent of the species U.S. range in which it has been identified as a problem by land managers
Some non-native species are not invasive everywhere they occur in U.S. but only in certain regions or habitats. For instance, Tamarisks are severe riparian and wetland pests from California to Texas and north at least to Kansas, but while they escape occasionally in the eastern United States, they have not been reported as a problem east of the Mississippi.

This species has been identified by land managers as a problem in approximately what portion of its U.S. range?
Choose one answer that best describes the extent of range in which considered to be a problem:

I. 0 to 5%
L. 6 to 20%
M. 20 to 50%
H. Greater than 50%

Comments (Include U.S. range information. If the species is a threat to only certain types of natural communities, please specify): Birdsfoot trefoil is reported from 45 states (Kartesz 1999). Reported to be a problem in tallgrass prairies in the Midwest (Randall and Marinelli 1996).

C. Potential cover of the species in strata where it occurs
Choose one answer that best describes the potential cover:

I. Infrequent (less than 10%)
L. Fair coverage but less than half (10 - 50%)
M. Dominant (50 - 90%)
H. Monospecific stand (90 - 100%)
Comments: Birdsfoot trefoil is reported to form dense mats that choke out most other vegetation at a site (Randall and Marinelli 1996).

- **Distribution and Abundance Subrank** (enter Insignificant, Low, Medium or High)**:**

INSIGNIFICANT

Subrank Guidance

Minimum ranking information: to determine this Subrank, you must answer A. and at least 1 other question in this section.

If H in A, and M or H in at least one other category, Subrank = High

If H in A, and L or I in all other categories, Subrank = Medium

If M in A, and H in at least one other category, Subrank = High

If M in A, and M in at least one other category, Subrank = Medium

If M in A, and L or I in all other categories, Subrank = Medium

If L in A, and H in at least one other category, Subrank = Medium

If L in A, and M in at least one other category, Subrank = Low

If I in A, and H in at least one other category, Subrank = Low

All others, Subrank = Insignificant

SECTION IV. MANAGEMENT POTENTIAL

Given the current state of knowledge regarding management methods, how difficult is it to control this species?

I. Management is not required (e.g., species does not persist without repeated disturbance)

L. Management is relatively easy and inexpensive; requires a minor investment in human and financial resources

M. Management requires a major short-term investment of human and financial resources, or a moderate long-term investment

H. Management requires a major, long-term investment of human and financial resources

- **Management Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Comments (Comment on both the difficulty of control and on the extent of knowledge that exists regarding the management of this species. Please keep comments brief -- do not go into detail on control methods): Mowing and herbicide treatments over a period of several years are reported to achieve control (Randall and Marinelli 1996).

SECTION V. OVERALL RANKING PROCEDURE FOR PLANT SPECIES INVASIVENESS RANK

The Plant Species Invasiveness Rank is a rating of the overall significance of the threat caused by this species to native species and native plant habitat in Virginia, based on the four subranks below.

- **SUBRANKS**

I.	**Impact subrank:**	**MEDIUM**
II.	**Biology and dispersal ability subrank:**	**MEDIUM**
III.	**Distribution and abundance subrank:**	**HIGH**
IV.	**Management subrank**:	**MEDIUM**

The Plant Species Invasiveness Rank is based on the four subranks. Please assign scores to the subranks as follows:

Weighted average/point system

SUBRANK:		**SCORE:**
I.	Impact	H = 4, M = 3, L = 2, I = 0
II.	Biology	H = 3, M = 2, L = 1, I = 0
III.	Distribution	H = 1, M = 0, L = 0, I = 0
IV.	Management	H = 2, M = 1, L = 0, I = 0

Add up these scores to get overall Plant Species Invasiveness Rank. Highest possible score = 10

Overall ranking scale:

I.	Insignificant:	total score = 0-3	Species represents an insignificant threat to natural communities
L.	Low:	total score = 4-6	Species represents low threat to natural communities
M.	Medium:	total score = 7-8	Species represents moderate threat to natural communities
H.	High:	total score = 9-10	Species represents high threat to natural communities

Examples: A species with the significance category of "I" may be exotic but poses little or no threat to natural communities. A species with the significance category of "H" poses a serious threat to native species and communities in Virginia.

- **PLANT SPECIES INVASIVENESS RANK**
  (Enter Insignificant, Low, Medium or High**: MEDIUM**

SECTION VI. REFERENCES

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PLANT SPECIES INVASIVENESS RANK FORM

SUMMARY SPECIES DATA

Scientific Name: ***Melilotus alba***
Synonyms: ***Melilotus albus***
Common Name(s): **White Melilot, White Sweetclover**
Native Range: **Mediterranean Europe**

AUTHOR INFORMATION

Author: **John F. Townsend**

Author's affiliation: **Department of Conservation and Recreation, Division of Natural Heritage**

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Edition date (mm/dd/yyyy): **04/23/2001**

RANKING CRITERIA

SECTION I. IMPACT ON NATIVE SPECIES, HABITATS AND ECOSYSTEMS

Where possible assess the *cumulative* (e.g., over a period of several decades) impact of the species on the natural areas and other wildlands where it typically occurs. Impacts will be re-assessed as more is learned and as the species moves into new areas.

A. Ability to Invade Natural Systems
Choose one answer (I-H) below that best describes the ability of this species to invade natural systems:

I. Not known to spread into natural areas on its own (e.g., species may persist from former cultivation)
L. Establishes only in areas where major disturbance has occurred in last 20 years (e.g., post-hurricane sites, highway corridors)
M Often establishes in mid- to late-successional natural areas where minor disturbances may occur (e.g., tree falls, hiking trails, streambank erosion), but no major disturbance in last 20-75 years
H. Often establishes in intact or otherwise healthy natural areas with no major disturbance for at least 75 yrs

Comments: This species readily invades following only minor disturbances, whether man-made or not, if a seed source is near. Periodically recurring natural or human-caused fires tend to actually increase the abundance of *Melilotus alba* unless a very specific sequence and timing of fire is used (Eckardt 1987).

B. Impact on Ecosystem Processes

Species that alter processes such as fire occurrence or frequency, erosion and sedimentation rates, hydrological regimes, or nutrient regimes often have the greatest long-term impacts on ecosystems. Some non-native invaders can completely transform natural systems so that they can no longer support native species.

Choose one answer that best describes the impact of this species on ecological processes:

I. No perceivable impact on ecosystem processes

L. Influences ecosystem processes (e.g., has perceivable but mild influence on soil nutrient availability)

M. Significant alteration in ecosystem processes (e.g., increases sedimentation rates along coastlines, reducing open water areas that are important for waterfowl)

H. Major, possibly irreversible, alteration or disruption of ecosystem processes (e.g., the species drains water from open water or wetland systems through rapid transpiration, making these areas more fire prone and unable to support native wetland species; species fixes nitrogen in the soil making soil unlikely to support certain native plants)

Comments: May alter edaphic conditions in prairies and prairie-like areas due to nitrogen fixing ability of this species. Also, thick stands of this species may be difficult to burn due to their low fuel content, causing degradation of natural grassland communities (Eckardt 1987)

C. Impact on Natural Community Structure

Choose one answer that best describes this species' impact on community structure:

I. No impact; establishes in an existing layer without influencing its structure

L. Influences structure in one layer (e.g., changes density of a layer)

M. Significant impact on at least one layer (e.g., creation of a new layer, elimination of an existing layer)

H. Major alteration of structure (e.g., covers canopy, eradicating most or all layers below)

Comments: Has ability to shade out species of smaller stature (primarily forbs) once it dominates a site (USDA 2001, USDA, NRCS 2001).

D. Impact on Natural Community Composition

Choose one answer that best describes this species' impact on community composition:

I. No impact; causes no perceivable change in native populations

L. Influences community composition (e.g., reduces the number of individuals in one or more native populations by reducing recruitment)

M. Significantly alters community composition (e.g., produces a significant reduction in the population size of one or more native species in the community)

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

Comments: This species readily invades open, prairie-like areas and degrades these habitats by shading out native species adapted to grassland habitat (Cole 1990).

E. Conservation Significance of the Natural Area(s) and Native Species Threatened
Many exotic plants occur primarily in disturbed, low quality habitats that are dominated by other exotic species. Exotic plants have a greater impact if they (a) directly or indirectly threaten native species or communities that are considered rare or vulnerable (e.g., Federally listed or ranked G1-G3 by The Nature Conservancy and Natural Heritage Network), or (b) threaten outstanding, high quality occurrences of common community types.

Choose one answer that best describes the overall conservation significance of native species or communities impacted by this exotic species:

I. Insignificant (e.g., found in human-disturbed habitats and is not known to impact any vulnerable or high quality native species or communities)
L. Low significance (e.g., usually inhabits common, unthreatened habitats and rarely impacts vulnerable or high quality species or communities)
M. Moderately significant (e.g., may occasionally threaten vulnerable or high quality species or communities)
H. Highly significant (e.g., known to inhabit one or more vulnerable or high quality communities and/or often threatens rare native species)

Comments: This species is more of a problem near planted or naturalized seed sources, but tendency of seed to disperse by water indicates that herbaceous riverine communities can be altered by invasion of *Melilotus* (Eckardt 1987). Terrestrial grassland communities (rare to uncommon in Virginia) are especially susceptible to invasion by this species. Numerous species listed as rare in the state of Virginia are components of grassland communities (Townsend 2001), and will be impacted negatively by invasion of this species. Since this alien species performs best on calcareous or other "rich" substrates, some of the most botanically unique habitats in Virginia are most vulnerable to invasion.

- **Impact Subrank** (enter Insignificant, Low, Medium or High)**:**

HIGH

Subrank Guidance
Minimum ranking information: to determine Impact Subrank, you must answer both categories A and B as well as at least one other category in this section.
If H in A and B, Subrank = High
If H in A or B, and M or H in at least one other category (A-E), Subrank = High
If M in A and B, and H in at least one other category, Subrank = High
If M in A or B, and M or H in at least one other category, Subrank = Medium
If L in A or B, and H in at least one other category, Subrank = Medium
If M in at least one category, Subrank = Low
All others, Subrank = Insignificant

SECTION II. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY

A. Biological Characteristics: Reproduction, Competitive Ability, and Dispersal

The following are some biological characteristics of invasive species. Check those that apply to this species and note any other weedy or invasive traits this species possesses in the space for comments below.

Reproduction:

- ☐ Reproduces readily both vegetatively and by seed
- ☒ If reproduction is by seed, produces over 1,000 seeds per plant annually
- ☐ Reproduces more than once per year
- ☒ Rapid growth to reproductive maturity
- ☒ Seeds remain viable in soil for 2 or more years
- ☐ Has quickly spreading rhizomes that may root at nodes
- ☒ Resprouts readily when cut, grazed or burned
- ☒ Other (please discuss in comments)

Competitive ability:

- ☐ Highly successful competitor for limiting resources
- ☒ Tolerance of a wide range of conditions or tolerance of stressful conditions
- ☐ Ability to germinate in vegetated areas under a wide range of conditions
- ☐ Allelopathic
- ☐ Known to hybridize with native species
- ☐ Lack of natural predators or control agents in the United States
- ☐ Other (please discuss in comments)

Dispersal ability:

- ☐ Rapid local proliferation of seeds
- ☐ Long-distance dispersal ability (e.g., bird dispersed seed, small seeds carried by water)
- ☐ Other (please discuss in comments)

Choose one answer that best describes the biological characteristics of this species:

I. Not aggressive (e.g., has none of the above characteristics or only one or two to a very small extent)
L. Somewhat aggressive (e.g., has only one or two of the above and to a small extent)
M. Moderately aggressive (e.g., has two or more of the above characteristics, but has only one or two to a great extent)
H. Extremely aggressive (e.g., has three or more of the above characteristics and has them to a great extent)

Comments: Source of data: USDA, NRCS 2001. This species also has a small seed size and high seed germination, both characteristics that increase its weediness but are not specific categories in the sections on reproduction and competitive ability (above). Using a suite of plant characteristics and data from NRCS PLANTS Database, a predictive model classified this species as invasive (Heffernan et al 2001).

B. Other regions invaded

Is this species known to be invasive beyond its native range in other areas outside the United States? **YES**
If yes, briefly list the other countries or regions invaded:

This species is present in all but two Canadian provinces (Kartesz 1999) and is considered moderately invasive (White et al. 1993).

C. Dispersal Ability and Speed of Spread

1. Speed of spread (increase in range) once reported as escaped
Choose one answer that best describes the speed of spread:

I. Does not spread
L. Slow -- doubling time (new local reports) > 50 years
M. Moderate -- doubling time (new local reports) 10-50 years
H. Rapid -- doubling time (new local reports) < 10 years

Comments (if possible, comment on the maximum speed of spread):

2. Current trend in total range within the United States
Choose one answer that best describes the current trend:

I. Declining or Historical
L. Stable
M. Increasing
H. Increasing rapidly

Comments: No data.

3. Potential to be spread by human activity
Is this species frequently spread or does it have has high potential to be spread by human activity (e.g., species is sold commercially for use in agriculture or ornamental horticulture; species takes advantage of transportation corridors such as highways; species is aquatic and is transported by boats or boat trailers)? **YES**

Comments: This species is planted widely and used for hay, a nitrogen source for "resting" agricultural fields, a nectar source for honeybees, and for soil stabilization. Any human – caused clearings in forest land are easily colonized by this species.

- **Biology/Dispersal Ability Subrank** (enter Insignificant, Low, Medium or High)**:**

HIGH

Subrank Guidance
Minimum ranking information: to determine this Subrank, you must answer at least 4 of the 5 questions above.
Use the following scoring system: 3 points for H, 2 for M, 1 for L; 2 for Yes. Highest possible score = 13
If total score is 9-13, Subrank = High
If total score is 6-8, Subrank = Medium
If total score is 3-5, Subrank = Low
If total score is 0-2, Subrank = Insignificant

SECTION III. DISTRIBUTION AND ABUNDANCE IN VIRGINIA AND THE UNITED STATES

A. Approximate number of distinct natural areas or other wildlands infested in Virginia.
Choose one answer that best matches the number of sites infested:

(Treat one site as the rough equivalent of one preserve, park, BLM district, wildlife refuge, wilderness area, etc.)

I. < 5 (few; scattered)
L. 6 to 10 sites
M. 11 to 30 sites
H. Greater than 30 sites
Enter approximate date of information (year): 1994

Comments: White sweetclover was reported from two state parks and two natural area preserves (Caljouw 1994). Harvill et al (1992) list this species from all but 2 Virginia counties.

B. Extent of the species U.S. range in which it has been identified as a problem by land managers
Some non-native species are not invasive everywhere they occur in U.S. but only in certain regions or habitats. For instance, Tamarisks are severe riparian and wetland pests from California to Texas and north at least to Kansas, but while they escape occasionally in the eastern United States, they have not been reported as a problem east of the Mississippi.

This species has been identified by land managers as a problem in approximately what portion of its U.S. range?
Choose one answer that best describes the extent of range in which considered to be a problem:

I. 0 to 5%
L. 6 to 20%
M. 20 to 50%
H. Greater than 50%

Comments (Include U.S. range information. If the species is a threat to only certain types of natural communities, please specify): White sweetclover is found in all 50 states and is reported as a problem in prairies in the Midwest and Canada (Kartesz 1999, Ekhardt 1987, White et al. 1993).

C. Potential cover of the species in strata where it occurs
Choose one answer that best describes the potential cover:

I. Infrequent (less than 10%)
L. Fair coverage but less than half (10 - 50%)
M. Dominant (50 - 90%)
H. Monospecific stand (90 - 100%)

Comments: No data.

- **Distribution and Abundance Subrank** (enter Insignificant, Low, Medium or High)**:**

INSIGNIFICANT

Subrank Guidance

Minimum ranking information: to determine this Subrank, you must answer A. and at least 1 other question in this section.

If H in A, and M or H in at least one other category, Subrank = High

If H in A, and L or I in all other categories, Subrank = Medium

If M in A, and H in at least one other category, Subrank = High

If M in A, and M in at least one other category, Subrank = Medium

If M in A, and L or I in all other categories, Subrank = Medium

If L in A, and H in at least one other category, Subrank = Medium

If L in A, and M in at least one other category, Subrank = Low

If I in A, and H in at least one other category, Subrank = Low

All others, Subrank = Insignificant

SECTION IV. MANAGEMENT POTENTIAL

Given the current state of knowledge regarding management methods, how difficult is it to control this species?

I. Management is not required (e.g., species does not persist without repeated disturbance)

L. Management is relatively easy and inexpensive; requires a minor investment in human and financial resources

M. Management requires a major short-term investment of human and financial resources, or a moderate long-term investment

H. Management requires a major, long-term investment of human and financial resources

- **Management Subrank** (enter Insignificant, Low, Medium or High)**:**

HIGH

Comments (Comment on both the difficulty of control and on the extent of knowledge that exists regarding the management of this species. Please keep comments brief -- do not go into detail on control methods):

Well timed burns can be helpful, but burning at inappropriate times will only encourage the species (Eckardt 1987, USDA 2001)

SECTION V. OVERALL RANKING PROCEDURE FOR PLANT SPECIES INVASIVENESS RANK

The Plant Species Invasiveness Rank is a rating of the overall significance of the threat caused by this species to native species and native plant habitat in Virginia, based on the four subranks below.

- **SUBRANKS**

I.	**Impact subrank:**	**HIGH**
II.	**Biology and dispersal ability subrank:**	**HIGH**
III.	**Distribution and abundance subrank:**	**INSIGNIFICANT**
IV.	**Management subrank**:	**HIGH**

The Plant Species Invasiveness Rank is based on the four subranks. Please assign scores to the subranks as follows:

Weighted average/point system

SUBRANK:		**SCORE:**
I.	Impact	H = 4, M = 3, L = 2, I = 0
II.	Biology	H = 3, M = 2, L = 1, I = 0
III.	Distribution	H = 1, M = 0, L = 0, I = 0
IV.	Management	H = 2, M = 1, L = 0, I = 0

Add up these scores to get overall Plant Species Invasiveness Rank. Highest possible score = 10

Overall ranking scale:

I.	Insignificant:	total score = 0-3	Species represents an insignificant threat to natural communities
L.	Low:	total score = 4-6	Species represents low threat to natural communities
M.	Medium:	total score = 7-8	Species represents moderate threat to natural communities
H.	High:	total score = 9-10	Species represents high threat to natural communities

Examples: A species with the significance category of "I" may be exotic but poses little or no threat to natural communities. A species with the significance category of "H" poses a serious threat to native species and communities in Virginia.

- **PLANT SPECIES INVASIVENESS RANK**
  (Enter Insignificant, Low, Medium or High)**: HIGH**

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PLANT SPECIES INVASIVENESS RANK FORM

SUMMARY SPECIES DATA

Scientific Name: ***Melilotus officinalis***
Synonyms: **None**
Common Name(s): **Yellow Melilot, Yellow Sweetclover, Ribbed Melilot**
Native Range: **Mediterranean Europe**

AUTHOR INFORMATION

Author: **John F. Townsend**

Author's affiliation: **Department of Conservation and Recreation, Division of Natural Heritage**

Edition date (mm/dd/yyyy): **04/20/2001**

RANKING CRITERIA

SECTION I. IMPACT ON NATIVE SPECIES, HABITATS AND ECOSYSTEMS

Where possible assess the *cumulative* (e.g., over a period of several decades) impact of the species on the natural areas and other wildlands where it typically occurs. Impacts will be re-assessed as more is learned and as the species moves into new areas.

A. Ability to Invade Natural Systems
Choose one answer (I-H) below that best describes the ability of this species to invade natural systems:

I. Not known to spread into natural areas on its own (e.g., species may persist from former cultivation)
L. Establishes only in areas where major disturbance has occurred in last 20 years (e.g., post-hurricane sites, highway corridors)
M Often establishes in mid- to late-successional natural areas where minor disturbances may occur (e.g., tree falls, hiking trails, streambank erosion), but no major disturbance in last 20-75 years
H. Often establishes in intact or otherwise healthy natural areas with no major disturbance for at least 75 yrs

Comments: This species readily invades following only minor disturbances, whether man-made or not, if a seed source is near. Periodically recurring natural or human-caused fires tend to actually increase the abundance of yellow sweetclover unless a very specific sequence and timing of fire is used (Eckardt 1987).

B. Impact on Ecosystem Processes

Species that alter processes such as fire occurrence or frequency, erosion and sedimentation rates, hydrological regimes, or nutrient regimes often have the greatest long-term impacts on ecosystems. Some non-native invaders can completely transform natural systems so that they can no longer support native species.

Choose one answer that best describes the impact of this species on ecological processes:

I. No perceivable impact on ecosystem processes

L. Influences ecosystem processes (e.g., has perceivable but mild influence on soil nutrient availability)

M. Significant alteration in ecosystem processes (e.g., increases sedimentation rates along coastlines, reducing open water areas that are important for waterfowl)

H. Major, possibly irreversible, alteration or disruption of ecosystem processes (e.g., the species drains water from open water or wetland systems through rapid transpiration, making these areas more fire prone and unable to support native wetland species; species fixes nitrogen in the soil making soil unlikely to support certain native plants)

Comments: May alter edaphic conditions in prairies and prairie-like areas due to nitrogen-fixing ability of this species. Also, thick stands of this species may be difficult to burn due to their low fuel content, causing degradation of natural grassland communities (Eckardt 1987).

C. Impact on Natural Community Structure

Choose one answer that best describes this species' impact on community structure:

I. No impact; establishes in an existing layer without influencing its structure

L. Influences structure in one layer (e.g., changes density of a layer)

M. Significant impact on at least one layer (e.g., creation of a new layer, elimination of an existing layer)

H. Major alteration of structure (e.g., covers canopy, eradicating most or all layers below)

Comments: Yellow sweetclover has the ability to shade out species of smaller stature (primarily forbs) once it dominates a site (USDA 2001, USDA, NRCS 2001).

D. Impact on Natural Community Composition

Choose one answer that best describes this species' impact on community composition:

I. No impact; causes no perceivable change in native populations

L. Influences community composition (e.g., reduces the number of individuals in one or more native populations by reducing recruitment)

M. Significantly alters community composition (e.g., produces a significant reduction in the population size of one or more native species in the community)

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

Comments: This species readily invades open, prairie-like areas and degrades these habitats by shading out native species adapted to grassland habitat (Illinois Nature Preserve Commission 1990).

E. Conservation Significance of the Natural Area(s) and Native Species Threatened
Many exotic plants occur primarily in disturbed, low quality habitats that are dominated by other exotic species. Exotic plants have a greater impact if they (a) directly or indirectly threaten native species or communities that are considered rare or vulnerable (e.g., Federally listed or ranked G1-G3 by The Nature Conservancy and Natural Heritage Network), or (b) threaten outstanding, high quality occurrences of common community types.

Choose one answer that best describes the overall conservation significance of native species or communities impacted by this exotic species:

I. Insignificant (e.g., found in human-disturbed habitats and is not known to impact any vulnerable or high quality native species or communities)
L. Low significance (e.g., usually inhabits common, unthreatened habitats and rarely impacts vulnerable or high quality species or communities)
M. Moderately significant (e.g., may occasionally threaten vulnerable or high quality species or communities)
H. Highly significant (e.g., known to inhabit one or more vulnerable or high quality communities and/or often threatens rare native species)

Comments: Yellow sweetclover is more of a problem near planted or naturalized seed sources, but tendency of seed to disperse by water indicates that herbaceous riverine communities can be altered by invasion of *Melilotus* (Eckardt 1987). Terrestrial grassland communities (rare to uncommon in Virginia) are especially susceptible to invasion by this species. Numerous species listed as rare in the state of Virginia are components of grassland communities (Townsend 2001), and will be impacted negatively by invasion of this species. Since this alien species performs best on calcareous or other "rich" substrates, some of the most botanically unique habitats in Virginia are most vulnerable to invasion.

- **Impact Subrank** (enter Insignificant, Low, Medium or High)**:**

HIGH

Subrank Guidance
Minimum ranking information: to determine Impact Subrank, you must answer both categories A and B as well as at least one other category in this section.
If H in A and B, Subrank = High
If H in A or B, and M or H in at least one other category (A-E), Subrank = High
If M in A and B, and H in at least one other category, Subrank = High
If M in A or B, and M or H in at least one other category, Subrank = Medium
If L in A or B, and H in at least one other category, Subrank = Medium
If M in at least one category, Subrank = Low
All others, Subrank = Insignificant

SECTION II. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY

A. Biological Characteristics: Reproduction, Competitive Ability, and Dispersal

The following are some biological characteristics of invasive species. Check those that apply to this species and note any other weedy or invasive traits this species possesses in the space for comments below.

Reproduction:

- ☐ Reproduces readily both vegetatively and by seed
- ☒ If reproduction is by seed, produces over 1,000 seeds per plant annually
- ☐ Reproduces more than once per year
- ☒ Rapid growth to reproductive maturity
- ☒ Seeds remain viable in soil for 2 or more years
- ☐ Has quickly spreading rhizomes that may root at nodes
- ☒ Resprouts readily when cut, grazed or burned
- ☒ Other (please discuss in comments)

Competitive ability:

- ☐ Highly successful competitor for limiting resources
- ☒ Tolerance of a wide range of conditions or tolerance of stressful conditions
- ☐ Ability to germinate in vegetated areas under a wide range of conditions
- ☐ Allelopathic
- ☐ Known to hybridize with native species
- ☐ Lack of natural predators or control agents in the United States
- ☐ Other (please discuss in comments)

Dispersal ability:

- ☐ Rapid local proliferation of seeds
- ☐ Long-distance dispersal ability (e.g., bird dispersed seed, small seeds carried by water)
- ☐ Other (please discuss in comments)

Choose one answer that best describes the biological characteristics of this species:

I. Not aggressive (e.g., has none of the above characteristics or only one or two to a very small extent)
L. Somewhat aggressive (e.g., has only one or two of the above and to a small extent)
M. Moderately aggressive (e.g., has two or more of the above characteristics, but has only one or two to a great extent)
H. Extremely aggressive (e.g., has three or more of the above characteristics and has them to a great extent)

Comments: Source: USDA, NRCS 2001. This species also has a small seed size and high seed germination, both characteristics that increase its invasiveness but are not specific categories in the sections on reproduction and competitive ability (above). Using a suite of plant characteristics and data from NRCS PLANTS Database, a predictive model classified this species as invasive (Heffernan et al 2001).

B. Other regions invaded

Is this species known to be invasive beyond its native range in other areas outside the United States? **YES**
If yes, briefly list the other countries or regions invaded:

This species is present in all but two Canadian provinces (Kartesz 1999) and is considered moderately invasive (White et al. 1993).

C. Dispersal Ability and Speed of Spread

1. Speed of spread (increase in range) once reported as escaped
Choose one answer that best describes the speed of spread:

I. Does not spread
L. Slow -- doubling time (new local reports) > 50 years
M. Moderate -- doubling time (new local reports) 10-50 years
H. Rapid -- doubling time (new local reports) < 10 years

Comments (if possible, comment on the maximum speed of spread):

2. Current trend in total range within the United States
Choose one answer that best describes the current trend:

I. Declining or Historical
L. Stable
M. Increasing
H. Increasing rapidly

Comments: No data.

3. Potential to be spread by human activity
Is this species frequently spread or does it have has high potential to be spread by human activity (e.g., species is sold commercially for use in agriculture or ornamental horticulture; species takes advantage of transportation corridors such as highways; species is aquatic and is transported by boats or boat trailers)? **YES**

Comments: This species is planted widely and used for hay, a nitrogen source for "resting" agricultural fields, a nectar source for honeybees, and for soil stabilization. Any human-caused clearings in forest land are easily colonized by yellow sweetclover.

- **Biology/Dispersal Ability Subrank** (enter Insignificant, Low, Medium or High)**:** **HIGH**

Subrank Guidance
Minimum ranking information: to determine this Subrank, you must answer at least 4 of the 5 questions above.
Use the following scoring system: 3 points for H, 2 for M, 1 for L; 2 for Yes. Highest possible score = 13
If total score is 9-13, Subrank = High
If total score is 6-8, Subrank = Medium
If total score is 3-5, Subrank = Low
If total score is 0-2, Subrank = Insignificant

SECTION III. DISTRIBUTION AND ABUNDANCE IN THE UNITED STATES

A. Approximate number of distinct natural areas or other wildlands infested in Virginia.
Choose one answer that best matches the number of sites infested:

(Treat one site as the rough equivalent of one preserve, park, BLM district, wildlife refuge, wilderness area, etc.)

I. < 5 (few; scattered)
L. 6 to 10 sites
M. 11 to 30 sites
H. Greater than 30 sites
Enter approximate date of information (year):

Comments: (Include Virginia range information from *Atlas of Virginia Flora*.) Harvill et al (1992) list this species from all but 10 Virginia counties.

B. Extent of the species U.S. range in which it has been identified as a problem by land managers
Some non-native species are not invasive everywhere they occur in U.S. but only in certain regions or habitats. For instance, Tamarisks are severe riparian and wetland pests from California to Texas and north at least to Kansas, but while they escape occasionally in the eastern United States, they have not been reported as a problem east of the Mississippi.

This species has been identified by land managers as a problem in approximately what portion of its U.S. range?
Choose one answer that best describes the extent of range in which considered to be a problem:

I. 0 to 5%
L. 6 to 20%
M. 20 to 50%
H. Greater than 50%

Comments (Include U.S. range information. If the species is a threat to only certain types of natural communities, please specify): Yellow sweetclover is found in all 50 states and is reported as a problem in prairies in the Midwest and Canada (Kartesz 1999, Ekhardt 1987, White et al. 1993).

C. Potential cover of the species in strata where it occurs
Choose one answer that best describes the potential cover:

I. Infrequent (less than 10%)
L. Fair coverage but less than half (10 - 50%)
M. Dominant (50 - 90%)
H. Monospecific stand (90 - 100%)

Comments: No data.

- **Distribution and Abundance Subrank** (enter Insignificant, Low, Medium or High)**:**

INSIGNIFICANT

Subrank Guidance

Minimum ranking information: to determine this Subrank, you must answer A. and at least 1 other question in this section.

If H in A, and M or H in at least one other category, Subrank = High

If H in A, and L or I in all other categories, Subrank = Medium

If M in A, and H in at least one other category, Subrank = High

If M in A, and M in at least one other category, Subrank = Medium

If M in A, and L or I in all other categories, Subrank = Medium

If L in A, and H in at least one other category, Subrank = Medium

If L in A, and M in at least one other category, Subrank = Low

If I in A, and H in at least one other category, Subrank = Low

All others, Subrank = Insignificant

SECTION IV. MANAGEMENT POTENTIAL

Given the current state of knowledge regarding management methods, how difficult is it to control this species?

I. Management is not required (e.g., species does not persist without repeated disturbance)

L. Management is relatively easy and inexpensive; requires a minor investment in human and financial resources

M. Management requires a major short-term investment of human and financial resources, or a moderate long-term investment

H. Management requires a major, long-term investment of human and financial resources

- **Management Subrank** (enter Insignificant, Low, Medium or High)**:**

HIGH

Comments (Comment on both the difficulty of control and on the extent of knowledge that exists regarding the management of this species. Please keep comments brief -- do not go into detail on control methods):

Well-timed burns can be helpful, but burning at inappropriate times will only enhance the population (Eckardt 1987, USDA 2001).

SECTION V. OVERALL RANKING PROCEDURE FOR PLANT SPECIES INVASIVENESS RANK

The Plant Species Invasiveness Rank is a rating of the overall significance of the threat caused by this species to native species and native plant habitat in Virginia, based on the four subranks below.

- **SUBRANKS**

I.	**Impact subrank:**	**HIGH**
II.	**Biology and dispersal ability subrank:**	**HIGH**
III.	**Distribution and abundance subrank:**	**INSIGNIFICANT**
IV.	**Management subrank**:	**HIGH**

The Plant Species Invasiveness Rank is based on the four subranks. Please assign scores to the subranks as follows:

Weighted average/point system

SUBRANK:		**SCORE:**
I.	Impact	H = 4, M = 3, L = 2, I = 0
II.	Biology	H = 3, M = 2, L = 1, I = 0
III.	Distribution	H = 1, M = 0, L = 0, I = 0
IV.	Management	H = 2, M = 1, L = 0, I = 0

Add up these scores to get overall Plant Species Invasiveness Rank. Highest possible score = 10

Overall ranking scale:

I.	Insignificant:	total score = 0-3	Species represents an insignificant threat to natural communities
L.	Low:	total score = 4-6	Species represents low threat to natural communities
M.	Medium:	total score = 7-8	Species represents moderate threat to natural communities
H.	High:	total score = 9-10	Species represents high threat to natural communities

Examples: A species with the significance category of "I" may be exotic but poses little or no threat to natural communities. A species with the significance category of "H" poses a serious threat to native species and communities in Virginia.

- **PLANT SPECIES INVASIVENESS RANK**

  (Enter Insignificant, Low, Medium or High)**: HIGH**

SECTION VI. REFERENCES

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PLANT SPECIES INVASIVENESS RANK FORM

SUMMARY SPECIES DATA

Scientific Name: ***Phleum pratense***
Synonyms: **None**
Common Name(s): **Timothy, Herd's Grass**
Native Range: **Eurasia**

AUTHOR INFORMATION

Author: **John F. Townsend**

Author's affiliation: **Department of Conservation and Recreation, Division of Natural Heritage**

Edition date (mm/dd/yyyy): **04/23/2001**

RANKING CRITERIA

SECTION I. IMPACT ON NATIVE SPECIES, HABITATS AND ECOSYSTEMS

Where possible assess the *cumulative* (e.g., over a period of several decades) impact of the species on the natural areas and other wildlands where it typically occurs. Impacts will be re-assessed as more is learned and as the species moves into new areas.

A. Ability to Invade Natural Systems
Choose one answer (I-H) below that best describes the ability of this species to invade natural systems:

I. Not known to spread into natural areas on its own (e.g., species may persist from former cultivation)
L. Establishes only in areas where major disturbance has occurred in last 20 years (e.g., post-hurricane sites, highway corridors)
M Often establishes in mid- to late-successional natural areas where minor disturbances may occur (e.g., tree falls, hiking trails, streambank erosion), but no major disturbance in last 20-75 years
H. Often establishes in intact or otherwise healthy natural areas with no major disturbance for at least 75 yrs

Comments: Timothy requires only a small disturbance to establish itself in a natural area, at which point it may compete aggressively with native species (USDA 2001).

B. Impact on Ecosystem Processes

Species that alter processes such as fire occurrence or frequency, erosion and sedimentation rates, hydrological regimes, or nutrient regimes often have the greatest long-term impacts on ecosystems. Some non-native invaders can completely transform natural systems so that they can no longer support native species.

Choose one answer that best describes the impact of this species on ecological processes:

I. No perceivable impact on ecosystem processes

L. Influences ecosystem processes (e.g., has perceivable but mild influence on soil nutrient availability)

M. Significant alteration in ecosystem processes (e.g., increases sedimentation rates along coastlines, reducing open water areas that are important for waterfowl)

H. Major, possibly irreversible, alteration or disruption of ecosystem processes (e.g., the species drains water from open water or wetland systems through rapid transpiration, making these areas more fire prone and unable to support native wetland species; species fixes nitrogen in the soil making soil unlikely to support certain native plants)

Comments:

C. Impact on Natural Community Structure

Choose one answer that best describes this species' impact on community structure:

I. No impact; establishes in an existing layer without influencing its structure

L. Influences structure in one layer (e.g., changes density of a layer)

M. Significant impact on at least one layer (e.g., creation of a new layer, elimination of an existing layer)

H. Major alteration of structure (e.g., covers canopy, eradicating most or all layers below)

Comments: Timothy can outcompete many native species in its own stratum, and possibly limit cryptogam colonization at the ground level (Tyser 1992).

D. Impact on Natural Community Composition

Choose one answer that best describes this species' impact on community composition:

I. No impact; causes no perceivable change in native populations

L. Influences community composition (e.g., reduces the number of individuals in one or more native populations by reducing recruitment)

M. Significantly alters community composition (e.g., produces a significant reduction in the population size of one or more native species in the community)

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

Comments: Timothy is a demonstrated invader of mountainous areas of the western United States, where it alters grasslands and forested sites, especially if soils are disturbed in the area. It is not known whether this species performs as aggressively in the eastern mountains (Weaver et al. 1990).

E. Conservation Significance of the Natural Area(s) and Native Species Threatened
Many exotic plants occur primarily in disturbed, low quality habitats that are dominated by other exotic species. Exotic plants have a greater impact if they (a) directly or indirectly threaten native species or communities that are considered rare or vulnerable (e.g., Federally listed or ranked G1-G3 by The Nature Conservancy and Natural Heritage Network), or (b) threaten outstanding, high quality occurrences of common community types.

Choose one answer that best describes the overall conservation significance of native species or communities impacted by this exotic species:

I. Insignificant (e.g., found in human-disturbed habitats and is not known to impact any vulnerable or high quality native species or communities)
L. Low significance (e.g., usually inhabits common, unthreatened habitats and rarely impacts vulnerable or high quality species or communities)
M. Moderately significant (e.g., may occasionally threaten vulnerable or high quality species or communities)
H. Highly significant (e.g., known to inhabit one or more vulnerable or high quality communities and/or often threatens rare native species)

Comments: Timothy's preference for rich soils of hillsides and bottomland areas poses a threat to riverine communities, especially in areas with little forest cover (USDA, NRCS 2001). Several state-rare perennial herbs are restricted to bottlomlands and adjacent slopes in Virginia (Townsend 2001). These species are easily out-competed by exotics that show a preference for such rich sites.

- **Impact Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Subrank Guidance
Minimum ranking information: to determine Impact Subrank, you must answer both categories A and B as well as at least one other category in this section.
If H in A and B, Subrank = High
If H in A or B, and M or H in at least one other category (A-E), Subrank = High
If M in A and B, and H in at least one other category, Subrank = High
If M in A or B, and M or H in at least one other category, Subrank = Medium
If L in A or B, and H in at least one other category, Subrank = Medium
If M in at least one category, Subrank = Low
All others, Subrank = Insignificant

SECTION II. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY

A. Biological Characteristics: Reproduction, Competitive Ability, and Dispersal

The following are some biological characteristics of invasive species. Check those that apply to this species and note any other weedy or invasive traits this species possesses in the space for comments below.

Reproduction:

- ☐ Reproduces readily both vegetatively and by seed
- ☒ If reproduction is by seed, produces over 1,000 seeds per plant annually
- ☐ Reproduces more than once per year
- ☒ Rapid growth to reproductive maturity
- ☐ Seeds remain viable in soil for 2 or more years
- ☐ Has quickly spreading rhizomes that may root at nodes
- ☒ Resprouts readily when cut, grazed or burned
- ☒ Other (please discuss in comments)

Competitive ability:

- ☐ Highly successful competitor for limiting resources
- ☐ Tolerance of a wide range of conditions or tolerance of stressful conditions
- ☐ Ability to germinate in vegetated areas under a wide range of conditions
- ☐ Allelopathic
- ☐ Known to hybridize with native species
- ☐ Lack of natural predators or control agents in the United States
- ☐ Other (please discuss in comments)

Dispersal ability:

- ☐ Rapid local proliferation of seeds
- ☐ Long-distance dispersal ability (e.g., bird dispersed seed, small seeds carried by water)
- ☐ Other (please discuss in comments)

Choose one answer that best describes the biological characteristics of this species:

I. Not aggressive (e.g., has none of the above characteristics or only one or two to a very small extent)
L. Somewhat aggressive (e.g., has only one or two of the above and to a small extent)
M. Moderately aggressive (e.g., has two or more of the above characteristics, but has only one or two to a great extent)
H. Extremely aggressive (e.g., has three or more of the above characteristics and has them to a great extent)

Comments: Source: USDA, NRCS 2001. High seed germination makes this species more competitive but was not a specific category under reproduction (see above). Using a suite of plant characteristics and data from NRCS PLANTS Database, a predictive model classified this species as invasive (Heffernan et al 2001).

B. Other regions invaded

Is this species known to be invasive beyond its native range in other areas outside the United States? **NO**
If yes, briefly list the other countries or regions invaded:

This species is known from all but two Canadian provinces (Kartesz 1999).

C. Dispersal Ability and Speed of Spread

1. Speed of spread (increase in range) once reported as escaped

Choose one answer that best describes the speed of spread:

I. Does not spread
L. Slow -- doubling time (new local reports) > 50 years
M. Moderate -- doubling time (new local reports) 10-50 years
H. Rapid -- doubling time (new local reports) < 10 years

Comments (if possible, comment on the maximum speed of spread): Timothy is a rapid grower and can regenerate quickly after harvest, but seedling vigor is described as medium and seed spread rate is slow (USDA, NRCS 2001).

2. Current trend in total range within the United States

Choose one answer that best describes the current trend:

I. Declining or Historical
L. Stable
M. Increasing
H. Increasing rapidly

Comments: No data.

3. Potential to be spread by human activity

Is this species frequently spread or does it have high potential to be spread by human activity (e.g., species is sold commercially for use in agriculture or ornamental horticulture; species takes advantage of transportation corridors such as highways; species is aquatic and is transported by boats or boat trailers)? **YES**

Comments: This species is widely cultivated and promoted as a forage, cover, and soils stabilization crop throughout the United States. It has also been used for mine stabilization (USDA 2001).

- **Biology/Dispersal Ability Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Subrank Guidance

Minimum ranking information: to determine this Subrank, you must answer at least 4 of the 5 questions above.
Use the following scoring system: 3 points for H, 2 for M, 1 for L; 2 for Yes. Highest possible score = 13
If total score is 9-13, Subrank = High
If total score is 6-8, Subrank = Medium
If total score is 3-5, Subrank = Low
If total score is 0-2, Subrank = Insignificant

SECTION III. DISTRIBUTION AND ABUNDANCE IN VIRGINIA AND THE UNITED STATES

A. Approximate number of distinct natural areas or other wildlands infested in Virginia.
Choose one answer that best matches the number of sites infested:

(Treat one site as the rough equivalent of one preserve, park, BLM district, wildlife refuge, wilderness area, etc.)
I. < 5 (few; scattered)
L. 6 to 10 sites
M. 11 to 30 sites
H. Greater than 30 sites
Enter approximate date of information (year): 1994

Comments: Timothy is reported from four State Parks and three Natural Area Preserves (Caljouw 1994). Harvill et al (1992) list this species from all but 17 Virginia counties.

B. Extent of the species U.S. range in which it has been identified as a problem by land managers
Some non-native species are not invasive everywhere they occur in U.S. but only in certain regions or habitats. For instance, Tamarisks are severe riparian and wetland pests from California to Texas and north at least to Kansas, but while they escape occasionally in the eastern United States, they have not been reported as a problem east of the Mississippi.

This species has been identified by land managers as a problem in approximately what portion of its U.S. range?
Choose one answer that best describes the extent of range in which considered to be a problem:

I. 0 to 5%
L. 6 to 20%
M. 20 to 50%
H. Greater than 50%

Comments (Include U.S. range information. If the species is a threat to only certain types of natural communities, please specify): Timothy is found in all 50 states (Kartesz 1999). Reported invasive by USDA FS (2001).

C. Potential cover of the species in strata where it occurs
Choose one answer that best describes the potential cover:

I. Infrequent (less than 10%)
L. Fair coverage but less than half (10 - 50%)
M. Dominant (50 - 90%)
H. Monospecific stand (90 - 100%)

Comments: Source: USDA FS (2001).

- **Distribution and Abundance Subrank** (enter Insignificant, Low, Medium or High)**:**

LOW

Subrank Guidance
Minimum ranking information: to determine this Subrank, you must answer A. and at least 1 other question in this section.
If H in A, and M or H in at least one other category, Subrank = High
If H in A, and L or I in all other categories, Subrank = Medium
If M in A, and H in at least one other category, Subrank = High
If M in A, and M in at least one other category, Subrank = Medium
If M in A, and L or I in all other categories, Subrank = Medium
If L in A, and H in at least one other category, Subrank = Medium
If L in A, and M in at least one other category, Subrank = Low
If I in A, and H in at least one other category, Subrank = Low
All others, Subrank = Insignificant

SECTION IV. MANAGEMENT POTENTIAL

Given the current state of knowledge regarding management methods, how difficult is it to control this species?

I. Management is not required (e.g., species does not persist without repeated disturbance)
L. Management is relatively easy and inexpensive; requires a minor investment in human and financial resources
M. Management requires a major short-term investment of human and financial resources, or a moderate long-term investment
H. Management requires a major, long-term investment of human and financial resources

- **Management Subrank** (enter Insignificant, Low, Medium or High)**: HIGH**

Comments (Comment on both the difficulty of control and on the extent of knowledge that exists regarding the management of this species. Please keep comments brief -- do not go into detail on control methods):
In areas of heavy infestation, reduction of timothy has been described as “not a realistic option” (USDA 2001).

SECTION V. OVERALL RANKING PROCEDURE FOR PLANT SPECIES INVASIVENESS RANK

The Plant Species Invasiveness Rank is a rating of the overall significance of the threat caused by this species to native species and native plant habitat in Virginia, based on the four subranks below.

- **SUBRANKS**

I.	**Impact subrank:**	**MEDIUM**
II.	**Biology and dispersal ability subrank:**	**MEDIUM**
III.	**Distribution and abundance subrank:**	**HIGH**
IV.	**Management subrank**:	**HIGH**

The Plant Species Invasiveness Rank is based on the four subranks. Please assign scores to the subranks as follows:

Weighted average/point system

SUBRANK:		**SCORE:**
I.	Impact	H = 4, M = 3, L = 2, I = 0
II.	Biology	H = 3, M = 2, L = 1, I = 0
III.	Distribution	H = 2, M = 1, L = 0, I = 0
IV.	Management	H = 1, M = 0, L = 0, I = 0

Add up these scores to get overall Plant Species Invasiveness Rank. Highest possible score = 10

Overall ranking scale:

I.	Insignificant:	total score = 0-3	Species represents an insignificant threat to natural communities
L.	Low:	total score = 4-6	Species represents low threat to natural communities
M.	Medium:	total score = 7-8	Species represents moderate threat to natural communities
H.	High:	total score = 9-10	Species represents high threat to natural communities

Examples: A species with the significance category of "I" may be exotic but poses little or no threat to natural communities. A species with the significance category of "H" poses a serious threat to native species and communities in Virginia.

- **PLANT SPECIES INVASIVENESS RANK**
  (Enter Insignificant, Low, Medium or High)**: MEDIUM**

Section VI. References

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PLANT SPECIES INVASIVENESS RANK FORM

SUMMARY SPECIES DATA

Scientific Name: ***Poa compressa***
Synonyms: **none**
Common Name(s): **Canada bluegrass**
Native Range: **Europe**

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RANKING CRITERIA

SECTION I. IMPACT ON NATIVE SPECIES, HABITATS AND ECOSYSTEMS

Where possible assess the *cumulative* (e.g., over a period of several decades) impact of the species on the natural areas and other wildlands where it typically occurs. Impacts will be re-assessed as more is learned and as the species moves into new areas.

A. Ability to Invade Natural Systems
Choose one answer (I-H) below that best describes the ability of this species to invade natural systems:

I. Not known to spread into natural areas on its own (e.g., species may persist from former cultivation)
L. Establishes only in areas where major disturbance has occurred in last 20 years (e.g., post-hurricane sites, highway corridors)
M Often establishes in mid- to late-successional natural areas where minor disturbances may occur (e.g., tree falls, hiking trails, streambank erosion), but no major disturbance in last 20-75 years
H. Often establishes in intact or otherwise healthy natural areas with no major disturbance for at least 75 yrs

Comments: Usually needs minor disturbance for establishment near natural areas, but can effectively penetrate native sod due to long, creeping rhizomes (Sather 1996). Canada bluegrass appeared as one of the most frequently found alien plant species in sample plots for the Virginia vegetation community classification project (Heffernan et al 2001).

B. Impact on Ecosystem Processes

Species that alter processes such as fire occurrence or frequency, erosion and sedimentation rates, hydrological regimes, or nutrient regimes often have the greatest long-term impacts on ecosystems. Some non-native invaders can completely transform natural systems so that they can no longer support native species.

Choose one answer that best describes the impact of this species on ecological processes:

I. No perceivable impact on ecosystem processes

L. Influences ecosystem processes (e.g., has perceivable but mild influence on soil nutrient availability)

M. Significant alteration in ecosystem processes (e.g., increases sedimentation rates along coastlines, reducing open water areas that are important for waterfowl)

H. Major, possibly irreversible, alteration or disruption of ecosystem processes (e.g., the species drains water from open water or wetland systems through rapid transpiration, making these areas more fire prone and unable to support native wetland species; species fixes nitrogen in the soil making soil unlikely to support certain native plants)

Comments:

C. Impact on Natural Community Structure

Choose one answer that best describes this species' impact on community structure:

I. No impact; establishes in an existing layer without influencing its structure

L. Influences structure in one layer (e.g., changes density of a layer)

M. Significant impact on at least one layer (e.g., creation of a new layer, elimination of an existing layer)

H. Major alteration of structure (e.g., covers canopy, eradicating most or all layers below)

Comments: This species tends not to form pure stands and grows intermixed with prairie species (Sather 1996)

D. Impact on Natural Community Composition

Choose one answer that best describes this species' impact on community composition:

I. No impact; causes no perceivable change in native populations

L. Influences community composition (e.g., reduces the number of individuals in one or more native populations by reducing recruitment)

M. Significantly alters community composition (e.g., produces a significant reduction in the population size of one or more native species in the community)

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

Comments: This species is mainly a problem in dry prairie sites, where it is capable of forming dense sods (Hoffman & Kearns 1997). The competitive effects of this cool-season grass are not felt as strongly in natural areas dominated by warm-season grasses (USDA 2001), but has the ability to replace prairie grasses and forbs due to shading (Hoffman & Kearns 1997).

E. Conservation Significance of the Natural Area(s) and Native Species Threatened
Many exotic plants occur primarily in disturbed, low quality habitats that are dominated by other exotic species. Exotic plants have a greater impact if they (a) directly or indirectly threaten native species or communities that are considered rare or vulnerable (e.g., Federally listed or ranked G1-G3 by The Nature Conservancy and Natural Heritage Network), or (b) threaten outstanding, high quality occurrences of common community types.

Choose one answer that best describes the overall conservation significance of native species or communities impacted by this exotic species:

I. Insignificant (e.g., found in human-disturbed habitats and is not known to impact any vulnerable or high quality native species or communities)
L. Low significance (e.g., usually inhabits common, unthreatened habitats and rarely impacts vulnerable or high quality species or communities)
M. Moderately significant (e.g., may occasionally threaten vulnerable or high quality species or communities)
H. Highly significant (e.g., known to inhabit one or more vulnerable or high quality communities and/or often threatens rare native species)

Comments: This plant is a colonizer of disturbed soils, but can also invade natural grasslands (Hoffman & Kearns 1997).

- **Impact Subrank** (enter Insignificant, Low, Medium or High)**:**

MEDIUM

Subrank Guidance
Minimum ranking information: to determine Impact Subrank, you must answer both categories A and B as well as at least one other category in this section.
If H in A and B, Subrank = High
If H in A or B, and M or H in at least one other category (A-E), Subrank = High
If M in A and B, and H in at least one other category, Subrank = High
If M in A or B, and M or H in at least one other category, Subrank = Medium
If L in A or B, and H in at least one other category, Subrank = Medium
If M in at least one category, Subrank = Low
All others, Subrank = Insignificant

SECTION II. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY

A. Biological Characteristics: Reproduction, Competitive Ability, and Dispersal

The following are some biological characteristics of invasive species. Check those that apply to this species and note any other weedy or invasive traits this species possesses in the space for comments below.

Reproduction:
☒ Reproduces readily both vegetatively and by seed
☒ If reproduction is by seed, produces over 1,000 seeds per plant annually
☐ Reproduces more than once per year
☐ Rapid growth to reproductive maturity
☐ Seeds remain viable in soil for 2 or more years
☒ Has quickly spreading rhizomes that may root at nodes
☒ Resprouts readily when cut, grazed or burned
☐ Other (please discuss in comments)

Competitive ability:
☐ Highly successful competitor for limiting resources
☒ Tolerance of a wide range of conditions or tolerance of stressful conditions
☐ Ability to germinate in vegetated areas under a wide range of conditions
☐ Allelopathic
☐ Known to hybridize with native species
☐ Lack of natural predators or control agents in the United States
☐ Other (please discuss in comments)

Dispersal ability:
☐ Rapid local proliferation of seeds
☐ Long-distance dispersal ability (e.g., bird dispersed seed, small seeds carried by water)
☐ Other (please discuss in comments)

Choose one answer that best describes the biological characteristics of this species:

I. Not aggressive (e.g., has none of the above characteristics or only one or two to a very small extent)
L. Somewhat aggressive (e.g., has only one or two of the above and to a small extent)
M. Moderately aggressive (e.g., has two or more of the above characteristics, but has only one or two to a great extent)
H. Extremely aggressive (e.g., has three or more of the above characteristics and has them to a great extent)

Comments: Source: USDA NRCS (2001)

B. Other regions invaded

Is this species known to be invasive beyond its native range in other areas outside the United States? **YES**
If yes, briefly list the other countries or regions invaded:

Found in all but two Canadian provinces (Kartesz 1999), Canada bluegrass is reported as invasive in Ontario (White et al. 1993).

C. Dispersal Ability and Speed of Spread

1. Speed of spread (increase in range) once reported as escaped
Choose one answer that best describes the speed of spread:

I. Does not spread
L. Slow -- doubling time (new local reports) > 50 years
M. Moderate -- doubling time (new local reports) 10-50 years
H. Rapid -- doubling time (new local reports) < 10 years

Comments (if possible, comment on the maximum speed of spread):

2. Current trend in total range within the United States
Choose one answer that best describes the current trend:

I. Declining or Historical
L. Stable
M. Increasing
H. Increasing rapidly

Comments: Found in all 50 states and all but two Canadian provinces (Kartesz 1999). Listed as an invasive weed by the state of Wisconsin (Hoffman & Kearns 1997).

3. Potential to be spread by human activity
Is this species frequently spread or does it have has high potential to be spread by human activity (e.g., species is sold commercially for use in agriculture or ornamental horticulture; species takes advantage of transportation corridors such as highways; species is aquatic and is transported by boats or boat trailers)? **YES**

Comments: Canada bluegrass has been planted widely as a pasture grass and for revegetation of disturbed or eroded soils (USDA 2001).

- **Biology/Dispersal Ability Subrank** (enter Insignificant, Low, Medium or High)**:**
HIGH

Subrank Guidance
Minimum ranking information: to determine this Subrank, you must answer at least 4 of the 5 questions above.
Use the following scoring system: 3 points for H, 2 for M, 1 for L; 2 for Yes. Highest possible score = 13
If total score is 9-13, Subrank = High
If total score is 6-8, Subrank = Medium
If total score is 3-5, Subrank = Low
If total score is 0-2, Subrank = Insignificant

SECTION III. DISTRIBUTION AND ABUNDANCE IN VIRGINIA AND THE UNITED STATES

A. Approximate number of distinct natural areas or other wildlands infested in Virginia.
Choose one answer that best matches the number of sites infested:

(Treat one site as the rough equivalent of one preserve, park, BLM district, wildlife refuge, wilderness area, etc.)
I. < 5 (few; scattered)
L. 6 to 10 sites
M. 11 to 30 sites
H. Greater than 30 sites
Enter approximate date of information (year): 1994

Comments: (Include Virginia range information from *Atlas of Virginia Flora*.) Canada bluegrass was reported from four state parks and five natural area preserves (Caljouw 1994). Harvill et al. (1992) list this species from all but 17 Virginia counties.

B. Extent of the species U.S. range in which it has been identified as a problem by land managers
Some non-native species are not invasive everywhere they occur in U.S. but only in certain regions or habitats. For instance, Tamarisks are severe riparian and wetland pests from California to Texas and north at least to Kansas, but while they escape occasionally in the eastern United States, they have not been reported as a problem east of the Mississippi.

This species has been identified by land managers as a problem in approximately what portion of its U.S. range?
Choose one answer that best describes the extent of range in which considered to be a problem:

I. 0 to 5%
L. 6 to 20%
M. 20 to 50%
H. Greater than 50%

Comments (Include U.S. range information. If the species is a threat to only certain types of natural communities, please specify): This species is found in 49 states (Kartesz 1999). Canada bluegrass is cited as a problem in prairie communities (Sather 2000) and reported as an invasive species in Wisconsin (Hoffman and Kearns 1997).

C. Potential cover of the species in strata where it occurs
Choose one answer that best describes the potential cover:

I. Infrequent (less than 10%)
L. Fair coverage but less than half (10 - 50%)
M. Dominant (50 - 90%)
H. Monospecific stand (90 - 100%)

Comments: Source: Hoffman and Kearns (1997).

- **Distribution and Abundance Subrank** (enter Insignificant, Low, Medium or High)**:**

HIGH

Subrank Guidance
Minimum ranking information: to determine this Subrank, you must answer A. and at least 1 other question in this section.
If H in A, and M or H in at least one other category, Subrank = High
If H in A, and L or I in all other categories, Subrank = Medium
If M in A, and H in at least one other category, Subrank = High
If M in A, and M in at least one other category, Subrank = Medium
If M in A, and L or I in all other categories, Subrank = Medium
If L in A, and H in at least one other category, Subrank = Medium
If L in A, and M in at least one other category, Subrank = Low
If I in A, and H in at least one other category, Subrank = Low
All others, Subrank = Insignificant

SECTION IV. MANAGEMENT POTENTIAL

Given the current state of knowledge regarding management methods, how difficult is it to control this species?

I. Management is not required (e.g., species does not persist without repeated disturbance)
L. Management is relatively easy and inexpensive; requires a minor investment in human and financial resources
M. Management requires a major short-term investment of human and financial resources, or a moderate long-term investment
H. Management requires a major, long-term investment of human and financial resources

- **Management Subrank** (enter Insignificant, Low, Medium or High)**:**

HIGH

Comments (Comment on both the difficulty of control and on the extent of knowledge that exists regarding the management of this species. Please keep comments brief -- do not go into detail on control methods):
The best defense against invasion by this species is a dense stand of warm season grasses (Sather 1996, USDA 2001).

SECTION V. OVERALL RANKING PROCEDURE FOR PLANT SPECIES INVASIVENESS RANK

The Plant Species Invasiveness Rank is a rating of the overall significance of the threat caused by this species to native species and native plant habitat in Virginia, based on the four subranks below.

- **SUBRANKS**

I.	**Impact subrank:**	**MEDIUM**
II.	**Biology and dispersal ability subrank:**	**HIGH**
III.	**Distribution and abundance subrank:**	**HIGH**
IV.	**Management subrank**:	**HIGH**

The Plant Species Invasiveness Rank is based on the four subranks. Please assign scores to the subranks as follows:

Weighted average/point system

SUBRANK:		**SCORE:**
I.	Impact	H = 4, M = 3, L = 2, I = 0
II.	Biology	H = 3, M = 2, L = 1, I = 0
III.	Distribution	H = 1, M = 0, L = 0, I = 0
IV.	Management	H = 2, M = 1, L = 0, I = 0

Add up these scores to get overall Plant Species Invasiveness Rank. Highest possible score = 10

Overall ranking scale:

I.	Insignificant:	total score = 0-3	Species represents an insignificant threat to natural communities
L.	Low:	total score = 4-6	Species represents low threat to natural communities
M.	Medium:	total score = 7-8	Species represents moderate threat to natural communities
H.	High:	total score = 9-10	Species represents high threat to natural communities

Examples: A species with the significance category of "I" may be exotic but poses little or no threat to natural communities. A species with the significance category of "H" poses a serious threat to native species and communities in Virginia.

- **PLANT SPECIES INVASIVENESS RANK**
  (Enter Insignificant, Low, Medium or High)**: MEDIUM**

SECTION VI. REFERENCES

Caljouw, C. 1994. Invasive Alien Plant Species Documented from DCR Parks and Natural Areas. Unpublished report to Virginia Department of Conservation and Recreation, Division of Natural Heritage.

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Appendix D.: Natural Heritage Rarity Ranks

Natural Heritage Rarity Ranks and Explanation

Each of the significant natural features (species, community type, etc.) monitored by DCR-DNH is considered an element of natural diversity, or simply an element. Each element is assigned a rank that indicates its relative rarity on a five-point scale (1 = extremely rare; 5 = abundant; Table 1). The primary criterion for ranking elements is the number of occurrences, i.e., the number of known distinct localities or populations. Also of great importance is the number of individuals at each locality or, for highly mobile organisms, the total number of individuals. Other considerations include the condition of the occurrences, the number of protected occurrences, and threats. However, the emphasis remains on the number of occurrences, so that ranks essentially are an index of known biological rarity. These ranks are assigned in terms of the element's rarity within Virginia (its State or S-rank), the element's rarity within a Nation (its National or N-rank), and the element's rarity across its entire range (its Global or G-rank). Subspecies and varieties are assigned a Taxonomic (T-) rank in addition to their G-rank. A Q indicates taxonomic uncertainty. Taken together, these ranks give an instant picture of an element's rarity. For example, a designated rank of G5S1 indicates an element which is abundant and secure range-wide, but rare in Virginia. In some cases, ranks are provisional or lacking, due to ongoing efforts by the Natural Heritage network to classify community syntaxa and cryptic plants or animals. Rarity ranks used by DCR-DNH are not legal designations, and they are continuously updated to reflect new information.

Table 1. Definition of Natural Heritage state rarity ranks. Global ranks are similar to state ranks, but refer to a species' range-wide status. Note that GA and GN are not used and GX means extinct. GM and GW are ranks used only for communities, and refer to highly modified (GM) and ruderal (GW) vegetation respectively. National ranks are similar as well, and refer to a species' rarity within a nation, such as the United States or Canada. Sometimes ranks are combined (e.g., S1S2) to indicate intermediate or somewhat unclear status. Elements with uncertain taxonomic validity are denoted by the letter Q, after the global rank. These ranks should not be interpreted as legal designations.

S1 Extremely rare; usually 5 or fewer occurrences in the state, or in the case of communities, covering less than 50 hectares in aggregate; or may have a few remaining individuals; often especially vulnerable to extirpation.

S2 Very rare; usually between 5 and 20 occurrences, or in the case of communities, covering less than 250 hectares in aggregate; or few occurrences with many individuals; often susceptible to becoming endangered.

S3 Rare to uncommon; usually between 20 and 100 occurrences; may have fewer occurrences, but with a large number of individuals in some populations; may be susceptible to large-scale disturbances.

S4 Common; usually more than 100 occurrences, but may be fewer with many large populations; may be restricted to only a portion of the state; usually not susceptible to immediate threats.

S5 Very common; demonstrably secure under present conditions.

SA Accidental in the state.

SH Historically known from the state, but not verified for an extended period, usually more than 15 years; this rank is used primarily when inventory has been attempted recently.

SM Applied to vegetation extensively modified by disturbance but considered recoverable by management, time, or restoration of ecological processes.

SN Regularly occurring migrants or transient species which are non-breeding, seasonal residents. (Note that congregation and staging areas are monitored separately).

SU Status uncertain, often because of low search effort or cryptic nature of the element.

SW Applied to vegetation dominated by ruderal or exotic species.

SX Apparently extirpated from the state.

The spot on the landscape that supports a natural heritage resource is an element occurrence. DCR-DNH has mapped over 7,500 element occurrences in Virginia. Information on the location and quality of these element occurrences is computerized within the Division's BCD system, and additional information is recorded on maps and in manual files.

In addition to ranking each element's rarity, each element occurrence is ranked to differentiate large, outstanding occurrences from small, vulnerable ones. In this way, protection efforts can be aimed not only at the rarest elements, but at the best examples of each. Species occurrences are ranked in terms of quality (size, vigor, etc.) of the population; the condition (pristine to disturbed) of the habitat; the viability of the population; and the defensibility (ease or difficulty of protecting) of the occurrence. Community occurrences are ranked according to their size and overall natural condition. These element occurrence ranks range from A (excellent) to D (poor). Sometimes these ranks are combined to indicate intermediate or somewhat unclear status, (e.g., AB or CD). In a few cases, especially those involving cryptic animal elements, field data may not be sufficient to reliably rank an occurrence. In such cases a rank of E (extant) may be given. A rank of H (historical) is used to indicate an historical occurrence that could not be relocated by recent survey. Element occurrence ranks reflect the current condition of the species' population or community. A poorly-ranked element occurrence can, with time, become highly-ranked as a result of successful management or restoration.

Element ranks and element occurrence ranks form the basis for ranking the overall significance of sites. Site biodiversity ranks (B-ranks) are used to prioritize protection efforts, and are defined in Table 2.

Table 2. Biodiversity ranks used to indicate site significance.

B1 Outstanding Significance: only site known for an element; an excellent occurrence of a G1 species; or the world's best example of a community type.

B2 Very High Significance: excellent example of a rare community type; good occurrence of a G1 species; or excellent occurrence of a G2 or G3 species.

B3 High Significance: excellent example of any community type; good occurrence of a G3 species.

B4 Moderate Significance: good example of a community type; excellent or good occurrence of state-rare species.

B5 General Biodiversity Significance: good or marginal occurrence of a community type or state-rare species.

The U.S. Fish and Wildlife Service (USFWS) is responsible for the listing of endangered and threatened species under the Endangered Species Act of 1973, as amended. Federally listed species (including subspecific taxa) are afforded a degree of legal protection under the Act, and therefore sites supporting these species need to be highlighted. USFWS also maintains a review listing of potential endangered and threatened taxa known as candidate species. Table 3 illustrates the various status categories used by USFWS and followed in this report. The status category of candidate species is based largely on the Service's current knowledge about the biological vulnerability and threats to a species.

As of February 27, 1996, species formerly referred to as Category 2 (C2) candidates for listing as threatened or endangered are no longer considered "candidates" under the Endangered Species Act. The USFWS no longer maintains a formal, comprehensive list of such species. However, the Virginia Field Office of the USFWS intends to maintain an informal list of these and other "Species of Concern" that may warrant future consideration as candidates. These "Species of Concern" can be regarded as species for which the Service has insufficient scientific information to support a listing proposal. Former Category 1 (C1) species are now considered "candidates" (C) for listing. "Candidate" species are species for which the USFWS has enough scientific information to warrant a proposal for listing. The designation of Category 3 species (3A, 3B, 3C) has been discontinued. However, the USFWS will continue to maintain its files on these species in case new information indicates a need for reevaluation.

Table 3. U.S. Fish and Wildlife Service species status codes, with abbreviated definitions

LE Listed endangered

LT Listed threatened

PE Proposed to be listed as endangered

PT Proposed to the listed as threatened

C Candidate: status data supports listing of taxon as endangered or threatened

SOC Species of Concern: no official status, evidence of vulnerability, but insufficient data exists.

In Virginia, two acts have authorized the creation of official state endangered and threatened species lists. One act (Code of Virginia ' 29.1-563 through 570), administered by the Virginia Department of Game and Inland Fisheries (DGIF), authorizes listing of fish and wildlife species, not including insects. The other act (Code of Virginia ' 3.1-1020 through 1030), administered by the Virginia Department of Agriculture and Consumer Services (VDACS), allows for listing of plant and insect species. In general, these acts prohibit or regulate taking, possessing, buying,

selling, transporting, exporting, or shipping of any endangered or threatened species appearing on the official lists. Species protected by these acts are indicated as either listed endangered (LE) or listed threatened (LT). Species under consideration for listing are indicated as candidates (C).

(November 2000)