NEW YORK
NON-NATIVE PLANT INVASIVENESS RANKING FORM

Scientific name:	Hordeum murinum L. ssp. leporinum (Link) Arcang. USDA Plants Code: HOMUL
Common names:	leporinum barley; hare barley
Native distribution:	Eurasia
Date assessed:	July 16, 2012
Assessors:	Steven D. Glenn
Reviewers:	LIISMA SRC
Date Approved:	14 August 2012 Form version date: 29 April 2011

New York Invasiveness Rank: Not Assessable

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

Invasiveness Ranking Summary (see details under appropriate sub-section)		Total (Total Answered*) Possible	Total
1	Ecological impact	40 (10)	3
2	Biological characteristic and dispersal ability	25 (22)	15
3	Ecological amplitude and distribution	25 (21)	8
4	Difficulty of control	10 (6)	2
	Outcome score	100 (59)[b]	28[a]
	Relative maximum score †		--
	New York Invasiveness Rank §	Not Assessable	

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

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

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

Documentation: All occurrences to date in NY PRISMs are from non-natural areas (Finger Lakes, Long Island, Lower Hudson. A survey of other records from Connecticut, New Jersey and Pennsylvania (BBG, 2012) likewise show all occurrences in non-natural areas.
Sources of information:
Brooklyn Botanic Garden, 2012; Weldy & Werier, 2012.

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

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

Documentation: All occurrences to date in NY PRISMs are from non-natural areas (Finger Lakes, Long Island, Lower Hudson. A survey of other records from Connecticut, New Jersey and Pennsylvania (BBG, 2012) likewise show all occurrences in non-natural areas..
Sources of information (e.g.: distribution models, literature, expert opinions):
Brooklyn Botanic Garden, 2012; Weldy & Werier, 2012.

If the species does not occur and is not likely to occur in any of the PRISMs, then stop here as there is no need to assess the species. Rank is "Not Assessable."

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

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

Documentation: Reported from nine localities on Staten and Long Islands since 1992; but all occurrences were from non-natural areas- train stations, railroad trestle, roadsides, pavement, sidewalks, parks, and intercity areas.
Sources of information:
Brooklyn Botanic Garden, 2012; Weldy & Werier, 2012.

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

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

Other potential or known suitable habitats within New York:

Documentation: waste places, disturbed areas, ballast, lawns, pavement cracks, curbsides, wool mills
Sources of information:

von Bothmer, et al. 2007; Brooklyn Botanic Garden, 2012; Dean, 1990; Tomaino, A. 2004.

B. INVASIVENESS RANKING

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

1. ECOLOGICAL IMPACT

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

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

Score: U

Documentation:
Identify ecosystem processes impacted (or if applicable, justify choosing answer A in the absence of impact information)
Tomaino (2004) states that Hordeum murinum does not have any characters that suggest it would severely alter ecosystem processes.
Sources of information:
Tomaino, 2004.

1.2. Impact on Natural Community Structure

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

Score: U

Documentation:
Identify type of impact or alteration:
Tomaino (2004) relates Hordeum murinum's impact on natural community structure, but all references are apparently from studies from the southwestern United States, their applicability to the Northeast is uncertain. All other studies of this species ecological impacts that could be located were from Australia or New Zealand; again, their applicability to the Northeast is uncertain. No studies of this species impact on natural community structure in eastern North America could be located.
Sources of information:
Tomaino, 2004.

1.3. Impact on Natural Community Composition

A.	No perceived impact; causes no apparent change in native populations	0
B.	Influences community composition (e.g., reduces the number of individuals in one or more	3

native species in the community)

C. Significantly alters community composition (e.g., produces a significant reduction in the population size of one or more native species in the community) 7

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

U. Unknown

Score: U

Documentation:

Identify type of impact or alteration:

Tomaino (2004) relates Hordeum murinum's impact on natural community composition, but all references are apparently from studies from the southwestern United States, their applicability to the Northeast is uncertain. All other studies of this species ecological impacts that could be located were from Australia or New Zealand; again, their applicability to the Northeast is uncertain. No studies of this species impact on natural community composition in eastern North America could be located.

Sources of information:

Tomaino, 2004.

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

A. Negligible perceived impact 0

B. Minor impact 3

C. Moderate impact 7

D. Severe impact on other species or species groups 10

U. Unknown

Score: 3

Documentation:

Identify type of impact or alteration:

Because the seed awn is often so damaging to stock animals, it is possible that the species could be harmful to wildlife as well, especially invading ear canals, nostrils, or other soft tissues (Dean, 1990; Reebs, 2009). One study found Hordeum murinum awns in dog bladders causing cystolithiasis (Del Angel-Caraza et al., 2011).

Even documented to cause aspirations in humans which can cause coughing, dyspnea and obstructive pneumonia by getting implanted in the airway mucosa, or with its migration ability, it may pass through the peripheral regions of the lung as well as the pleural cavity and cause chronic complications including abscess, cavity formation, atelectasis and empyema (Sayir et al., 2012).

Sources of information:

Dean,. 1990; Del Angel-Caraza et al., 2011; Reebs, 2009; Sayir et al., 2012.

Total Possible: 10

Section One Total: 3

2. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY

2.1. Mode and rate of reproduction

A.	No reproduction by seeds or vegetative propagules (i.e. plant sterile with no sexual or asexual reproduction).	0
B.	Limited reproduction (fewer than 10 viable seeds per plant AND no vegetative reproduction; if viability is not known, then maximum seed production is less than 100 seeds per plant and no vegetative reproduction)	1
C.	Moderate reproduction (fewer than 100 viable seeds per plant – if viability is not known, then maximum seed production is less than 1000 seeds per plant - OR limited successful vegetative spread documented)	2
D.	Abundant reproduction (more than 100 viable seeds per plant – if viability is not known, then maximum seed production reported to be greater than 1000 seeds per plant OR vegetative asexual spread documented as one of the plants prime reproductive means)	4
U.	Unknown	

Score: 4

Documentation:

Describe key reproductive characteristics (including seeds per plant):
Seed production described as "copious" (Dean, 1990; Grant & Rumball, 1971) or "abundant" (Madden, 1961). One study in England (Davison, 1977) documented a mean number of 720 fruits per plant in one population. Has demonstrated a superior capacity to set seed in difficult seasons, such as during droughts (Dean, 1990).

Spikelets highly fertile (92%); this species "possess a high level of adaptation in making maximal use of photosynthate for regenerative needs" (Halloran & Pennell. 1981).

Sources of information:
Davison, 1977; Dean, 1990; Grant & Rumball, 1971; Halloran & Pennell, 1981; Madden, 1961.

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

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

Score: 2

Documentation:

Identify dispersal mechanisms:
Epizoochory- seeds easily disperse when the long awn attaches to wildlife and stock (Dean, 1990; Manzano & Malo, 2006; Reebs, 2009).

Sources of information:
Dean, 1990; Manzano & Malo, 2006; Reebs, 2009.

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

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

numerous, frequent, and successful)

U. Unknown

Score 1

Documentation:
Identify dispersal mechanisms:
One study found Hordeum murinum seed was spread by the shipment of contaminated hay and straw.
Sources of information:
Conn et al., 2010

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

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

Score 6

Documentation:
Evidence of competitive ability:
Shade tolerance- Hutchinson (1967) showed that H. murinum seedlings could survive total darkness for over 30 days if subsequently returned to the light.

This species has shown an ability to survive temporary drought; while an annual, the early maturation of barley grass enables it to complete its life cycle ahead of later-maturing associated annual and perennial species (Dean, 1990).

Reported to tolerate a wide range of soil conditions (Metson et al. 1971).
Sources of information:
Dean, 1990; Hutchinson, 1967; Metson et al. 1971.

2.5. Growth vigor

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

Score 0

Documentation:
Describe growth form:
No reports of this species forming thickets or possessing a climbing or smothering growth habit.
Sources of information:

2.6. Germination/Regeneration

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

Score 2

Documentation:
Describe germination requirements:

Good germinate rates even buried at depths of 75-100 mm (Popay & Sanders, 1975; Smith, 1968). Light not required (Cocks & Donald, 1973; Davison, 1971).

Most barley grass germination occurs on soil surfaces that tend to set hard (Smith 1968).

Wide tolerance to temperatures for germination, ability to remain dormant at high summer temperatures, can germinate easily when lying on the soil surface (Dean, 1990).

Germination rapid (Harris, 1961).

One researcher in a greenhouse study of California-collected Hordeum leporinum achieved 100% germination in one trial (Laude, 1956). A controlled experiment in England achieved 95% germination (Davison, 1977).

Sources of information:
Cocks & Donald, 1973; Davison, 1971; Davison, 1977; Dean, 1990; Harris, 1961; Laude, 1956; Popay & Sanders, 1975; Smith, 1968.

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

A. No — 0
B. Yes — 3
U. Unknown

Score: U

Documentation:
Species:
The non-native Hordeum brachyantherum, H. jubatum, and H. marinum and H. vulgare occur in eastern North America. Von Bothmer et. al (2007) state that Hordeum jubatum is "a weedy species", but their invasive impacts are not yet established for eastern North America.

Total Possible: 22
Section Two Total: 15

3. ECOLOGICAL AMPLITUDE AND DISTRIBUTION

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

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

Score: 0

Documentation:
Identify reason for selection, or evidence of weedy history:
No large stands reported from the Northeast.
Sources of information:

3.2. Number of habitats the species may invade

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

Score: 1

Documentation:
Identify type of habitats where it occurs:
Grasslands'oldfields; plus numerous managed habitats- ditches, roadsides, waste places, disturbed areas, ballast, lawns, pavement cracks, curbsides, wool mills.
Sources of information:
von Bothmer, et al. 2007; Brooklyn Botanic Garden, 2012; Dean, 1990; Tomaino, A. 2004.

3.3. Role of disturbance in establishment

A.	Requires anthropogenic disturbances to establish.	0
B.	May occasionally establish in undisturbed areas but can readily establish in areas with natural or anthropogenic disturbances.	2
C.	Can establish independent of any known natural or anthropogenic disturbances.	4
U.	Unknown	

Score: 2

Documentation:
Identify type of disturbance:
Some workers have found that late winter and early spring grazing increases the abundance and percentage of barley grass in pastures; speculated that the higher biomass resulted from an increase in tiller number stimulated by fresh growth from basal buds after flowering shoots were removed (Dean, 1990).

One Australian study found that minimising bare ground can significantly reduce the establishement of Hordeum murinum ssp. leporinum (Tozer et al., 2008).

Sources of information:
Dean, 1990; Tozer et al., 2008.

3.4. Climate in native range

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

Score: 1

Documentation:
Describe what part of the native range is similar in climate to New York:
Hordeum murinum subsp. leporinum ranges in southern Europe as far north as northwest France and central Ukraine.
Sources of information:
Humphries, 1980.

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

A.	Not known from the northeastern US and adjacent Canada	0
B.	Present as a non-native in one northeastern USA state and/or eastern Canadian province.	1
C.	Present as a non-native in 2 or 3 northeastern USA states and/or eastern Canadian provinces.	2

D.	Present as a non-native in 4–8 northeastern USA states and/or eastern Canadian provinces, and/or categorized as a problem weed (e.g., "Noxious" or "Invasive") in 1 northeastern state or eastern Canadian province.	3
E.	Present as a non-native in >8 northeastern USA states and/or eastern Canadian provinces. and/or categorized as a problem weed (e.g., "Noxious" or "Invasive") in 2 northeastern states or eastern Canadian provinces.	4
U.	Unknown	

Score: 4

Documentation:
Identify states and provinces invaded:
CT, DC, DE, MA, MD, ME, NJ, NY, PA, VA
Sources of information: See known introduced range in plants.usda.gov, and update with information from states and Canadian provinces.
Angelo & Boufford, 2012; von Bothmer, et al. 2007; USDA Plants, 2012.

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

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

Score: U

Documentation:
Describe distribution:
Reoprted from the Finger Lakes, Lower Hudson, and LIISMA PRISMs, but all occurrences from the Lower Hudson and LIISMA were from non-natural areas- train stations, railroad trestle, roadsides, pavement, sidewalks, parks, and intercity areas. The habitat of the Finger Lakes PRISM occurrence is unknown.
Sources of information:
Brooklyn Botanic Garden, 2012; Weldy & Werier, 2012.

Total Possible	21
Section Three Total	7

4. DIFFICULTY OF CONTROL

4.1. Seed banks

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

Score: 2

Documentation:
Identify longevity of seed bank:
Some seed banking has been reported (Makarian et al., 2007); while most seeds germinate the first autumn after flowering, a small proportion of seeds can have longer term (at least 1 year) dormancy (Deans, 1990; Harris, 1959; Popay, 1981; Popay & Sanders, 1975; Rumball, 1971).

One study found a 200 year old seed embedded an adobe brick still viable (Spira & Wagner, 1983).
Sources of information:
Deans, 1990; Harris, 1959; Makarian et al., 2007; Popay, 1981; Popay & Sanders, 1975; Rumball, 1971; Spira & Wagner, 1983.

4.2. Vegetative regeneration

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

Score: 0

Documentation:
Describe vegetative response:
Annual
Sources of information:
von Bothmer, 2007; Dean, 1990.

4.3. Level of effort required

A.	Management is not required: e.g., species does not persist without repeated anthropogenic disturbance.	0
B.	Management is relatively easy and inexpensive: e.g. 10 or fewer person-hours of manual effort (pulling, cutting and/or digging) can eradicate a 1 acre infestation in 1 year (infestation averages 50% cover or 1 plant/100 ft^2).	2
C.	Management requires a major short-term investment: e.g. 100 or fewer person-hours/year of manual effort, or up to 10 person-hours/year using mechanical equipment (chain saws, mowers, etc.) for 2-5 years to suppress a 1 acre infestation. Eradication is difficult, but possible (infestation as above).	3
D.	Management requires a major investment: e.g. more than 100 person-hours/year of manual effort, or more than 10 person hours/year using mechanical equipment, or the use of herbicide, grazing animals, fire, etc. for more than 5 years to suppress a 1 acre infestation. Eradication may be impossible (infestation as above).	4
U.	Unknown	

Score: U

Documentation:
Identify types of control methods and time-term required:
Hordeum murinum sensu lato has been classified as one species with 3 subspecies (Humphries, 1980; Jacobson & von Bothmer, 1995; von Bothmer et al., 2007) or as three species (Baum & Bailey, 1984; Covas, 1949). Giles and Lefkovitch (1986) concluded there were three distinct groups of equal status but could not draw a conclusion whether they represent 3 different spp. or 3 subspp. It has been suggested that most North American plants classified as murinum are mostly Hordeum murinum subsp. leporinum (Covas, 1949) and that most occurrences in the Northeast are also Hordeum murinum subsp. leporinum (Weldy & Werier, 2102; USDA Plants, 2012).

Most of the ecological and management research has been concentrated in Australia and New Zealand, and a little in the southwestern United States; the applicability of non-herbicidal managment strategies from these regions to the Northeast is uncertain. No studies related to the management of this species in eastern North America could be located.

Mowing in Australia has been found to control barley grass, but the time and type of cutting must be adjusted so as not to replicate the effects that grazing can have on Hordeum leporinum (some researchers have found that late winter and early spring grazing increases the abundance and percentage of barley grass in pastures; [Tozer et al., 2008; Tozar et al.

2008b, suggests rotational grazing is a more effective control than continuous grazing]). Some degree of control was achieved when the grass was cut close to the ground about ten days after the head started to turn color. The herbage was then removed and native seeds could then be sown to further discourage establishment of barley grass. This treatment was most effective when repeated for one or two years, though there is little indication in the literature of precisely how many years of treatment would be required to completely eliminate barley grass; mowing in California was found to have only an immediate effect of eradication, with the grass returning the following year (Dean, 1990).

In California on the response of grasslands to prescribed burns, Hordeum leporinum was found to be the annual grass most sensitive to burning. When a grassland contained up to 90% of barley grass, this percentage was reduced to less than 5% after burning. This level was found to remain the same for up to three years with no other management (Dean, 1990).

In Australia, herbicides have proven effective in controlling barley grass, these include paraquat di (methyl sulphate), pronamid, 2,2-DPA, diquat dibromide and glyphosate (Dean, 1990).

In New Zealand, Trichloracetic acid, dichloropropionic acid, paraquat, simazine, diuron, and bromacil provide temporary improvement, but are inadequate to completely eliminate H. murinum for more than one year (Meeklah, 1966).

Some studies have shown some populations becoming resistance to certain herbicides (Matthews et al., 2000; Owen et al., 2012; Preston et al., 2000; Purba et al, 1995; Tucker & Powles, 1991).

One study achieved some control along roadsides using natural products- acetic acid, pine oil, and plant essentials; but were deemed economically unfeasible (Young, 2004).

One California study of control of Centaurea solstitialis with clopyralid found Hordeum murinum increaesed as a result (Enloe et al., 2005).

One Australian study concluded that the use of the fungal pathogen Pyrenophora semeniperda as a seed-borne bioherbicide may be a "biologically reasonable tactic" (Medd & Campbell, 2005).

For the full text discussion on control including multiple manipulations in Dean, 1990, see APPENDIX B

Sources of information:
Baum & Bailey, 1984; von Bothmer, 2007; Covas, 1949; Dean, 1990; Enloe et al., 2005; Giles & Lefkovitch, 1986; Humphries, 1980; Jacobson & von Bothmer, 1995; Matthews et al., 2000; Medd & Campbell, 2005; Meeklah, 1966; Owen et al., 2012; Preston et al., 2000; Purba et al., 1995; Tozer et al., 2008; Tozar et al., 2008b; Tucker & Powles, 1991; Weldy & Werier, 2102; USDA Plants, 2012; Young, 2004.

Total Possible	6
Section Four Total	2

Total for 4 sections Possible	59
Total for 4 sections	28

C. STATUS OF CULTIVARS AND HYBRIDS:

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

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

Some cultivars of the species known to be available:

References for species assessment:

Angelo, R. & D. E. Boufford. 2012. Atlas of the Flora of New England. <http://neatlas.org/>. [Accessed on July 16, 2012].

Baum, B. R. & L. G. Bailey. 1984. Taxonomic studies in wall barley (Hordeum murinum sensu lato) and sea barley (Hordeum marinum sensu lato). 2. Multivariate morphometrics. Canad. J. Bot. 62(12):2754-2764.

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also see extensive bibliography in: Dean, 1990.
APPENDIX B: Control ex Dean, 1990.

GRAZING: Hordeum leporinum can be an important component of pastures in southern Australia in late autumn, winter and early spring. Sheep preferentially graze barley grass and it comprises a major part of their winter diet. However, in late spring and summer, especially after flowering, it has an adverse effect on sheep production, causing production losses (in extreme cases causing death) as a result of seedheads penetrating the eyes, mouth, feet, wool and skin (Smith 1972, Warr 1981). Research has been conducted in Australia on the relationship of grazing to both early season growth of barley grass and to later season control. This research is extensive, sometimes conflicting, but is summarized here because it includes additional ecological information on Hordeum leporinum.

Some workers have found that late winter and early spring grazing increases the abundance and percentage of barley grass in pastures (Smith 1968d, 1972, McIvor and Smith 1973). For instance, in pastures containing roughly 80% barley grass in addition to subterranean clover, capeweed (Arctotheca calendula) and Wimmera ryegrass, sheep were allowed to graze until late winter when grass growth was accelerating in response to rising temperatures. At that time three different levels of grazing were tested for two years. Moderately grazed plots were those where pasture was grazed to a length of 2.5 to 5 cm until early spring, then remaining ungrazed until mid-summer. Heavily grazed plots were grazed intensively until the cessation of spring growth. (No animal densities were noted in these descriptions of grazing levels). After one year, seed set was not significantly affected in grazed plots and amounted to more than half a ton of seeds per acre. However, grazing did increase subsequent barley grass germination significantly, especially on the heavily grazed pasture. Moderate grazing resulted in the highest number of viable seeds (855/ sq. lk.), as well as the largest seeds (6.25 mg). After two years of treatments, the area that was heavily grazed was almost completely dominated by barley grass with very little ryegrass or clover remaining. The heavily grazed treatment thus resulted in a significantly higher percentage of barley grass, though with a lower total yield of all plants than in the moderately grazed plots. Heavy grazing reduced both the dry matter production (lb/ac) at seed set as well as the length of stems on which seeds were set, but it increased tillering and heads produced. Moderately grazed plots resulted in the highest total seed production, germination and numbers of viable seeds of barley grass (Smith 1968d).

Capeweed dominant pastures (36% with 27% barley grass and 4% subterranean clover) were also subjected to grazing treatments. (The other annual grasses present included Bromus mollis, silver grass and ryegrass, with additional miscellaneous species. Grazing treatments included no grazing after August 18, close grazing until September 21 ("early grazing") and close grazing until November 4 ("full grazing"). (Again no animal densities are mentioned). Dry matter production was then determined at the end of April, with the result that total dry pasture residue was significantly reduced in the full grazing treatment. The number of viable barley seeds germinated was highest in the early grazing treatment, and lowest in the full grazing treatment. In this one year study, the percentage of barley grass increased with grazing and was highest under full grazing (almost 50%), as was the percentage of capeweed. The study gives no explanation, however, as to why the highest number of viable seeds were found when pastures were not grazed or were grazed early, or why the number of seedlings was highest when the pasture was not grazed (1.8/sq. dm.)(McIvor and Smith 1973).

Robards and Leigh (1967) found that the biomass of Hordeum leporinum increased when grazing took place as plants were approaching maturity in late winter (August and September). These results were found when "crash grazing" was imposed over different combinations of months from May to December. The authors speculate that the higher biomass resulted from an increase in tiller number stimulated by fresh growth from basal buds after flowering shoots were removed by stock animals.

In annual subterranean clover pastures, Hordeum leporinum was the most abundant invading species after four years of grazing treatments. At two different stocking rates (8.1 and 12.3 ewes/ha) invasion was minimal until after a dry spring of the third year. At the higher stocking rate, barley grass dominated over ryegrass and silver grass. The most significant difference between the two stocking rates was only seen only when the pastures were sown with oats and/or alfalfa; in these cases barley grass invasion (percentage in relation to invasion by ryegrass and silver grass) was much greater at the lower stocking rate (Fitzgerald 1976).

Hordeum leporinum has been reported to first increase and then decline with progressively heavier grazing on subclover pastures in Australia (Rossiter 1966). Similar results were found on the Pacific coast range of northern California. Here, both grass-woodland and improved grasslands were subjected over five years to three grazing treatments. The Hordeum leporinum component of grasslands increased under 150% of moderate grazing but declined to its lowest frequency at 200% of moderate stocking. (The means of these stocking rates ranged from 0.6 to 8.0 ewes/ha in woodlands and from 1.8 to 10.0 ewes/ha in grasslands). Wild barley and Bromus Mollis were more sensitive than Festuca spp. to heavy use (Rosiere 1987).

Another test successfully controlled Hordeum leporinum through the use of very heavy grazing rates in southern Australia. Over three years, grazing was deferred to different time periods after the start of irrigation with the result that all barley grass densities were reduced and clover establishment enhanced. Barley grass was almost completely eliminated when grazing was deferred for 20 days after the opening of autumn irrigation with continuous grazing after this at approximately 20 sheep/ha. This grazing level was extremely high and not even typical of livestock management for that area (Myers and Squires 1970). Smith (1972) points out that such a deferment period would be more difficult to achieve in dryland pastures and that such heavy grazing in autumn could damage other components and reduce pasture production.

In a five year experiment also involving high stocking rates, Carter (1987) found that by the third year in medic fields, barley grass was so dominant that associated subterranean clover set no seed. However, at the highest stocking rate (22 sheep/ha), barley grass was present but was sparse; only cluster clover and "winter grass" increased in percentable botanical composition with this treatment. The author suggests that barley grass was rare at this stocking level because its seeds do not survive passage through the digestive tract of sheep.

Hordeum leporinum proportions were also found to decrease with increased grazing in fields that were dominated by Hordeum leporinum, Erodium crinitum, medics and silver grass. Field experiments over four years resulted in a lower contribution by barley grass to the pasture within each year when stocking rates were higher. The least barley grass grew at the highest and unchanging stocking rate of 4.9 sheep per hectare. However, over the four year period of grazing treatments, the average barley grass content of the three grazing levels increased from 19% to 62%. Perhaps the tested grazing levels were still low enough to favor barley grass growth over a period of four years (Campbell and Beale 1973).

RESPONSE TO MANIPULATIONS (IRRIGATION, MOWING, FIRE, CHEMICAL): The seasonal onset of irrigation appears to be critical in determining barley grass populations. If irrigation begins in late autumn (April to May), the pasture is grass dominant. If it starts in early autumn (February), the pasture tends to be clover dominant. However, barley grass invades irrigated pastures irrespective of the starting date (Myers and Squires 1970).

Some forms of mowing have proven effective in controlling barley grass. Three different mowing treatments were found to significantly reduce seed set and germination in a two year experiment on pastures that initially contained approximately 80% barley grass. (Irrigation, however, caused a significant increase in seed numbers and germination on mowed plots). The greatest reductions occurred when the barley grass was cut close to the ground about ten days after the heads started turning color and the herbage then removed. When subterranean clover was sown, seed setting of barley grass was significantly reduced. When these treatments were performed a second season, the effects were not cumulative. Nevertheless, after the second year, the proportion of barley grass decreased to 17% where it had been cut for hay as compared to approximately 50% where pastures were lightly grazed and not mowed (Smith 1968d). In California, if barley grass is mowed or grazed before the heads appear, areas become less infested (Sampson et al. 1951).

Mowing also reduced the proportion of Hordeum leporinum and hay cutting almost eliminated it from pastures initially containing 27% of Hordeum leporinum. (Hay cutting in this experiment consisted of cutting to 2.5 cm in the spring and removing the herbage; the other mowing treatments included "topping", where plants were cut to 5 cm with herbage left on the plots and "silage" which was identical to hay cutting, but with plants cut one month earlier). As barley grass decreased, capeweed (Arctotheca calendula) and clover increased (McIvor and Smith 1973). Similar results were found in medicago spp. dominant pastures. When barley grass was cut to ground level 28 days after the first January rains, yields were lower than in other grazing and cutting treatments. This defoliation in the establishment phase severely depressed subsequent growth and germination of barley grass. Germination of barley grass seed was enhanced by a covering of surface mulch, but this benefit declined with successive germinations (Campbell and Beale 1973).

Other attempts at mowing in California only resulted in barley grass returning in full vigor the following season. These treatments were attempted with no additional management, such as burning, grazing or planting with native grasses. It is speculated that replanting with native ryes following mowing could initiate a replacement of barley grasses; planting with native bunch grasses is thought to be less effective (T. Briggs 1990).

Rossiter (1966) notes an effect of fire on annual grasses, with their pasture content decreasing from 77% to 12% during the spring following a summer's severe burn. This effect on composition change was less when preceded by heavy grazing.

Several years of data have been collected in California on the response of grasslands to prescribed burns (T. Briggs 1990). Hordeum leporinum was found to be the annual grass most sensitive to burning. When a grassland contained up to 90% of barley grass, this percentage was reduced to less than 5% after burning. This level was found to remain the same for up to three years with no other management.

Invasion of wild barley on seedling alfalfa in the high desert of southern California prompted application of pronamid (1 lb. ai/acre) and propham (6 lb. ai/acre). These amounts, applied in mid-February, when the barley was 20-25 cm tall, provided control. In another test on grasses already 15 cm tall, DPX-Y6202 and fluazifop provided superior control, with no apparent phytotoxicity in the alfalfa (Cudney and Orloff 1986). When herbicides were applied to the soil just after emergence (Jan. 25), they had little effect. Of pre-emergent herbicides, pronamid offered the best control, with a combination of 2 lbs. ai/acre of pronamid and paraquat the best overall. (Orloff and Cudney 1986). Neither of these brief research reports notes deactivation rates.

Invasion of legumes by barley grass was also controlled with paraquat and 2,2- DPA at Cowra, Australia. Paraquat killed barley grass and other weeds when sprayed at 1 pt./acre on July 20. The 2,2-DPA had a more specific effect on barley grass when sprayed at 3 lb./acre. The alfalfa was retarded by 2,2-DPA for about five weeks, while the retarding effect of paraquat was only seven days (Tickner 1968).

In northeastern Victoria, 2,4-D, 2,2-DPA, paraquat and diquat were tested on pastures composed of phalaris, Wimmera ryegrass, barley grass, silver grass and subterranean clover. Only 2,2-DPA and paraquat affected grass compositions, as measured on October 17. Paraquat applied in May reduced the proportion of barley and silver grass. Barley grass was also reduced by 2,2-DPA applications in either May or July, although ryegrass increased. (Herbicides were applied with 25 gallons of water per acre). All plants were fairly resistant to an April spraying. The higher the proportion of clover in the pasture, the greater its loss from 2,4-D, whereas when the grasses were more abundant in relation to the clover, they were also more affected by paraquat or diquat. Both grasses and clover were severely affected by high rates of 2,2-DPA. Effects on clover did not carry over into the following year (McGowan 1970).

Squires (1963) also found no carryover affect on clover by herbicides from one year to the next. In irrigated subterranean clover, barley grass was treated with three herbicides (also in southern Australia). The clover was found too intolerant of 2,2-DPA to warrant further testing. White clover (TRIFOLIUM REPENS), however, withstood an application of 2 pounds/acre of 2,2-DPA. Spraying paraquat di (methyl sulphate) several days after first irrigation burned all vegetation, though a new germination of clover later occurred. Applied at rates from .25 to 1 lb./acre it controlled barley grass, especially at the higher rates. Diquat dibromide was also thought promising for the control of barley grass if applied as an early post emergence spray at 2 lb/acre. In field trials in 1980 to 1982 on cereal/pasture ley rotations, application of 300-450 ml glyphosate reduced populations of Hordeum leporinum, Bromus and Vulpia by up to 98%. These tests in southern Australia found that the optimum application was at the early head to milky dough stages of the grasses. The authors recommend that one day should allow for adequate adsorption and translocation of the herbicide. While the legume seed production was reduced, this was offset by increased legume vigor the following season due to reduced grass competition (Jones et al. 1984).

At the Plant Materials Center in Tucson, Arizona, Hordeum jubatum (foxtail barley) is controlled with Surflan, a pre-emergent herbicide. Foxtail barley can also be controlled with post emergent sprays that won't enter the soil and that are applied soon after the seedlings emerge (B. Munda, pers. comm.).

NEW YORK
NON-NATIVE PLANT INVASIVENESS RANKING FORM

Citation: This NY ranking form may be cited as: Jordan, M.J., G. Moore and T.W. Weldy. 2008. Invasiveness ranking system for non-native plants of New York. Unpublished. The Nature Conservancy, Cold Spring Harbor, NY; Brooklyn Botanic Garden, Brooklyn, NY; The Nature Conservancy, Albany, NY. Note that the order of authorship is alphabetical; all three authors contributed substantially to the development of this protocol.

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