spotted knapweed
Centaurea stoebe ssp. *micranthos* (Gugler) Hayek

Synonyms: *Acosta maculosa* auct. non Holub, *Centaurea biebersteinii* DC., *C. maculosa* auct. non Lam, *C. maculosa* ssp. *micranthos* G. Gmelin ex Gugler
Other common names: None
Family: Asteraceae

Invasiveness Rank: 86 The invasiveness rank is calculated based on a species' ecological impacts, biological attributes, distribution, and response to control measures. The ranks are scaled from 0 to 100, with 0 representing a plant that poses no threat to native ecosystems and 100 representing a plant that poses a major threat to native ecosystems.

Description
Spotted knapweed is a biennial to short-lived perennial plant. Stems are 30½ to 91 cm tall and generally branched. Rosette leaves are compound with several irregularly lobed segments. Stem leaves are alternate, 5 to 15 cm long, more or less hairy, and resin-dotted. Lower stem leaves are narrowly divided, while the upper stem leaves are undivided. Flower heads are 19 to 25½ mm wide and are composed of purple disc florets (Royer and Dickinson 1999, Whitson et al. 2000).

Centaurea stoebe L.

Similar species: Spotted knapweed can be confused with two other species potentially occurring in Alaska. Diffuse knapweed (*C. diffusa*) can be distinguished from spotted knapweed by its spine-tipped floral bracts. Unlike spotted knapweed, yellow star-thistle (*C. solstitialis*) has yellow flowers and floral bracts that are tipped with sharp yellow spines (Royer and Dickinson 1999). Knapweeds can be distinguished from thistles (*Cirsium* species) by their lack of spiny leaves.

Ecological Impact
Impact on community composition, structure, and interactions: Spotted knapweed often forms dense stands in natural communities. Infestations reduce the vigor of native plants, decrease the species diversity of plant communities, and degrade the forage quality of wildlife habitats. Winter-ranging elk may avoid foraging in spotted knapweed dominated communities (Rice et al. 1997). Knapweeds are allelopathic, inhibiting the establishment and growth of surrounding vegetation (Whitson et al. 2000).
Impact on ecosystem processes: Infestations of spotted knapweed have been shown to increase the erosion of topsoil. Sediments in surface run-off were approximately three times the amount in sites dominated by spotted knapweed than they were in sites dominated by native bunchgrass (Rice et al. 1997).

Biology and Invasive Potential
Reproductive potential: Spotted knapweed reproduces by seeds only. Large plants can produce over 20,000 seeds (Royer and Dickinson 1999). Approximately 30% of seeds buried in the soil remain viable after eight years (Mauer et al. 1987).
Role of disturbance in establishment: Anthropogenic disturbances, including overgrazing and mechanical soil disturbance, accelerate the establishment of spotted knapweed. Both biotic and abiotic soil disturbances (frost heaves, burrowing by small mammals, and trampling and grazing by native ungulates) can facilitate the invasion of spotted knapweed (Tyser and Kye 1988).
Potential for long-distance dispersal: Seeds lack pappi, but have been reported to be dispersed by wind. They can be transported by rodents and livestock (Mauer et al. 1987).
Potential to be spread by human activity: The dispersal of spotted knapweed seeds is primarily related to human activities. Seeds can be transported on vehicles, machinery, and aircraft. They are also widely dispersed as a contaminant in hay, commercial seed, and floral arrangements (Mauer et al. 1987).
Germination requirements: Spotted knapweed seeds germinate over a wide range of soil depths, moisture

conditions, and temperature regimes. Seedlings that emerge early in spring have a high probability of survival and reproduction during the following year. Those emerging later (in June or July) have reduced survival rates and almost no stem production during the following season (Schirman 1981).

Growth requirements: Spotted knapweed grows well in light, porous, fertile, well-drained, high pH soils, especially in areas with warm summers. It tolerates both dry and moist conditions (Beck 2003).

Congeneric weeds: Twelve *Centaurea* species are considered noxious weeds in one or more state of the U.S. or province of Canada. All *Centaurea* species are listed as noxious weeds in Ontario (Invaders 2010, USDA 2010).

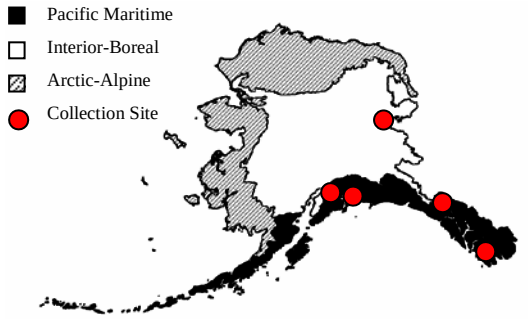
Legal Listings

- ☐ Has not been declared noxious
- ☐ Listed noxious in Alaska
- ☒ Listed noxious by other states (AZ, CA, CO, CT, ID, MA, MT, ND, NE, NM, NV, OR, SD, UT, WA, WY)
- ☐ Federal noxious weed
- ☒ Listed noxious in Canada or other countries (AB, BC, MB, ON, SK; New South Wales)

Distribution and abundance

Spotted knapweed establishes primarily along highways, waterways, railroads, and pipelines. Semi-arid grasslands and open forests have been invaded by spotted knapweed in Montana, Idaho, Colorado, Massachusetts, and North Dakota (Lym and Zollinger 1992, Rice et al. 1997).

Native and current distribution: Spotted knapweed is native to central and southeastern Europe. It now grows in nearly all states of the U.S. (USDA 2010). It has also invaded northern Europe, Asia, and Australia, where it is listed as a noxious weed in New South Wales (Weeds Australia 1998). Spotted knapweed has been documented from the Pacific Maritime and Interior-Boreal ecogeographic regions of Alaska (AKEPIC 2010).



Distribution of spotted knapweed in Alaska

Management

Long-term control requires a combination of grazing management, herbicide use, and biological control. Areas must be monitored for several years to control seedlings as they emerge from the seed banks. Most spotted knapweed control has been conducted in agricultural settings, with relatively little information available on the use of herbicides in native communities for conservation purposes (Lym and Zollinger 1992, Rice et al. 1997). However, a number of biological control agents have proven moderately successful at controlling spotted knapweed in Montana and other western states (Story et al. 1989, Story et al. 1991).

References:

AKEPIC database. Alaska Exotic Plant Information Clearinghouse Database. 2010. Available: http://akweeds.uaa.alaska.edu/

Beck, K.G. 2003. Diffuse and Spotted Knapweed. Colorado State University Cooperative Extension. http://www.ext.colostate.edu/index.html

Invaders Database System. 2010. University of Montana. Missoula, MT. http://invader.dbs.umt.edu/

Lym, R.G. and R.K. Zollinger. 1992. Spotted Knapweed (*Centaurea maculosa* Lam.). North Dakota State University. NDSU Extension Service. http://www.ag.ndsu.edu/pubs/plantsci/weeds/w842w.htm

Mauer, T., M.J. Russo, M. Evans. 1987 Element Stewardship Abstract for *Centaurea maculosa* Spotted Knapweed. The Nature Conservancy, Arlington, VA.

Rice, P.M., J.C. Tonye, D.J. Bedunah and C.E. Carlson. 1997. Plant community diversity and growth form responses to herbicide applications for control of *Centaurea maculosa*. Journal of Applied Ecology 34: 1397-1412.

Royer, F. and R. Dickinson. 1999. Weeds of the Northern U.S. and Canada. The University of Alberta press. 434 pp.

Schirman, R. 1981. Seed production and spring seedling establishment of diffuse and spotted knapweed. J. Range Management 34: 45-47.

Story, J.M., K.W. Boggs, and R.M. Nowierski. 1989. Effect of two introduced seed head flies on spotted knapweed. Montana AgResearch Winter 1989: 14-17.

Story, J.M., K.W. Boggs, and W.R. Good. 1991. First report of the establishment of *Agapeta zoegana* L. (Lepidoptera: Cochylidae) on spotted knapweed, *Centaurea maculosa* Lamarck, in

the United States. The Canadian Entomologist March/April 1991: 411-412.
Tyser, R.W. and C.W. Key. 1988. Spotted knapweed in natural area fescue grasslands: an ecological assessment. Northwest Science, 62: 151-160.
USDA. 2010. The PLANTS Database. National Plant Data Center, Natural Resources Conservation Service, United States Department of Agriculture. Baton Rouge, LA. http://plants.usda.gov
Weeds Australia. 1998. Noxious Weed List. On Line Database. http://www.weeds.org.au/noxious.htm
Whitson, T. D., L. C. Burrill, S. A. Dewey, D. W. Cudney, B. E. Nelson, R. D. Lee, R. Parker. 2000. Weeds of the West. The Western Society of Weed Science in cooperation with the Western United States Land Grant Universities, Cooperative Extension Services. University of Wyoming. Laramie, Wyoming. 630 pp.

Canada thistle
Cirsium arvense (L.) Scop.

Synonyms: *Breea arvensis* Less., *B. incana* (Gmel.) W.A. Weber, *Carduus arvensis* (L.) Robson, *Cirsium arvense* var. *argenteum* (Vest) Fiori, *C. arvense* var. *horridum* Wimmer & Grab., *C. arvense* var. *integrifolium* Wimmer & Grab., *C. arvense* var. *mite* Wimmer & Grab., *C. arvense* var. *vestitum* Wimmer & Grab., *C. incanum* (Gmel.) Fisch., *C. setosum* (Willd.) Bess. ex. Bieb., *Serratula arvensis* L.
Other common names: California thistle, Canadian thistle, creeping thistle, field thistle
Family: Asteraceae

Invasiveness Rank: 76 The invasiveness rank is calculated based on a species' ecological impacts, biological attributes, distribution, and response to control measures. The ranks are scaled from 0 to 100, with 0 representing a plant that poses no threat to native ecosystems and 100 representing a plant that poses a major threat to native ecosystems.

Description
Canada thistle is a perennial plant with deep and extensive horizontal roots that can form new shoots. Stems usually grow 30½ to 122 cm tall and branch above. Leaves are alternate, sessile, and shallowly to deeply pinnatifid or lobed with spiny margins. The lower surfaces of leaves are often covered with soft, woolly hairs. Male and female flower heads appear on separate plants. Flower heads measure 13 to 19 cm in diameter. Flowers are purple and almost exclusively insect-pollinated. Seeds are brownish with a tuft of hairs at the top (Whitson et al. 2000).

Cirsium arvense (L.) Scop.

Similar species: Canada thistle is the only thistle in Alaska that has narrow flower heads and lacks winged stems.

Ecological Impact
Impact on community composition, structure, and interactions: Canada thistle threatens natural communities by competing for water and nutrients, displacing native vegetation, and decreasing species diversity. It produces allelopathic chemicals that assist in displacing competing plant species (Hayden 1934, Evans 1984). Pollinating insects appear to be drawn away from native species to visit Canada thistle (Zouhar 2001). This species has been reported to accumulate nitrates that cause poisoning in animals. The spiny leaves scratch skin, sometimes causing infections. Canada thistle is a host for bean aphid, stalk borer, and sod-web worm (Nuzzo 1997).
Impact on ecosystem processes: Canada thistle can increase fire frequency and severity because of its abundant, readily ignited litter (Zouhar 2001).

Biology and Invasive Potential
Reproductive potential: Canada thistle reproduces sexually by seeds and vegetatively from its lateral roots, which send up new shoots every year. It readily propagates from stem and root fragments. An individual plant can produce over 40,000 seeds per year (Royer and Dickinson 1999).
Role of disturbance in establishment: Canada thistle has been observed in natural areas around ponds and wetlands where water levels fluctuate. It has also been documented growing in areas of soil erosion and on gopher mounds. This species cannot establish or spread in undisturbed habitats or pastures in good condition (Evans 1984, Bossard et al. 2000, Zouhar 2001). Cultivation stimulates the growth of the horizontal roots, thereby increasing the number of new upright shoots borne by the horizontal runners (Hayden 1934).
Potential for long-distance dispersal: Each seed has a pappus, but the pappus breaks off the seed easily. Most seeds land near the parent plant. However, a small proportion of seeds (0.2%) can disperse 1 km or further from the parent plant (Bostock and Benton 1979, Nuzzo 1997). Seeds float and are dispersed by water. They can also be dispersed in dung. Ducks and other waterfowl

may be agents of distribution for Canada thistle seeds (Hayden 1934).

Potential to be spread by human activity: Canada thistle spreads as a contaminant in crop seed, hay, and packing material. Additionally, it can be spread in mud attached to vehicles or farm equipment (Nuzzo 1997).

Germination requirements: Canada thistle seeds germinate best in the top 1 cm of soil under conditions with abundant soil moisture and temperatures between 20°C and 30°C. New seeds will germinate in bright light. Approximately 90% of seeds germinate within one year. Some seeds, however, can remain dormant in the soil for up to 20 years (Hutchison 1992). The amount of time for which a seed remains viable increases as the depth at which the seed is buried increases (Nuzzo 1997).

Growth requirements: Canada thistle can grow on a variety of soil types, including clay, loam, silt, gravel, and chalk. It does not tolerate shade (Nuzzo 1997).

Congeneric weeds: Bull thistle (*Cirsium vulgare*), prairie thistle (*C. canescens*), meadow thistle (*C. scariosum*), Flodman's thistle (*C. flodmanii*), Japanese thistle (*C. japonicum*), yellowspine thistle (*C. ochrocentrum*), marsh thistle (*C. palustre*), and wavyleaf thistle (*C. undulatum*) are each considered noxious weeds in one or more states of the U.S. or provinces of Canada (Invaders 2010, USDA 2010).

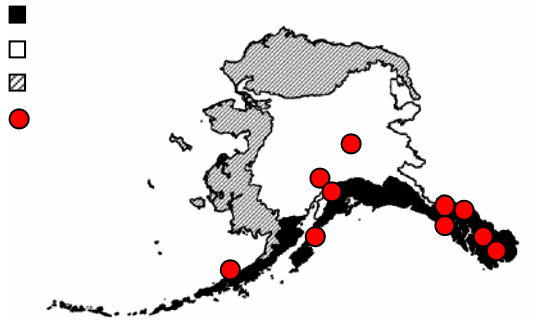
Legal Listings

- ☐ Has not been declared noxious
- ☒ Listed noxious in Alaska
- ☒ Listed noxious by other states (AL, AR, AZ, CA, CO, CT, DE, HI, IA, ID, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MT, NC, ND, NE, NJ, NM, NV, NY, OH, OK, OR, PA, RI, SD, TX, UT, VT, VA, WA, WI, WY)
- ☐ Federal noxious weed
- ☒ Listed noxious in Canada or other countries (AB, BC, MB, ON, PQ, SK; considered a serious pest in 37 countries)

Distribution and Abundance

Canada thistle commonly grows in roadsides, railroad embankments, lawns, gardens, abandoned fields, agricultural fields, and pastures. Natural areas that have been invaded by Canada thistle include prairies, wet grasslands (Canada, North Dakota, and South Dakota), and sedge meadows (Wisconsin and Illinois). In eastern North America, Canada thistle grows in swamps, ditches, sand dunes, stream banks, and lakeshores (Nuzzo 1997).

Native and current distribution: Canada thistle is native to southeastern Europe, western Asia, and northern Africa. It was introduced to North America in the early 17th century and was declared a noxious weed by the state of Vermont in 1975 (Nuzzo 1997). It grows throughout most of Canada and the U.S. (USDA 2010). Canada thistle currently has a nearly global distribution, exclusive of Antarctica. It is known to grow throughout Europe, northern and southern Africa, western and central Asia, India, Japan, China, North America, South America, New Zealand, Tasmania, and Australia (Hultén 1968, Nuzzo 1997). Canada thistle has been documented from the Pacific Maritime and Interior-Boreal ecogeographic regions of Alaska (Hultén 1968, AKEPIC 2010, UAM 2010).



Distribution of Canada thistle in Alaska

Management

Canada thistle is very difficult to control once it has established. Most research on Canada thistle control focuses on agricultural systems. Currently, there are no control methods suitable for wide-spread use in natural areas. Greater effort is warranted in areas that have new or small invasions. A combination of mechanical, cultural, and chemical control methods are more effective than any single control method alone. Potential biological control organisms are not adequately synchronized with Canada thistle's life cycle in North America to provide effective control (Nuzzo 1997).

References:

AKEPIC database. Alaska Exotic Plant Information Clearinghouse Database. 2010. Available: http://akweeds.uaa.alaska.edu/

Alaska Administrative Code. Title 11, Chapter 34. 1987. Alaska Department of Natural Resources. Division of Agriculture.

Bossard, C.C., J.M. Randall, M.C. Hoshovsky. 2000. Invasive plants of California's wildlands. University of California Press. 360 pp.

Bostock, S.J. and R.A. Benton. 1979. The reproductive strategies of five perennial Compositae. The Journal of Ecology 67: 91-107.

Evans, J.E. 1984. Canada thistle (*Cirsium arvense*): A literature review of management practices.

Natural Areas Journal 4:11-21.
Hayden, A. 1934. Distribution and reproduction of Canada thistle in Iowa. American Journal of Botany 21: 355-373.
Hultén, E. 1968. Flora of Alaska and Neighboring Territories. Stanford University Press, Stanford, CA. 1008 pp.
Hutchison, M. 1992. Vegetation management guideline: Canada thistle (*Cirsium arvense* (L.) Scop.). Natural Areas Journal. 12: 160-161.
Invaders Database System. 2010. University of Montana. Missoula, MT. http://invader.dbs.umt.edu/
Nuzzo, V. 1997. Element Stewardship Abstract for *Cirsium arvense*. The Nature Conservancy, Arlington, VA.
Royer, F. and R. Dickinson. 1999. Weeds of the Northern U.S. and Canada. The University of Alberta press. 434 pp.
UAM. 2010. University of Alaska Museum, University of Alaska Fairbanks. Available: http://arctos.database.museum/home.cfm
USDA. 2010. The PLANTS Database. National Plant Data Center, Natural Resources Conservation Service, United States Department of Agriculture. Baton Rouge, LA. http://plants.usda.gov
Whitson, T.D., L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, R. Parker. 2000. Weeds of the West. The Western Society of Weed Science in cooperation with the Western United States Land Grant Universities, Cooperative Extension Services. University of Wyoming. Laramie, Wyoming. 630 pp.
Zouhar, K. 2001. *Cirsium arvense*. In: Fire Effect Information System, (Online). U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer) Available: http://www.fs.fed.us/database/feis/

white sweetclover
Melilotus alba Medikus

Synonyms: *Melilotus albus* Medik.
Other common names: None
Family: Fabaceae

Invasiveness Rank: 81 The invasiveness rank is calculated based on a species' ecological impacts, biological attributes, distribution, and response to control measures. The ranks are scaled from 0 to 100, with 0 representing a plant that poses no threat to native ecosystems and 100 representing a plant that poses a major threat to native ecosystems.

Description

White sweetclover is a biennial plant that grows from 61 to 152 ½ cm tall. Stems are erect and branched. Leaves are trifoliate, alternate, and 13 to 64 mm long. Flowers are fragrant, white, 3 to 6 mm long, and arranged in many-flowered terminal and axillary racemes. Plants generally flower from June to October during their second year and then die. Pods are normally black to dark grey with a single seed each. Seeds are yellow and ovate to kidney-shaped (Hultén 1968, Royer and Dickinson 1999).

Melilotus alba Medikus

Similar species: White sweetclover can be distinguished from all other trifoliate legumes in Alaska because it is erect, tall, and branching. White sweetclover has white flowers, whereas yellow sweetclover (*Melilotus officinalis*) has yellow flowers.

Leaves of *Melilotus alba* Medikus

Ecological Impact

Impact on community composition, structure, and interactions: White sweetclover degrades natural grassland communities by overtopping and shading native species. It contains coumarin, which is toxic to animals. The flowers are visited by introduced honeybees, native solitary bees, wasps, and flies (Eckardt 1987). White sweetclover is associated with over 28 viral diseases (Royer and Dickinson 1999, CUPPID 2003). It is allelopathic (USDA 2002).

Impact on ecosystem processes: White sweetclover alters soil conditions by fixing atmospheric nitrogen (USDA 2002). It has the potential to alter the sedimentation rates of river ecosystems (M. Shephard – pers. comm.).

Biology and Invasive Potential

Reproductive potential: Each plant is capable of producing up to 350,000 seeds. Seeds can remain viable in the soil for up to 81 years (Klemow and Raynal 1981, Rutledge and McLendon 1996, Royer and Dickinson 1999). Large seed banks are common (Eckardt 1987).

Role of disturbance in establishment: White sweetclover readily invades open areas. Natural and human-caused fires produce excellent growing conditions because they scarify seeds and stimulate germination. Clearings in forested lands are easily colonized by white sweetclover. This plant has established extensively along early successional river bars on a number of river systems in interior, south-central, and southeast Alaska. White sweetclover resprouts readily when cut or grazed (Eckardt 1987, WDNR 2003).

Potential for long-distance dispersal: Seeds can be dispersed by the movement of water (Eckardt 1987, Rutledge and McLendon 1996).

Potential to be spread by human activity: White sweetclover is used extensively as a forage crop, soil builder, and nectar source for honeybees (Eckhardt 1987, WDNR 2003). Seeds can be transported on vehicle tires. This species has been documented as a contaminant in cereal grains (Royer and Dickinson 1999, Densmore et al. 2001).

Germination requirements: White sweetclover has high seed viability. Seeds do not require cold-stratification to germinate. Most seeds germinate and develop into seedlings in the spring with sufficient moisture. Temperatures of less than 15°C are optimal for germination; germination is inhibited at temperatures above 15°C (Eckardt 1987).

Growth requirements: White sweetclover is adapted to all soil textures with pH levels between 5 and 8. It is tolerant of fire, high calcium carbonate ($CaCO_3$) contents, and moderate salinity, but it cannot tolerate shade. This species can withstand temperatures as low as -39°C. It requires 120 frost-free days to grow and reproduce successfully (USDA 2002).

Congeneric weeds: Yellow sweetclover (*Melilotus officinalis*) is an invasive species in Alaska with an invasiveness rank of 69 (AKEPIC 2010). Several *Melilotus* species are known to occur as non-native weeds in North America (USDA 2002).

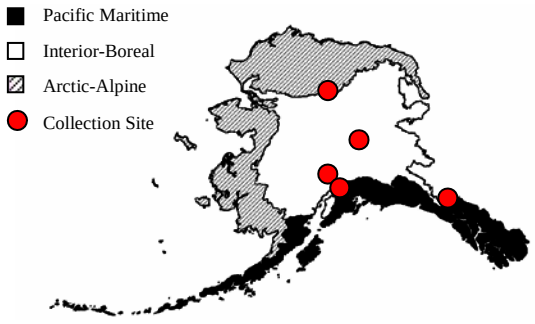
Legal Listings

- ☐ Has not been declared noxious
- ☐ Listed noxious in Alaska
- ☐ Listed noxious by other states
- ☐ Federal noxious weed
- ☒ Listed noxious in Canada or other countries (QC)

Distribution and Abundance

White sweetclover was first reported in North America as early as 1664 as a forage crop. It has spread from cultivation and thrives in waste places and roadsides. White sweetclover can be found in all 50 states of the U.S. and all but two Canadian provinces (Royer and Dickinson 1999, USDA 2002). It establishes in aspen woodlands, prairies (Butterfield et al. 1996, Rutledge and McLendon 1996), and riparian communities (Stensvold 2000, Conn 2003).

Native and current distribution: White sweetclover is native to the Mediterranean area and from central Europe to Tibet. It has been introduced into South Africa, North America, South America, New Zealand, Australia, and Tasmania (Hultén 1968). This species has been documented from all three ecogeographic regions of Alaska (AKEPIC 2010).



Distribution of white sweetclover in Alaska

Management

White sweetclover infestations can be managed with mechanical control methods, such as pulling and cutting; however, several treatments may be necessary. Biological control options have not been investigated because of the plant's value as an agricultural crop. Because seeds remain viable for a long time, sites must be monitored for many years following control actions (Eckardt 1987, J. Conn – pers. comm.).

References:

AKEPIC database. Alaska Exotic Plant Information Clearinghouse Database. 2010. Available: http://akweeds.uaa.alaska.edu/

Butterfield, C., J. Stubbendieck, and J. Stumpf. 1996. Species abstracts of highly disruptive exotic plants. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/plants/exoticab/index.htm (Version 16JUL97).

Conn, J. 2003. White sweet clover invasions on Alaskan rivers. Paper presented at 2003 Alaska Noxious and Invasive Plants Management Workshop. Anchorage, Alaska.

Conn, J., Ph.D., Weed Scientist, USDA Agricultural Research Service, P.O. Box 757200, Fairbanks, Alaska 99775-7200. Tel: (907) 474 2423. – Pers. comm.

CUPPID - Cornel University: Poisonous Plants Informational Database. http://www.ansci.cornell.edu [Oct 29, 2003].

Densmore, R. V., P. C. McKee, C. Roland. 2001. Exotic plants in Alaskan National Park Units. Report on file with the National Park Service – Alaska Region, Anchorage, Alaska. 143 pp.

Eckardt, N. 1987. Element stewardship abstract for *Melilotus alba* – sweetclover or white sweetclover, *Melilotus officinalis* – yellow sweetclover. The Nature Conservancy, Minneapolis. 10 pp.

Hultén, E. 1968. Flora of Alaska and Neighboring Territories. Stanford University Press, Stanford, CA. 1008 p.

Invaders Database System. 2010. University of Montana. Missoula, MT. http://invader.dbs.umt.edu/

Klemow, K.M. and D.J. Raynal. 1981. Population Ecology of *Melilotus alba* in a limestone quarry. Journal of Ecology 69: 33-44.

Royer, F. and R. Dickinson. 1999. Weeds of the Northern U.S. and Canada. The University of Alberta press. 434 pp.

Rutledge, C.R., and T. McLendon. 1996. An Assessment of Exotic Plant Species of Rocky Mountain National Park. Department of Rangeland Ecosystem Science, Colorado State University. 97 pp. Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/plants/explant/index.htm (Version 15DEC98).

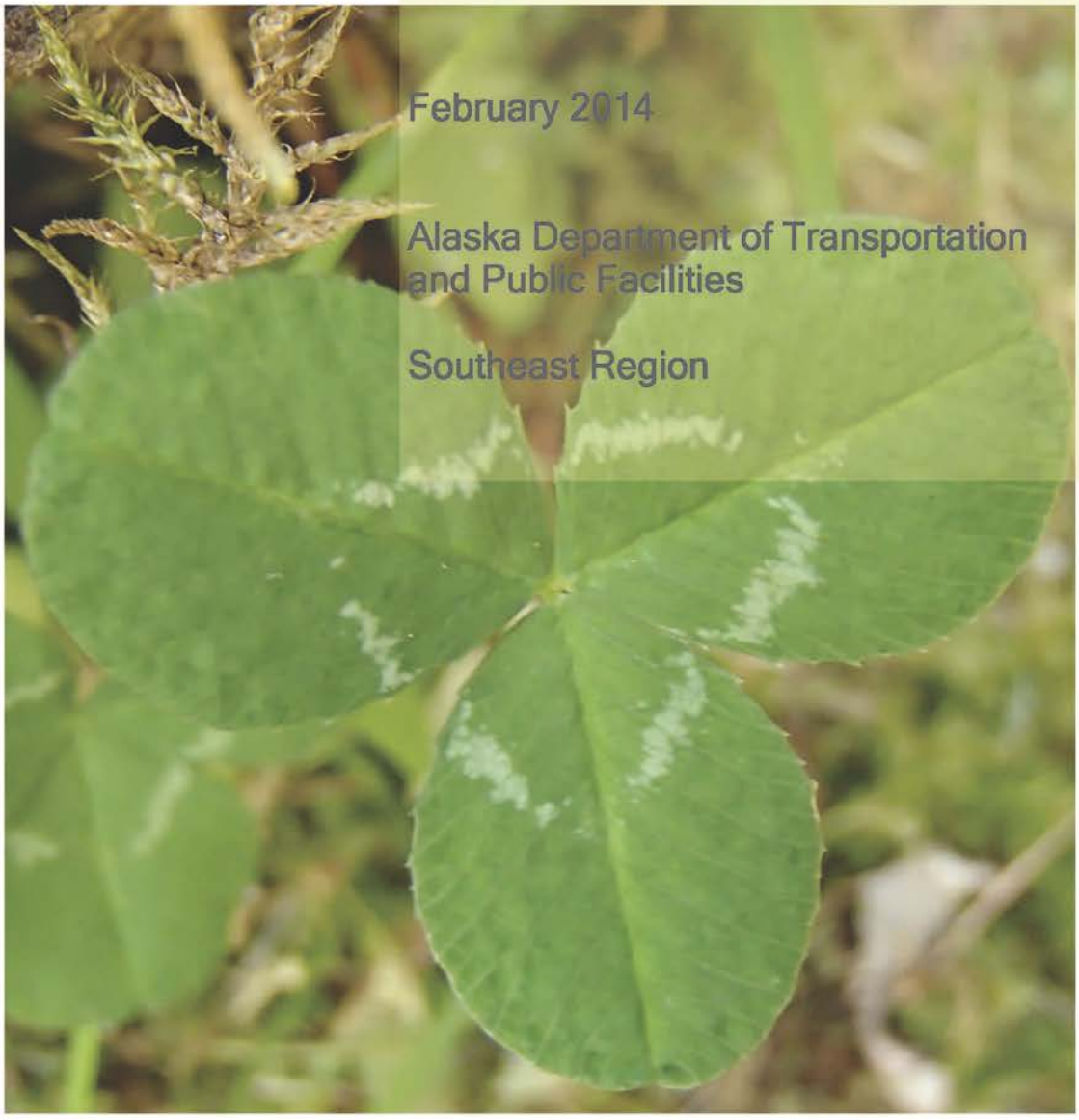
Shephard, M. Vegetation Ecologist, USDA, Forest Service, Forest Health Protection, State and Private Forestry, 3301 C Street, Suite 202, Anchorage, Alaska 99503. Tel: (907) 743-9454 - Pers. com.

Stensvold, M. 2000. Noxious weed surveys and projects conducted on the Tongass National Forest 1997-2000. Technical report on file, Tongass National Forest. 2 pp.

USDA (United States Department of Agriculture), NRCS (Natural Resource Conservation Service). 2002. The PLANTS Database, Version 3.5 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

WDNR - Wisconsin Department of Natural Resources. 2003. Yellow sweet clover (*Melilotus officinalis*) White sweet clover (*Melilotus alba*). www.dnr.state.wi.us/org/land/er/invasive/factsheet/clovers.htm

Disposal and Control of Invasive Plant Species



February 2014

Alaska Department of Transportation and Public Facilities

Southeast Region

Disposal and Control of Invasive Plant Species

Final

February 2014

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TABLE OF CONTENTS

Page

TABLES

APPENDICES

ACRONYMS

Term	Definition
3PPI	Three Parameters Plus, Inc.
ADEC	Alaska Department of Environmental Conservation
AKEPIC	Alaska Exotic Plant Information Clearinghouse
AKNHP	Alaska Natural Heritage Program
BMP	Best management practice
DNR	Alaska Department of Natural Resources
DOT&PF	Alaska Department of Transportation and Public Facilities
ISCDM	Invasive Species Control and Disposal Matrices (Appendix A & B)
IVMP	Integrated Vegetation Management Plan
NRCS	Natural Resources Conservation Service
ROW	Right-of-Way
UK	United Kingdom
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

1.0 Introduction

Management of non-native invasive plant species is a growing concern in Alaska. The State of Alaska Department of Transportation and Public Facilities (DOT&PF) Southeast Region has requested a review of available information regarding options for control and disposal of invasive species plant material for 37 invasive species (target species) identified by DOT&PF for study (Table 1.1).

Table 1.1
List of Target Invasive Species Organized by Status and by AKNHP Invasiveness Rank

Common Name	Latin Name	AKNHP Invasiveness Rank[1]
Prohibited Noxious Weeds - Alaska Department of Natural Resources		
Leafy spurge	*Euphorbia esula*	84
Purple loosestrife	*Lythrum salicaria*	84
Orange hawkweed	*Hieracium aurantiacum*	79
Canada thistle	*Cirsium arvense*	76
Perennial sowthistle	*Sonchus arvensis*	73
Whitetops and its varieties	*Cardaria draba, C. pubescens, Lepidium latifolium*	71
Russian knapweed	*Acroptilon repens*	66
Quackgrass	*Elymus repens*	59
Field bindweed	*Convolvulus arvensis*	56
Hempnettle	*Galeopsis tetrahit*	50
Galinsoga	*Galinsoga parviflora*	*
Austrian fieldcress	*Rorippa austriaca*	*
Horsenettle	*Solanum carolinense*	*
Blue-flowering lettuce	*Lactuca tatarica, (L. pulchella)*	*
Other Invasive Plants Addressed in this Study[2]		
Japanese knotweed	*Polygonum cuspidatum, P. bohemicum*	87
Spotted knapweed	*Centaurea stoebe (C. maculosa)*	86
Reed canarygrass	*Phalaris arundinacea*	83
Ornamental jewelweed	*Impatiens glandulifera*	82
White sweetclover	*Melilotus alba*	81
Meadow hawkweed	*Hieracium caespitosum*	79
Cheatgrass	*Bromus tectorum*	78
Siberian pea shrub	*Caragana arborescens*	74
European bird cherry	*Prunus padus*	74
Bird vetch	*Vicia cracca*	73
Garlic mustard	*Alliaria petiolata*	70
Common toadflax	*Linaria vulgaris*	69
Scotchbroom	*Cytisus scoparius*	69

Common Name	Latin Name	AKNHP Invasiveness Rank[1]
Rampion bellflower	*Campanula rapunculoides*	64
Foxtail barley	*Hordeum jubatum*	63
Tansy ragwort	*Senecio jacobaea*	63
Bull thistle	*Cirsium vulgare*	61
Oxeye daisy	*Leucanthemum vulgare*	61
Common tansy	*Tanacetum vulgare*	60
Narrowleaf hawksbeard	*Crepis tectorum*	56
Splitlip hempnettle	*Galeopsis bifida*	50
Western salsify	*Tragopogon dubius*	50
Hairy catsear	*Hypochaeris radicata*	44

Notes: [1] Invasiveness ranks have been assigned to over 40 percent of non-native species known or suspected to occur in Alaska by ecologists associated with the AKNHP (Carlson et al. 2008, Nawrocki et al. 2011). Ranks reflect an assessment of the potential threat posed by a non-native species to natural habitats in Alaska. A rank greater than 70 is considered indicative of a species likely to pose a serious threat to natural ecosystems in Alaska. Species with scores 60-69 are considered "Moderately Invasive", while those with scores 50-59 are "Modestly Invasive". These groups pose threats to natural habitats in Alaska but are less likely to successfully invade. Scores between 40 and 49 indicate a "Weakly Invasive" species and scores below 40 are considered "Very Weakly Invasive" (Carlson et. al. 2008 as in Nawrocki et al. 2011).
[2] This list was generated by John Barnett of the Alaska Department of Transportation and Public Facilities Southeast Region.
* No Invasiveness Ranking has been assigned (AKEPIC 2013).

In response, Three Parameters Plus, Inc. (3PPI) conducted an extensive literature review and interviewed invasive species management experts. The results are summarized in this report and associated appendices. General commentary regarding practical experience with control and disposal of non-native species was gathered during interviews and is summarized in the text of the report. Statements culled from sources that directly address management of a particular species are compiled in the Invasive Species Disposal Matrix (Appendix A) and Invasive Species Control Matrix (Appendix B). The project plant list organized alphabetically by Latin name is provided in Appendix C. Interview contact details and an extensive annotated bibliography linked to the disposal and control matrices is provided in Appendix D.

2.0 Objectives

The primary objective of this study was to research the current state of knowledge regarding options for control and disposal of 37 invasive plant species (Table 1.1) of management concern to DOT&PF Southeast Region, Design and Engineering Services. Fourteen of the target species are prohibited noxious weeds (DNR 2007, Table 1.1) and 23 are additional species requested for review by the DOT&PF. During the construction phase of a project, the DOT&PF strives to manage infestations in existing and acquired right-of-ways (ROW) where activities will disturb vegetation and/or soil. During this phase, the DOT&PF prefers mechanical methods of species management, such as excavation; thus, approaches that do not require herbicides are highlighted in this report (John Barnett pers. comm. 2013).

3.0 Methods

3PPI reviewed published sources and conducted phone interviews to gather the information presented in this report, but did not conduct field trials or otherwise independently test the accuracy of the data.

One hundred thirty sources are cited in this report. They include publications from national, state, and local government agencies; weed management associations; peer-reviewed journals, and university cooperative extension programs. Interviews were conducted with professionals with expertise in management of invasive species in Alaska and other western states, Rhode Island, and Canada. Interviewees include employees of transportation departments and other government agencies as well as experts employed by or serving on county and state weed boards, conservation organizations, and university weed management affiliates.

4.0 Results

The species-specific results of the literature review and interviews are summarized in the Invasive Species Control and Disposal Matrices (ISCDM) (Appendixes A & B); supplemental information is provided in this report. The ISCDM consists of two tables in which results are presented individually for each target species. Table A.1 Invasive Species Disposal Matrix (Appendix A) includes information on disposal of plant material and/or life history traits relevant to management, such as rooting depth, while Table B.1 Invasive Species Control Matrix (Appendix B) contains findings regarding control of invasive plant infestations. In contrast, Section 5.0 of this report is organized by disposal or control technique. The anecdotal information gathered during interviews was often general in scope rather than species-specific and, thus, is summarized in the report but seldom appears in the ISCDM (Appendices A & B).

Ninety-two sources are cited in the ISCDM (Table D.2); however, as a general observation, there was less species-specific data available in the literature regarding the disposal of plant material than there was regarding the control of these species or relevant aspects of their life history. The DOT&PF Southeast Region specifically requested information regarding recommended species-specific burial depths for disposal, thus, a “Burial Depth Summary and Suggested Field Tests” column has been added to the Invasive Species Disposal Matrix (Table A.1). The information included in this column is either the species-specific recommended burial depth as it appears in cited literature (as in the Burial/Burial Depth column, Table A.1) or, if no referenced burial depth was found during the literature review, a recommended burial depth for field trials based on an analysis of life history traits cited in this report (e.g. reproduction and rooting depth, Table A.1). Further information is provided in the footnotes to Table A.1 and in Section 5.2.1.

Independent verification or field testing of the efficacy of the techniques summarized in this study was outside the scope of this literature review; and, at times, sources provided internally inconsistent information. In these cases, the reader may find it helpful to refer to the annotated bibliography (Table D.2, Appendix D) for more information. The linkages between the sources and the statements appearing in the ISCDM have been carefully preserved. Statements in the ISCDM are followed by a reference number that corresponds to a citation appearing in the annotated bibliography and in the comprehensive listing of references, Section 7.0 Literature Cited. The annotated bibliography also may facilitate follow-up research and features a brief description of the references cited in the ISCDM. References are organized numerically by

ISCDM reference number in the annotated bibliography and are organized alphabetically in the comprehensive reference section (Section 7.0 Literature Cited). Unlike the annotated bibliography, the comprehensive reference section includes all interviews and other references cited in throughout the report (130 sources), not just those cited in the ISCDM. A complete list of interview contacts is provided in Table D.1 (Appendix D).

5.0 Discussion

5.1 Preventing the spread of invasive species

There are a number of management practices that may reduce or prevent the spread of invasive species. Guidelines are addressed in a best management practices guide currently in preparation by the University of Alaska Cooperative Extension Service (expected publication date: 2014) (Graziano 2013). Some of the more common means to control the spread of invasive species during DOT&PF construction activities are discussed below.

Invasive species composition and abundance should be inventoried at the project site during the planning phase to ensure that appropriate control or disposal options are incorporated into the project design. Infestations on project sites may be targeted for control by community groups, so coordination with stakeholders and weed control groups may be beneficial. Generally speaking, disturbances to infested areas should be avoided to minimize the spread of invasive species. If activity in these areas is unavoidable, disturbances should be scheduled to occur when the risk of dispersal is minimal, either by timing the disturbance to occur at advantageous times in the season (e.g., before seeds mature, while there is less risk of dispersal of viable seeds into new areas) and/or by targeting these areas for infestation control prior to ground-disturbance. During site rehabilitation, only weed-free soil and weed-free seed should be utilized. One of the best means to prevent the spread of weed seed or other viable plant parts is by washing vehicles before leaving a construction site and, particularly, before getting on the state ferry system or otherwise transporting equipment and vehicles between islands and communities in southeast Alaska. Washing vehicles can remove 66 – 95 percent of soil (and presumably plant material) (Taylor et al. 2011).

5.2 Disposal

The literature review and interviews that form the basis of this report indicate that species-specific information regarding disposal of invasive species and infested soil is sparse and basic research and guidance on effective disposal methods is lacking. Table B.1 (Appendix B) contains specific disposal information for 35 of the 37 target species. No species-specific disposal information was found for common toadflax *(Linaria vulgaris)* or blue-flowering lettuce *(Lactuca tartarica).*

5.2.1 Burial

Onsite burial of invasive species biomass and infested soil is a common disposal method (Czernick 2013, Salisbury 2013, Shippey 2013) and is used by all the transportation departments contacted for this project (Table D.1, Appendix D). However the research conducted as part of this project indicate there are few established minimum burial depth recommendations for specific species (see Section 4.0, Results). Furthermore, a minimum burial depth must be selected carefully and field testing is required before a new burial depth is used in a region (also see Section 4.0, results, and notes below Table A.1, Appendix A). If

reproductive plant materials, such as seeds, resprouting stems, stolons, or rhizomes, are not buried to a depth sufficient to inhibit regrowth, the buried material originating from one plant may produce multiple shoots (e.g., Japanese knotweed, Francis et al. 2008). The minimum burial depth required to inhibit regrowth may vary with changes in site conditions, such as hydrology, soil type, temperature variation, and compaction, and will vary among species and even among ecotypes within a given species (Chicouene 2007).

The University of New Hampshire cooperative extension office cautions against the use of burial for disposal of invasive species due to the risk of inadvertent dispersal of the invasive species. They do, however, suggest that many invasive species may be buried to a depth of 3 feet as long as the following guidelines are followed:

> **Burying:** This is risky, but can be done with watchful diligence. Lay thick plastic in a deep pit before placing the cut up plant material in the hole. Place the material away from the edge of the plastic before covering it with more heavy plastic. Eliminate as much air as possible and toss in soil to weight down the material in the pit. Note that the top of the buried material should be at least three feet underground. Japanese knotweed should be at least 5 feet underground!
>
> (University of New Hampshire Cooperative Extension 2010)

To decrease the probability of resprouting after burial, plant material first may be subjected to treatments intended to adversely impact viability ("pre-treatments"). The examples described below may not be suitable for all species. A series of studies reviewed in Chicuoene (2007) (including species such as *Cirsium arvense, Elymus repens,* and *Sonchus arvensis*) support the assumption that minimizing the resources available to rhizome and stolon buds will limit resprouting. For example, in some cases, timing ground disturbance for periods when stored resources are low (Gustavsson 1997) or fragmenting roots into tiny pieces may reduce the potential for species to resprout (Francis et al 2008, Chicouene 2007). Response to fragmentation varies, however, according to species and according to the degree of fragmentation (e.g., Sciegienka et al. 2011, Dong et al. 2011) and, if done incorrectly, may lead to spread of an invasive rhizomatous species.

Other pre-treatment options that may prove advantageous depending on the species and site conditions, include prior treatment with herbicides at a stage when the probability of translocation to roots is high (Miller 2013), aboveground storage of excavated rhizomes and stolons of sufficient duration to induce desiccation (Minnesota Department of Agriculture 2014), and, possibly, soaking plant reproductive parts in salt water. Tim Miller, Washington State University, concurred that exposure to salt water might adversely affect the ability of Japanese knotweed to resprout and deserves further investigation (pers. comm. Dec 2013).

Note that the pre-treatments described above would not be expected to impact an established seed bank; however, the information compiled in Table A.1 (Appendix A) suggests germination from seeds, which contain fewer reserves than rhizomes, often is inhibited at burial depths still considered conducive to rhizome resprouting. Since the depth at which infested soil must be buried to inhibit sprouting from rhizomes is often far below the depth required to inhibit emergence from seeds, rhizome characteristics and condition will likely have a greater influence on determining the minimum burial depth for soil infested with invasive species seeds and rhizomes.

The discussion below summarizes the results of telephone interviews conducted as part of this report:

When assessing a burial location, the potential for future excavation or erosion should be carefully considered, as these activities could expose viable seeds or plant parts; thus enabling an invasive species to re-sprout. Burial of invasive species waste and infested soil under road beds was not recommended by the transportation departments contacted for this project due to concern that the addition of organics in the roadbed and their subsequent decay may result in road surface failure. While burial under an asphalt cap would presumably inhibit re-growth, caution was advised with regard to the invasive knotweeds. Transportation departments who manage knotweed caution that this species will grow up through pavement edges, cracks in pavement, and has the potential to grow through new asphalt paving if placed under road beds (Czernick 2013, Salisbury 2013).

Some contacts indicated they trench before burying weed waste at construction sites (Shippey 2013), while others indicated they "bury" waste soil by grading it into the road shoulder. Occasionally, burial depth specifications may be determined by contractors (Salisbury 2013). In all cases, interviewees employed by government transportation departments indicated burial sites are monitored and re-growth is controlled, generally with herbicides (e.g., Salisbury 2013, Shippey 2013, Czernick 2013).

The use of geotextiles to inhibit regrowth of buried invasive species has not been attempted by any of the transportation departments contacted for this project. All agreed, however, that these materials would likely discourage regrowth. Geotextiles such as DGW700, RootX, and Root Barrier C3 are required when burying Japanese knotweed in the United Kingdom, (UK Environment Agency 2013); however, the use of geotextiles alone, may not be effective in controlling this resilient species (see Manual Control, Section 5.3.1)

A variety of approaches have been utilized to revegetate burial sites with non-invasive species. Non-invasive grasses are often planted and managed until they establish (Lackey 2013). A healthy, non-invasive grass community may take several years to establish but, once installed, can generally inhibit colonization by invasive species (Salisbury 2013, Boulet 2013). Reseeding disturbed areas with non-invasive grasses and/or fertilization is common in Alberta (Boulet 2013) and has been recommended for some situations in Alaska (Cortés-Burns and Flagstad 2013; Klein et al. 2012) Soil amendments, such as topsoil, (Salisbury 2013), fertilizer, and/or mycorrhizal fungi inoculum (Washington State Department of Transportation 2013) may be applied to encourage re-growth of planted species. In Washington, soil amendments with high carbon/nitrogen ratios, such as compost and wood chips, are recommended (Salisbury 2013).

5.2.2 Stockpiling

Some transportation departments have been known to temporarily stockpile soil that may contain weed seed, but it is often done temporarily and the material is later reused (Caswell 2013). There are, however, potential drawbacks to this disposal method. For example, the transportation cost to move material from the project site to the stockpile location may be prohibitive. Furthermore, stockpile sites can become weed-infested if the site is not properly monitored and managed (Nickelson 2013).

The monitoring period may be extensive; the seeds of some invasive species can remain viable in untreated soil for decades (Table B.1, Appendix B).To prevent re-growth of invasive species,

stockpiled material may be treated periodically with herbicides (Salisbury 2013, Shippey 2013, Czernick 2013). Alternatively, some of the techniques discussed in Section 5.2.1, such as geotextile use and establishment of non-invasive grass species, may inhibit re-growth in stockpile sites. The Minnesota Department of Agriculture (website accessed Feb 2014) recommends on-site stockpiling of plant material collected for disposal as long as site conditions and management of the stockpile promotes desiccation of reproductive plant parts, such as rhizomes.

5.2.3 Burning or Incineration

Unlike the other disposal techniques discussed in this report, burning or incineration to ash has the potential to quickly and completely destroy invasive species plant material, including reproductive parts such as seeds and rhizomes. This method, if properly conducted, could be used to address disposal of any invasive species listed in Table 1.1, including those for which no species-specific disposal information was found during this project (Table A.1, Appendix A)

Enclosed incinerators provide an intense heat and may be used to burn plant material and to sterilize soil. In a recent report, Cortés-Burns and Flagstad (2013) recommended bagging and incineration of all plant materials collected at the Campbell Tract in Anchorage, Alaska, where a small incinerator is in operation. In Falher, Alberta a small, semi-mobile incinerator is used by the municipal district to burn bags of invasive plant material and small amounts of soil (Boulet 2013). The city of Skagway, Alaska operates an incinerator that accepts weed waste and very small amounts of soil (Skagway Public Works Department 2013) and the community of Metlakatla, Alaska uses modified 55 gallon drums to burn bags of weed waste when weather permits (Winter 2013). An alternate form of incinerating weed infested soil has been used by the Montana Department of Transportation. In some cases, particularly around Yellowstone National Park, weed-infested soil and base course aggregate is processed through an asphalt hot plant prior to use in road construction projects (Johnson 2013).

Weed waste is sometimes openly burned, especially in drier parts of the country, although in other locations, such as British Columbia on-site burning of weed waste may be discouraged due to the potential for wildland fire, issues with smoke affecting road traffic, and negative effects to nearby communities (Czernick 2013). Transportation departments in Washington and Oregon have burned weed waste east of the Cascades (Willard 2013, Lackey 2013) and open burning is occasionally done, as weather permits, to remove invasive species growing along roadside fences (Lackey 2013). The DOT&PF Northern Region has on occasion burned bags of hand pulled invasive species at some of their maintenance stations (Gronquist 2013) and, in other areas of Alaska, city “burn piles” are repositories for weed waste in Cordova (Verna 2013) and Kodiak (Brown 2013).

5.2.4 Landfill

Landfills are common repositories for weed waste in Alaska and elsewhere. Landfills, however, may have limitations on the type or volume of soil or weed waste they will accept (Holland 2013, Caswell 2013). Community “weed pulls” are a common tool used to enhance public awareness of invasive species and simultaneously manage small infestations; the extracted plant debris is often bagged and disposed of in landfills. When plant debris is transported to the landfill it should be covered or otherwise secured to prevent the spread of seeds or other viable plant parts along roadways.

5.2.5 Composting

On occasion transportation departments may use composting to dispose of weed waste (e.g. the British Columbia Ministry of Transportation, Czernick 2013). However, composting has not been shown to consistently break down weed seed unless properly monitored (Grundy et al. 1998) and may be ineffective for disposal of invasive knotweeds, particularly in cool climates, unless strict protocols are carefully followed (Miller 2013).

S. Salisbury of the Washington State Department of Transportation also cautions that proper composting requires controlled conditions. The feedstock must be actively aerated (e.g., by rotating the piles). The temperature must be regularly monitored and, for example, in Washington state needs to be maintained above 131 degrees Fahrenheit for a minimum of 72 hours or five turns of the pile (as per the Washington Administrative Code 173-350-220). These conditions may be hard to maintain in cool wet climates; however, the Haines city landfill in southeast Alaska has a compost program and may be contacted for further information regarding compost management in this climate.

5.3 Control

Controlling an infestation of non-native species prior to construction activities will reduce the quantity of live material requiring disposal during construction. Thus, integrating control strategies into project design may reduce the overall level of effort required at a project construction site. This strategy has been used successfully by the Washington Department of Transportation (Salisbury 2013). Controlling the spread of invasive species can be challenging, however, and will likely require a multi-faceted approach that takes into consideration the morphology, phenology, and reproduction characteristics of target species as well as the size of the infestation, site conditions, current regulations, and project goals. Control strategies may be divided into four main categories; manual control, mechanical control, chemical control, and biocontrol.

5.3.1 Manual Control

Manual control of invasive species includes digging, cutting, pulling by hand, and may include covering with plastic tarps or geotextiles (tarping).

Control by manual means is widely used by organized groups to combat invasive species in small areas (e.g., community “weed pulls”) or where other control methods are not suitable for use. Several contacts (e.g., Kraft 2013, Lackey 2013, Willard 2013), including the Department of Transportation in Washington and Oregon, indicated personnel occasionally use manual methods to control invasive species, but cautioned this technique may require multiple treatments per year or over several years (Winter 2013).

The reproductive biology of the target species should be considered when determining whether an infestation can be controlled by uprooting. For example, hand pulling a rhizomatous species is generally not effective unless all the rhizomes can be extracted from the soil; otherwise, uprooting may stimulate regrowth and inadvertently lead to spread of the infestation (British Columbia Ministry of Agriculture 2013).

Tarps, such as geotextiles, have not been used for weed control by the transportation departments interviewed during this literature review (Table D.1, Appendix D). They have,

however, been part of successful control strategies by other organizations to control orange hawkweed (*Hieracium aurantiacum*) in Washington (Nickelson 2013) and reed canary grass (*Phalaris arundinacea*) in Alaska (Brown 2013). If an infestation site is covered with a tarp as part of a control strategy, the tarp must be monitored for rips and tears, invasive species re-growth, and animal damage. Black bears (*Ursus americanus*) are known to be attracted to and have damaged geotextile fabric used in weed control projects in Washington (Nickelson 2013). The length of time the tarp must remain onsite and be monitored will depend on the dormancy period for seeds and rhizomes of the target species (Table A.1, Appendix A).

Tarping may be insufficient as a control method for the invasive knotweeds. These species have extensive, long-lived rhizomes and may resprout around the edges of tarps (Maupin 2013, Nickelson 2013, Table A.1, Appendix A) or following the removal of tarps (Beaulieu 2013). According to two sources, tarping alone has not successfully controlled Japanese knotweed in southeast Alaska; however, it has weakened plants to the extent that follow-up herbicide applications have been successful (Lendrum 2013, Maupin 2013). Lendrum (2013) specified the tarp material in use was an opaque 6-8 mil black plastic covered with a geotextile layer to protect the plastic. Tarping is discussed further in Section 5.2.1.

5.3.2 Mechanical Control

Mechanical control of invasive species involves the use of machinery such as mowers, hydro-axes, bulldozers, chainsaws, or brush cutters.

Management of vegetation along roadsides often relies on mechanical control. If used correctly, this approach will reduce the volume of invasive species material present at a project site during construction (e.g., hempnettle, *Galeopsis tetrahit,* Table B.1, Appendix B) and can reduce the vigor of an infestation. If used improperly, however, mechanical control methods can lead to dispersal of an invasive species.

It is critical to consider the reproductive traits (Table A.1, Appendix A) and phenology of a target species when designing a plan for mechanical control. Some species can regrow from vegetative fragments; thus, cutting or chopping the plant likely will increase the size of an infestation. For example, invasive knotweed root and stem fragments as small as 1/2 inch can sprout on moist soil and form new colonies (British Columbia Ministry of Agriculture 2013). Mowing in roadside ROWs has contributed to the spread of knotweed in southeast Alaska and elsewhere (Maupin 2013, Nickelson 2013).

If mechanical control occurs when the target species is in seed, the resulting physical disturbance to the plants may facilitate seed dispersal. Furthermore, seeds clinging to machinery may be dispersed to new locations as the machinery is moved.

5.3.3 Chemical Control

Chemical weed control of invasive species involves the use of selective or nonselective herbicides. Selective herbicides are formulated to control specific types of plants (e.g., broadleaved species) while nonselective herbicides are formulated to kill all vegetation.

A wide range of herbicides are available for use in both upland and wetland situations and often may be more economical and effective than other control alternatives. Chemical control is a common tool for management of vegetation in roadside ROWs; herbicides are used by all the

transportation departments contacted during research for this project (Table D.1, Appendix D). Often target weed species are sprayed in advance of planned road construction projects (Salisbury 2013), thus reducing the volume of live plant material requiring disposal during the construction phase. Post-construction roadside rehabilitation projects often employ herbicides to control invasive species until native vegetation becomes established (Kraft 2013, Bockness 2013). Nickelson (2013) has found herbicides to be the most successful and cost effective control option for Bohemian knotweed. An unusual form of chemical control, i.e., a mixture of vinegar and salt, was used with success in Haines, Alaska to control Canada thistle (*Cirsium arvense*) (Randles 2013).

The Alaska Department of Environmental Conservation (ADEC) recently authorized the application of pesticides (includes herbicides) on land owned or leased by an agency of the state, or on right-of-way managed by the state agency, eliminating the requirement for a permit for most applications on state lands (ADEC 2013a). ADEC has approved 269 pesticides for use in Alaska (ADEC 2013b). DOT&PF's guidance for herbicide use is provided in an *Integrated Vegetation Management Plan* (DOT&PF 2013). Three herbicides proposed for use in the IVMP include Glyphosate, Imazapyr, and Triclopyr. Products containing Glyphosate and/or Imazapyr are available and registered for use in and near aquatic systems where impacts to salmon could be a concern. An environmental assessment was published recently that addresses the use of herbicides within the City and Borough of Juneau (USFWS 2013) and contains detailed information about herbicides, toxicity, and applications. Herbicides have been used effectively on several species in southeast Alaska (Seefeldt and Conn 2011, USFWS 2013) and offer one of the most effective alternatives of an integrated control strategy.

5.3.4 Biocontrol

Controlling invasive species with other living organisms, i.e., biocontrol, offers great potential as a long term management option. Biocontrol is also one of the least common methods used because of the extensive research and permitting required to ensure the control species does not become a pest. A petition to release a sap-sucking insect (*Aphalara itadori*) into North America to control the invasive knotweeds is currently in review (Andreas 2013). The species has recently been released in England but its effectiveness there has yet to be determined (Royal Horticultural Society 2013).

No reports on the use of biocontrol agents in Alaska were uncovered during this project. Biocontrol may prove to be a viable method of controlling some invasive species in the future; however, due to the extensive amount of research and permitting required to establish a program, biocontrol is unlikely to be a practical control measure in southeast Alaska at this time.

6.0 Summary

Information from over 130 sources was reviewed during the research summarized in this report. The results indicate species-specific guidelines regarding disposal of invasive plant materials is often lacking for the 37 species listed in Table 1.1. Since the non-specific disposal method currently used by the Alaska DOT&PF Southeast Region (burial under 6 feet of soil) is often impractical, there is a clear benefit to minimizing the biomass requiring disposal during construction activities. This may be achieved by continuing to use best management practices to inhibit the spread of invasive species and by actively controlling infestations in areas where project activities are planned. Protocols and additional resources applicable to prevention and

control of invasive species, including reference to a new manual for preventing the spread of invasive species (not yet published) and to new developments in herbicide laws, have been described in this report.

Two disposal methods, incineration to ash and burial, have been highlighted during this work. Incineration to ash is a highly effective disposal method that works on all plant species and requires no additional monitoring plan. Resources for information on incineration to ash are provided in Section 5.2.3. Burial of plant matter is commonly used by practitioners, but is generally considered effective at intermediate depths only when coupled with a monitoring program and a commitment to eradicate any re-sprouts. Species-specific recommendations for effective burial depths are scarce, perhaps due to the influence of variations in site conditions and rhizome condition on the ability of individual species to emerge after burial. Species-specific recommendations for field trial burial depths have been developed in this report, however, following an analysis of relevant life history traits noted during the research portion of this project (Table D.2, Appendix D).

Future efforts might focus on developing strategies for minimization of biomass requiring disposal at project sites, research into incinerators, and/or designing and conducting field trials to establish species-specific minimum burial depths.

7.0 Literature Cited

NOTE: Bolded numbers in ( ) cross reference to Appendix D, Table D.2 Annotated Bibliography of Sources cited in Invasive Species Disposal Matrix Table A.1, Appendix A & Invasive Species Control Matrix Table B.1, Appendix B.

AKEPIC (2013). Alaska Exotic Plant Information Clearinghouse database (http://aknhp.uaa.alaska.edu/maps/akepic/). Alaska Natural Heritage Program, University of Alaska, Anchorage. (October 24, 2013).

Alaska Department of Environmental Conservation. 2013a. Division of Environmental Health Pesticide Control Program. http://dec.alaska.gov/eh/pest/ (October 15, 2013).

Alaska Department of Environmental Conservation. 2013b. Alaska Department of Environmental Conservation Pesticide Control Program. http://www.kellysolutions.com/ak/pesticideindex.htm (October 15, 2013).

Alaska Department of Natural Resources. 2007. Prohibited & Restricted Noxious weeds. http://dnr.alaska.gov/ag/akpmc/invasives/noxious-weeds.htm (October 14, 2013).

Alaska Department of Transportation and Public Facilities. 2014. Southeast Alaska Invasive Species Management / Matrix for Transportation Projects. Preliminary Draft. Comments January 2014.

Alaska Department of Transportation and Public Facilities. 2013. Integrated Vegetation Management Plan for the Alaska Department of Transportation and Public Facilities. Prepared for the DOT&PF, Juneau, Alaska by Shannon and Wilson, Inc. Seattle, Washington. http://dec.alaska.gov/eh/docs/pest/PermitsIPMs/ADOT&PF%20IVMP%20(June%202013).pdf

Alaska Natural Heritage Program. March 11, 2010. Tracking weeds along the Iditarod National Historic Trail. Available at: http://aknhp.uaa.alaska.edu/wp-content/uploads/2010/11/Flagstad_Cortés_2010.pdf (October 8, 2013) **(20)**

Alberta Invasive Plants Council. Invasive alien species: creeping bellflower (*Campanula rapunculoides*). Available at: https://www.invasiveplants.ab.ca/factsheets/FS-CreepingBellflower.pdf (October 25, 2013) **(77)**

Andreas, Jennifer. 2013. Washington State University Cooperative Extension. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Roadside weed disposal in Washington. October 16.

Asgharipour, M R. 2011. Effects of planting depth on germination and the emergence of field bindweed (*Convolvulus arvensis* L.). Asian Journal of Agricultural Sciences 3(6):459-461. Available at: http://maxwellsci.com/print/ajas/v3-459-461.pdf (October 22, 2013) **(64)**

Barker, A.V., and R.G. Prostak. 2008. Herbicide Alternatives Research. Prepared for the Executive Office of Transportation and Public Works, Boston, MA. Prepared by: Plant Soil and Insect Sciences Univ of Mass. Available at: http://www.mhd.state.ma.us/downloads/vmp/Herbicide_Alternatives.pdf (September 7,2013) **(31)**

Barnett, John. C. 2013. Acting Regional Environmental Manager DOT&PF Southeast Region. Telephone conversation with KC Rains, 3PPI, Inc. Subject: Invasive Species Management Plan/Matrix. August 21.

Beaulieu, D. 2013. Tips from Japanese knotweed specialists: Removal of "Fleeceflower". http://landscaping.about.com/od/weedsdiseases/a/fleeceflower.htm (October 16, 2013).

Bockness, Scott. 2013. Center for Invasive Species Management. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Disposal of weed waste, weed infested soil and the use of geotextiles. October 21.

Bossard, C.C., J.M. Randall, and M.C. Hoshovsky, Editors. 2000. Invasive plants of California's wildlands. University of California Press. Berkeley, California, USA. Available at: http://www.cal-ipc.org/ip/management/ipcw/online.php (September 27, 2013) **(1)**

Boulet, Normand. 2013. Municipal District of Smoky River Number 130, Falher, Alberta. Telephone conversation with Clint Cooper, 3PPI, Inc. Subject: Invasive species disposal and management, incineration of plant materials, November 7.

British Columbia Ministry of Agriculture. No Date. Weed management. Available at: http://www.agf.gov.bc.ca/cropprot/weeds.htm#IWM (October 8, 2013) **(32)**

Brown, Blythe. 2013. Kodiak Soil and Water Conservation District. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Invasive species management and disposal on Kodiak. October 28.

California Department of Food and Agriculture. Plant Health and Pest Prevention Services. Integrated Pest Control. Available at: http://www.cdfa.ca.gov/plant/ipc/weedinfo/winfo_table-sciname.htm (October 22, 2013) **(42)**

Carlson, M., I. Lapina, M. Shephard, J. Conn, R. Densmore, P. Spencer, J. Heys, J. Riley, and J. Nielsen. 2008. Invasiveness Ranking System for Non-Native Plants of Alaska. Alaska Region, Forest Service, U.S. Department of Agriculture. R10-TP-143. 218 p.

Caswell, Patti. 2013. Oregon Department of Transportation. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Roadside weed disposal and control by Oregon Department of Transportation. October 16.

Chippindale H.G. and W.E.J Milton 1934. On the viable seeds present in the soil beneath pastures. Journal of Ecology Vol. 22: 508-531.

City of Calgary. 2013. Creeping bellflower. Available at: http://www.calgary.ca/CSPS/Parks/Pages/Planning-and-Operations/Pest-Management/Creeping-bellflower.aspx (October 25, 2013) **(76)**

Clark, J.C. 2003. Invasive Plant Prevention Guidelines. Center for Invasive Plant Management, Bozeman, MT. Available at: http://www.weedcenter.org/store/docs/CIPM_prevention.pdf (September 15, 2013) **(30)**

Colorado Department of Agriculture. 2008. Oxeye daisy identification and management. Colorado Department of Agriculture, Conservation Services Division. Lakewood, CO, USA. Available at: http://www.colorado.gov/cs/Satellite?blobcol=urldata&blobheader=application%2Fpdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1191397772841&ssbinary=true (October 17, 2013) **(45)**

Colorado State Parks. 2005. Colorado State Parks; BMPs; weed profile whitetop/hoary cress (Cardaria draba). Available at: http://parks.state.co.us/SiteCollectionImages/parks/Programs/ParksResourceStewardship/Whitetop.pdf (October 4, 2013). **(18)**

Colorado Weed Management Association. Noxious weed information. Available at: http://www.cwma.org/noxweeds.html#list (October 18, 2013) **(71)**

Connecticut Department of Energy and Environmental Protection and University of Connecticut. 2011. Guidelines for disposal of terrestrial invasive plants. Available at: http://www.hort.uconn.edu/CIPWG/pdfs/Invasive_plant_disposal_guide_8-2011.pdf (October 1, 2013) **(4)**

Cooperative Extension Service, University of Alaska Fairbanks. Noxious weed identification and prevention. FGV-00144. 2006. Available at: http://uaf.edu/files/ces/aiswg/resources/FGV-00144-noxiousweed-IDprevention.pdf (October 23, 2013) **(69)**

Cortés-Burns, H., and L. Flagstad. 2013. Non-native plant management plan for Campbell Tract, Anchorage, Alaska. Prepared for the Bureau of Land Management-Anchorage Field Office. Alaska Natural Heritage Program, University of Alaska, Anchorage, AK. 74 pp. **(80)**

Cortés-Burns, H., and L. A. Flagstad. 2010. Invasive plant inventory and bird cherry control trials. The Alaska Natural Heritage Program, University of Alaska Anchorage. Available at: http://anchoragecreeks.org/media/publications/Final%20Bird%20Cherry%20Report.pdf (October 23, 2013) **(68)**

Cortés-Burns, H., T. Nawrocki, E. Johnson, and D. Collet. Unalakleet wild river invasive plant management plan. 2011. The Alaska Natural Heritage Program, University of Alaska Anchorage. Available at: http://aknhp.uaa.alaska.edu/big-files/Botany/Publications/2011/Unalakleet_Wild_River_Invasive_Plant_Management_Plan.pdf (October 23, 2013) **(66)**

Crop Compendium: Weeds. Bayer CropScience, Global Internet Portal. 2012. Available at: http://www.cropscience.bayer.com/en/Crop-Compendium/Pests-Diseases-Weeds/Weeds.aspx (October 23, 2013) **(67)**

Czernick, Greg. 2013. British Columbia Ministry of Transportation and Infrastructure. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Invasive species control and disposal by BC MOT&I. October 10.

Devon County Council, United Kingdom. Japanese knotweed advice for developers and haulers. Available at: http://www.devon.gov.uk/index/environmentplanning/natural_environment/biodiversity/japanese_knotweed/advice_dev_and_haul.htm (October 10, 2013) **(36)**

Donaldson, S. and G. Bowers. Weed Identification and Control Guide. Educational Bulletin 98-01. University of Nevada Cooperative Extension. 32 pp. Available at: http://www.unce.unr.edu/publications/files/nr/other/eb9801.pdf (October 2, 2013) **(11)**

Donaldson, S., and W. Hanson Mazet. 2011. University of Nevada Cooperative Extension. A Northern Nevada Homeowner's Guide to Identifying and Managing Western Salsify.

Available at: http://www.unce.unr.edu/publications/files/ho/2011/fs1162.pdf (October 9, 2013). **(26)**

Door County Soil and Water Conservation Department and Door County Invasive Species Team. Compost with care: how to dispose of invasive plants responsibly. Available at: http://map.co.door.wi.us/swcd/invasive/Get%20EDUCATED_files/Compost.pdf (October 17, 2013) **(54)**

Duval, J. 2006. Controlling Quackgrass. Available at: http://www.cog.ca/documents/ControlQuackgrassSU06.pdf (October 4, 2013) **(29)**

Environment Agency. 2013. Japanese knotweed. http://www.environment-agency.gov.uk/homeandleisure/wildlife/130079.aspx United Kingdom (November 5). **(79)**

Federal Register. 1999. Executive Order 13112 of February 3 1999, Invasive Species. Vol. 64, Number 25. Monday, February 8, 1999. http://www.gpo.gov/fdsys/pkg/FR-1999-02-08/pdf/99-3184.pdf (October 14, 2013)

Francis, R.A., K.A. Riley, and S.P.G Hoggart 2008. Vegetative regeneration of *Fallopia japonica* (Houtt.) Ronse Decraene (Japanese knotweed) at varying burial depths. Weed Biology and Management 8: 69-72 **(85)**

Garry Oak Ecosystems Recovery Team. 2013. Field manual: Invasive species in Garry Oak and associated ecosystems in BC. Available at: http://www.goert.ca/publications_resources/invasive_species.php#GDP (October 22, 2013) **(49)**

Graziano, Gino. 2013. University of Alaska Fairbanks Cooperative Extension Service. Personal communication with JD Mason, 3PPI, Inc. Subject: Best management practices for controlling the spread of invasive plants during road maintenance. November 20.

Graziano, G., A. Grant, and T. Wurtz, Trish. 2012. University of Alaska Fairbanks Cooperative Extension Service. Control of bird vetch (*Vicia cracca*). September. Available at: 7http://www.uaf.edu/files/ces/publications-db/catalog/anr/PMC-00341.pdf (October 9, 2013) **(25)**

Gronquist, Ruth. 2013. U.S. Bureau of Land Management. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Invasive species management and disposal. October 28.

Grundy, A.C., J.M. Green, B. Bond, S. Burston, and M. Lennartsson. 1998. The development of methods to determine weed seed contamination in municipal composts. Acta Hort. (ISHS) 469:179-186 http://www.actahort.org/books/469/469_17.htm

Gustavsson, A.D. 1997. Growth and regenerative capacity of plants of *Cirsium arvense*. Weed Research Volume 37: 229-236 **(86)**

Hilty, J. 2012. Weedy Wildflowers of Illinois Available at: http://www.illinoiswildflowers.info/weeds/weed_index.htm (February 10, 2014). **(84)**

Holland, Emilie. 2013. Rhode Island Department of Transportation. Telephone conversation with M Shaffer, 3PPI, Inc. Subject: Roadside weed disposal and control in RI. October 23.

Homer and Kenai Soil and Water Conservation Districts. 2007. Managing invasive plants in wetlands of the Kenai Peninsula: developing a management program for reed canary grass infestations. FY 2007 Progress Summary. Available at: http://www.homerswcd.org/invasives/FY07RCGsummary.pdf (October 3, 2013). **(12)**

Invasive Species Specialist Group. Global Invasive Species Database. Available at: http://www.issg.org/database/welcome/ (October 23, 2013). **(72)**

Johnson, Phil. 2013. Montana Department of Transportation. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Invasive species management and disposal in Montana. November 13.

Kagima, D. 2000. Bibliography and biology outline of *Galinsoga* spp. April. Available at: http://agron-www.agron.iastate.edu/~weeds/weedbiollibrary/517%20student%20pages/2000/Galinsogad.htm (October 16, 2013) **(52)**

Kansas Department of Agriculture. 2006. Plant protection and weed control – Quackgrass. Available at: http://www.ksda.gov/plant_protection/content/349/cid/583 (October 4, 2013) **(27)**

King County Noxious Weed Control Program. 2007. King county noxious weed control program weed alert: field bindweed (aka morning glory) (*Convolvulus arvensis*). King County Department of Natural Resources and Parks, Water and Land Resources Division, Noxious Weed Control Program. Available at: http://your.kingcounty.gov/dnrp/library/water-and-land/weeds/Brochures/Bindweed_factsheet.pdf (September 27, 2013) **(3)**

King County Noxious Weed Control Program. 2013. Noxious weeds; weed identification photos; index for identification and control of noxious weeds. Available at: http://www.kingcounty.gov/environment/animalsAndPlants/noxious-weeds/weed-identification.aspx (October 1, 2013) **(5)**

Klein, H., C. Greenstein, M. Phelps, L. Flagstad, H. Cortés-Burns, and M. Carlson. 2012. Municipality of Anchorage Non-native Plant Survey: a survey of non-native plants along major and secondary roads in the Municipality of Anchorage, Alaska. Prepared for the Anchorage Park Foundation and Municipality of Anchorage. Alaska Natural Heritage Program, University of Alaska Anchorage, AK. 144 pp. **(81)**

Kraft, Julie. 2013. Sublette County, WY Weed and Pest District. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Roadside weed disposal and control in WY. October 16.

Lackey, Will. 2013. Oregon Department of Transportation. Telephone conversation with JD Mason, 3PPI, Inc. Subject: ODOT weed management and disposal in OR. October 17.

Lancaster City Council. 2013. Home composting. Available at: https://www.lancaster.gov.uk/community-and-living/sustainable-living/the-great-outdoors/home-composting-advice/ (October 24, 2013) **(46)**

Lendrum, David. 2013. University of Alaska Southeast. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Invasive species control and disposal on the UAS campus. October 10.

Li X, Shen Y, Huang Q, Fan Z, Huang D (2013) Regeneration Capacity of Small Clonal Fragments of the Invasive *Mikania micrantha* H.B.K.: Effects of Burial Depth and Stolon Internode Length. PLoS ONE 8(12): e84657. doi:10.1371/journal.pone.0084657

Maupin, Brian. 2013. Alaska Association of Conservation Districts. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Invasive species disposal and management in southeast Alaska. October 9 and 10. **(37)**

Messersmith, C.G., R.G. Lym, and D.S. Galitz. 1985. Biology of leafy spurge in Watson, A.K. Ed. Leafy spurge, monograph series of the Weed Society of America. Weed Science Society of America. Available at: http://wssa.net/ pp 42-56. Available at: http://lib.ndsu.nodak.edu/repository/bitstream/handle/10365/3196/475MES85.pdf?sequence=1 (October 17, 2013) **(57)**

Michigan State University Extension. 2009. An Identification Guide to Invasive Plants in Michigan's Natural Communities. December. Available at: http://mnfi.anr.msu.edu/invasive-species/InvasivePlantsFieldGuide.pdf (October 8, 2013) **(21)**

Miller, Tim. 2013. Washington State University. Webinar sponsored by UAF Cooperative Extension. Subject: Knotweed Control, November 20, 2013. Presentation posted at: http://www.uaf.edu/ces/pests/cnipm/k12/webinars/ **(83)**

Minnesota Department of Agriculture. A guide to removal and disposal of noxious weeds in Minnesota. Available at: http://www.mda.state.mn.us/en/plants/pestmanagement/weedcontrol/disposalnoxweed.aspx (February 12, 2014).

Minnesota Department of Natural Resources factsheets. Available at: http://www.dnr.state.mn.us/invasives/terrestrialplants/ (October 3, 2013). **(16)**

Minnesota Department of Transportation. 2013. Minnesota noxious weeds. Available at: http://www.dot.state.mn.us/roadsides/vegetation/pdf/noxiousweeds.pdf (October 8, 2013) **(35)**

Montana State University Cooperative Extension. 2013. Narrow leaf Hawk's beard (*Crepis tectorum*). July. Available at: http://www.msuextension.org/invasiveplantsMangold/documents/Weed_Posts/2013/post/narrowleaf_hawksbeard_July.pdf (October 3, 2013) **(19)**

Montana State University Extension. Weeds. Available at: http://store.msuextension.org/Departments/Agriculture-Topic-Categories/Weeds.aspx (October 24, 2013) **(61)**

National Roads Authority. 2010. The management of noxious weeds and non-native invasive plant species on national roads. National Roads Authority. Available at: http://www.nra.ie/environment/environmental-construction-guidelines/Management-of-Noxious-Weeds-and-Non-Native-Invasive-Plant-Species-on-National-Road-Schemes.pdf (October 22, 2013) **(6)**

Natural Resources Conservation Service. NRCS plants database, fact sheets and plant guides. Available at: http://plants.usda.gov/ (October 18, 2013) **(70)**

Nawrocki, T., H. Klein, M. Carlson, L. Flagstad, J. Conn, R. DeVelice, A. Grant, G. Graziano, B. Million, and W. Rapp. 2011. Invasiveness Ranking of 50 Non-Native Plant Species for Alaska. Report prepared for the Alaska Association of Conservation Districts. Alaska Natural Heritage Program, University of Alaska Anchorage, Anchorage, AK. 253 pp.

Nevada Department of Agriculture noxious weed program. Horsenettle (*Solanum carolinense*). Available at: http://agri.nv.gov/Noxious_Weed-Horsenettle/ (October 2, 2013) **(8)**

New Hampshire Department of Transportation. 2008. BMPs for roadside invasive plants. Available at:

http://www.fws.gov/northeast/cpwn/pdf/activities/InvasiveSpecies/BMPsforRoadsideInvasivePlantsNH.pdf (October 23, 2013). **(13)**

Nice, G. 2007. Japanese knotweed in Indiana. Available at: https://ag.purdue.edu/btny/weedscience/documents/japaneseknotweed07.pdf (October 11, 2013) **(38)**

Nickelson, Sally. 2013. Cedar River Municipal Watershed, Seattle Public Utilities. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Use of geotextiles to control invasive species. October 17 and 23. **(82)**

Nuzzo V., G. Fell, and J. Kennay. 2013. Vegetation Management Guideline Garlic Mustard. Illinois Natural History Survey. Available at: http://wwx.inhs.illinois.edu/research/vmg/gmustard/ (October 16, 2013) **(55)**

Oregon State University Rangeland Ecology and Management. 2005. Foxtail barley (*Hordeum jubatum L*.). Available at: http://oregonstate.edu/dept/range/sites/default/files/Foxtail_20Barley.pdf (October 18, 2013) **(58)**

Peninsula Clarion. Weekly Weeder "Narrowleaf hawksbeard (*Crepis tectorum*)" 2007. Available at: http://peninsulaclarion.com/stories/071307/outdoors_2948.shtml (October 23, 2013) **(65)**

Penn State Extension. Weed Identification. 2013. Available at: http://extension.psu.edu/pests/weeds/weed-id (October 23, 2013) **(74)**

Penn State University College of Agricultural Sciences Agricultural Research and Cooperative Extension. Quackgrass Management: An Integrated Approach. Available at: http://pubs.cas.psu.edu/freepubs/pdfs/uc041.pdf (October 9, 2013) **(24)**

Pyle C. 2006 Invader of the month - Garlic Mustard - *Alliara petiolata* (Bieb.) Cavara & Grande. Connecticut Invasive Plant Working Group. Available at: http://www.hort.uconn.edu/cipwg/invader_month/invader_of_the_month_Mar06_alliaria.pdf **(89)**

Raleigh, S. M., T. R. Flanagan, and C. Veatch. 1962. Life history studies as related to weed control in the Northeast. Number 4 – Quackgrass. Agricultural Experiment Station, University of Rhode Island, Kingston. Available at: http://www.caf.wvu.edu/~forage/library/forglvst/bulletins/bul365.pdf (October 4, 2013) **(28)**

Randles, Pam. 2013. Takshanuk Watershed Council. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Invasive species management and disposal in Haines, AK. November 12.

Ristau, R. J. 1994. Foxtail barley: biology and management. Colorado State Cooperative Extension. No. 3.109. Available at: http://www.co.laplata.co.us/sites/default/files/departments/weed/documents/education/Foxtailbarleymgmt.pdf (October 18, 2013) **(59)**

Royal Horticulture Society. 2013. Japanese knotweed. http://apps.rhs.org.uk/advicesearch/profile.aspx?pid=218 (October 11, 2013). **(39)**

Rutledge, C. R., and T. McLendon. 1996. An Assessment of Exotic Plant Species of Rocky Mountain National Park. Department of Rangeland Ecosystem Science, Colorado State

University. Jamestown, ND: Northern Prairie Wildlife Research Center Online. Available at: http://www.npwrc.usgs.gov/resource/plants/explant/index.htm (October 23, 2013). **(15)**

Salisbury, Sandy. 2013. Washington State Department of Transportation. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Invasive species control and disposal by WSDOT. October 10.

Sciegienka, J.K, E.N Keren, and F.D. Menalled 2011. Impact of root fragment dimension, weight, burial depth, and water regime on *Cirsium arvense* emergence and growth **(87)**

Seefeldt, S. S., and J. S. Conn. 2011. Control of orange hawkweed (*Heracium aurantiacum*) in Southern Alaska. Invasive Plant Science and Management 4: 87-94.

Shippey, Michael. 2013. Oregon Department of Transportation. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Roadside weed disposal and control by ODOT. October 16.

Skagway Public Works Department. 2013. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Invasive species disposal and the Skagway city incinerator. November 12.

Smayda Environmental Associates, Inc. 2009. Noxious Weed Management Plan for the Henry M. Jackson Hydroelectric Project (FERC No. 2157) Prepared for the PUD No 1 of Snohomish County, Everett, WA. Available at: http://www.snopud.com/Site/Content/Documents/relicensing/License/NWMP.pdf **(88)**

Soll, J. 2004. Controlling knotweed in the Pacific Northwest. Available at: http://www.invasive.org/gist/moredocs/polspp01.pdf (October 14, 2013) **(40)**

Southeast Exotic Pest Plant Council. Yellow and white sweet clover *Melilotus officinalis* and *Melilotus alba*. Available at: http://www.se-eppc.org/pubs/musk_clover_treatment.pdf (October 2, 2013) **(9)**

Taylor, K., F. Pollnac, T. Brummer, J. Mangold, and L. J. Rew. 2011. Washing vehicles to prevent weed seed dispersal. Montana State University Cooperative Extension. Montguide number MT201106AG.

Toole E.H. and E. Brown. 1946 Final results of the Duvel buried seed experiment. Journal of Agricultural Research Vol 27:201-210 **(92).**

Tu, M., C. Hurd, and J. M. Randall. 2001. The Global Invasive Species Team: Weed Control Methods Handbook. The Nature Conservancy. Available at: http://www.invasive.org/gist/handbook.html (September 10, 2013) **(2)**

University of Alaska Anchorage. Alaska Natural Heritage Program. Alaska Exotic Plants Information Clearinghouse. 2013. Available at: http://aknhp.uaa.alaska.edu/botany/akepic/non-native-plant-species-list/#content (October 24, 2013). **(44)**

University of California Agriculture and Natural Resources. UC Integrated Pest Management Program. 2011. Available at: http://www.ipm.ucdavis.edu/PMG/menu.weeds.html (October 22, 2013) **(41)**

University of California Cooperative Extension and Agricultural Experiment Station. 2013. Weed Research and Information Center, weeds in natural areas. Available at: http://wric.ucdavis.edu/information/crop/natural_areas_common_C.htm (October 22, 2013) **(10)**

University of Nevada Cooperative Extension. Managing Austrian fieldcress. University of Nevada Cooperative Extension. Factsheet 04-11. Available at: http://www.unce.unr.edu/publications/files/nr/2004/FS0411.pdf (October 24, 2013) **(43)**

University of Nevada Cooperative Extension. Oxeye daisy. Nevada weeds project factsheet 06-23. Available at: http://www.unce.unr.edu/publications/files/ag/2006/fs0623.pdf (October 17, 2013) **(47)**

University of Nevada Reno Cooperative Extension. Leafy spurge. Nevada weeds project factsheet 98-68. Available at: http://www.unce.unr.edu/publications/files/ho/other/fs9868.pdf (October 16, 2013) **(56)**

University of New Hampshire Cooperative Extension. 2010. Methods for disposing non-native invasive plants. Available at: http://extension.unh.edu/resources/files/Resource000988_Rep1720.pdf (October 17, 2013) **(53)**

University of Wyoming Cooperative Extension Service. 2006. Weed alert: Austrian fieldcress or Austrian yellowcress (*Rorippa austriaca*) synonym: (*Nasturtium austriacum*). Available at: http://www.uwyo.edu/capsweb/_files/docs/pest-alerts/weed-alert-austrian-fieldcress.pdf (October 24, 2013) **(23)**

Upadhyaya, M. K., M. Q. Qi, N. H. Furness, and R. S. Cranston. 1993. Meadow salsify and western salsify-two rangeland weeds of British Columbia. Rangelands 15: 148-150. Available at: https://journals.uair.arizona.edu/index.php/rangelands (October 24, 2013) **(51)**

U. S. Department of Agriculture. 1970. Common Weeds of the United States Agricultural Research Service. Illustrations are available through the Robert W. Freckmann Herbarium website http://wisplants.uwsp.edu/scripts/detail.asp?SpCode=LACPUL

U.S. Department of Agriculture Forest Service, Forest Health Staff. 2006. Weed of the week: whitetop Cardaria draba. U.S. Department of Agriculture Forest Service, Forest Health Staff, Newtown Square, PA. Available at: http://na.fs.fed.us/fhp/invasive_plants/weeds/whitetop.pdf. (October 23, 2013) **(17)**

U.S. Department of Agriculture Forest Service, Forest Health Staff. 2005. Weed of the week: quackgrass Elymus repens. U.S. Department of Agriculture Forest Service, Forest Health Staff, Newtown Square, PA. Available at: http://na.fs.fed.us/fhp/invasive_plants/weeds/quackgrass.pdf (October 23, 2013) **(22)**

U.S. Department of Agriculture Forest Service. 2007. Invasive plant treatment guide-summer home lots. Available at: https://fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_036467.doc (October 25, 2013) **(78)**

U.S. Department of Agriculture Forest Service. 2012. Field guide for managing Russian Knapweed in the southwest. U.S. Department of Agriculture Forest Service Southwestern Region TP-R3-16-13. Available at: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5410125.pdf (October 22, 2013) **(48)**

U.S. Department of Agriculture Forest Service. 2012. Field guide for managing annual and biennial invasive thistles in the southwest. U.S. Department of Agriculture Forest Service Southwestern Region TP-R3-16-8. Available at:

http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5410130.pdf (October 15, 2013) **(50)**

U.S. Department of Agriculture Forest Service. Dangerous travelers: controlling invasive plants along America's roadways. Available at: http://www.fs.fed.us/invasivespecies/prevention/dangeroustravelers.shtml (October 8, 2013) **(34)**

U.S. Department of Agriculture Forest Service. Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available at: http://www.fs.fed.us/database/feis/plants/ (October 8, 2013) **(33)**

U.S. Geological Survey Northern Prairie Wildlife Research Center. 2013. Native wildflowers of the North Dakota grasslands. Available at: http://www.npwrc.usgs.gov/resource/plants/wildflwr/species/lactoblo.htm (October 24, 2013). **(75)**

U.S. Fish and Wildlife Service. 2013. Environmental Assessment: Integrated Pest Management of Invasive Plants in the City and Borough of Juneau. 95p.

Verna, Danielle. 2013. Copper River Watershed Project. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Invasive species management and disposal in Cordova, AK. October 28.

Washington State Department of Transportation. 2013. Construction Specifications, Amendments, and General Special Provisions. http://www.wsdot.wa.gov/Business/Construction/SpecificationsAmendmentsGSPs.htm (October 23, 2013).

Washington State Noxious Weed Control Board. 2010. Home page Washington State Noxious Weed Control Board. Available at: http://www.nwcb.wa.gov/default.asp (October 1, 2013) **(7)**

Washington State Department of Transportation. 2013. Construction Specifications, Amendments, and General Special Provisions. http://www.wsdot.wa.gov/Business/Construction/SpecificationsAmendmentsGSPs.htm (October 23, 2013).

Willard, Ray. 2013. Washington State Department of Transportation. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Invasive species disposal in Washington state. October 9.

Whatcom County Noxious Weed Board. Whatcom County Noxious Weed Fact Sheets. Available at: http://www.co.whatcom.wa.us/publicworks/weeds/factsheets.jsp (October 18, 2013) **(60)**

Wiese, A. F., J. M. Sweeten, B. W. Bean, C. D. Salisbury, and E. W. Chenault. 1998. High temperature composting of cattle feedlot manure kills weed seeds. American Society of Agricultural Engineers Vol. 14(4): 377-380. Available at: http://amarillo.tamu.edu/files/2010/11/bean6_High-Temperature-Composting.pdf (October 22, 2013) **(63)**

Winter, Genelle. 2013. Metlakatla Indian Community. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Invasive species control and disposal on Annette Island. October 9.

Wisconsin Department of Natural Resources. Terrestrial invasive species-regulated plants. Available at: http://dnr.wi.gov/topic/Invasives/species.asp?filterBy=Terrestrial&filterVal=Y&catVal=PlantsReg#RegSelect (October 3, 2013). **(14)**

Wisconsin Reed Canary Grass Management Working Group. 2009. Reed canary grass (Phalaris arundinacea) management guide: recommendations for landowners and restoration professionals. U.S. Department of Agriculture Cooperative State Research, Education, and Extension Service PUB-FR-428 2009. Available at: ftp://ftp-fc.sc.egov.usda.gov/WA/Tech/RCG_management_0509.pdf (October 23, 2013). **(73)**

Appendices

Appendix A: Invasive Species Disposal

Appendix B: Invasive Species Control

Appendix C: Invasive Species Project Plant List

Appendix D: Project Contacts Summary & Bibliography

Appendix A
Invasive Species Disposal

Table A.1 Invasive Species Disposal Matrix

NOTE: Numbers in ( ) cross reference to Section 7.0 Literature Cited and Appendix D.2 Annotated Bibliography

Table A.1
Invasive Species Disposal Matrix[1]

Species	Invasive Species Disposal Methods				Rooting Depth/Excavation Depth	Reproduction	Burial Depth Summary and Suggested Field Tests [1]
	General Disposal Information	Burning / Incineration[2]	Burial/Burial Depth	Composting			
Prohibited Noxious Weeds							
Russian knapweed *Acroptilon repens*	Plant material can be disposed of by burning or by bagging and transferring to a landfill (48).	Plant may be incinerated (48). Above ground biomass can be killed by prescribed fire but the extensive below ground root system would likely survive and resprout (33).	Roots up to 16 inches long can be killed by capping with 12 inches of soil (33).	Non-flowering plants can be mowed and composted (5).	Roots can grow up to 23 feet deep (33).	Roots can extend radially from the base and cover 126 sq. feet. Reproduces to a lesser degree by seeds and a much greater degree by roots which form buds that develop into independent plants. Seed viability is reported as 2-3 years but has been as long as 9 (33).	Chop excavated roots to sizes less than 16 inches and bury aboveground plant material, root fragments and infested soil below a moderate amount (e.g., 24 inches) of weed–free soil.
Whitetops and its varieties *Cardaria draba, C. pubescens, Lepidium latifolium*	No information found.	Plant material can be burned for disposal (17).	No information found on burial depth for rhizomes. Seed germination is reduced if buried (1). Deeply buried seeds are unlikely to germinate (33).	Prior to flowering, plants can be composted (53).	Roots are rhizome-like and can grow up to 3 feet deep and up to 6 feet horizontally (1). Roots can easily resprout (33). Roots have been found more than 9 feet deep (33). Roots must be removed to a depth of > 20 inches below the soil surface to avoid regeneration (1). They may spread horizontally from depths down to 32 inches (18).	*C. draba* reproduces by seed and creeping roots. Buried seeds can remain viable for three years (18).	Field test[1]: Bury plant and infested soil below a moderate to deep amount (e.g., 36 inches) of weed–free soil.
Canada thistle *Cirsium arvense*	Plants have extensive roots and reproduce rhizomatously. Care should be taken in disposing of vegetative and root material (1)(4).	Plant material may be bagged and incinerated (80).	When plants have 8-10 leaves, root reserves are depleted. When plants with 8-10 leaves were buried to 8 inches, no shoots emerged (86). When leaves were not monitored and plants buried to 8 inches, average emergence rate per root was 15 percent and emergence was most successful from longer root fragments (87). Weed material may be buried deeply below a 24-inch or greater layer of weed free soil or rock fill (88)[3].	Do not compost (4).	Plant has extensive roots and reproduces by rhizomes (1)(4)(5). Root system may spread horizontally 12 ft. (11). The majority of roots occurs 8-16 inches deep, and can reach to 6 ft. deep (78). More than 50% of the root buds are within 8 inches of the soil surface (as in 87).	Reproduces by seeds, which can be viable for 20 years. Root fragments can also regenerate into plants (8). Spreads mainly by creeping rhizomes (21)(35). Seeds are tufted and may be spread by the wind (5).	Bury plant and seed-infested soil below 24 inches of weed-free soil or rock.[3]

Species	Invasive Species Disposal Methods				Rooting Depth/Excavation Depth	Reproduction	Burial Depth Summary and Suggested Field Tests [1]
	General Disposal Information	Burning / Incineration[2]	Burial/Burial Depth	Composting			
Field bindweed *Convolvulus arvensis*	Management lapses of even one year can allow species to restore original population size (42).	May be burned (3).	No information found on burial depth for rhizomes. Seeds were unable to germinate when buried to a depth of 3 inches (64).	Composting seeds takes 7 days at temperatures of 180 degrees to kill all seeds (63). Do not place in brush pile or compost pile (3).	Rooting depth can be as deep as 20 feet or more but the majority (70% by mass) of the roots are within the top 2 feet of soil (41).	Reproduces by seed and vegetatively. Lateral roots as deep as 14 feet can bud into new plants; roots and stems can regenerate. Seeds remain viable for up to 60 years (41).	Bury plants and infested soil deeply (>14 feet) under weed-free soil. Or initiate field test[1]: Since most roots are found within 24 inches of the soil surface, field trials may indicate a moderate to deep burial depth (e.g., 36 inches) is effective.
Quackgrass *Elymus repens*	No information found.	Repeated prescribed burns can be effective in the spring to control this species (42)(33). Burn regimes in the summer have been found to increase species cover (33).	Seed burial depth should be greater than 4 inches (28)(29). Rhizomes may be controlled by “deep burial” (cited as in 89).	Do not compost (46).	Rooting depth is 2-18 inches (27). Roots extend approximately 4 to 8" (10.2-20.3 cm) below surface (42).	Reproduces by seeds and rhizomes (15). Roots can extend approximately 3 feet horizontally. Rhizome tips are hard and could rip landscape fabric. Seeds are viable up to 4 years and can sprout from depths to 4 inches of soil (43) (33). Few seeds are viable after 3 years burial (92).	Field test[1]: Since most roots are found within 18 inches of the soil surface, field trials may indicate a moderate burial depth (e.g., 24 inches) is effective.
Leafy spurge *Euphorbia esula*	Plants are very hard to control (33). If plant is removed it should be dug up and all roots, shoots, and seeds should be bagged and disposed of in a landfill (56)(54).	Burning is a good option for disposing of these plant materials (54).	Root fragments have re-sprouted after this plant was buried in 35 inches of soil (57).	Do not place in brush or compost pile (4).	Roots extend up to 21 feet (35). Roots may extend 40 feet deep (11).	Reproduces by seeds, and from the root crown and root buds. (7). Reproduces from roots, rhizomes, or root cuttings. Also produces seeds, which can remain viable in soil for up to 8 years (35).	Bury plants and infested soil deeply (3 feet is insufficient) under weed-free soil. Or initiate field test[1]: Field trials may indicate a moderate to deep burial depth (e.g., 36 inches) is effective if roots are stressed prior to burial (see table note).
Hempnettle *Galeopsis tetrahit*	If pulled in flowering stage, plants should be bagged and disposed of in landfill as seeds can still mature after plants are removed (14). The two species of hempnettle treated in this report (*G. bifida* and *G. tetrahit*) are very similar, sometimes producing hybrids, and are sometimes treated as the same species (44).	No information found.	Since this plant reproduces only by seed, a burial depth sufficient to prevent seed germination should suffice.	No information found.	Fibrous taproot (32).	Reproduces by seed (20). Plant is an annual and reproduces by seed only (44)(14). Seeds may be viable for up to 14 years (44). They are spread by wind and through equipment and vehicles (32) and emerge from a depth of 0.4-1.6 inches (44).	Field test[1]: Since reproduction is by seed and seed germination generally occurs within 2 inches of the soil surface, burial of plants and infested soil under a shallow amount (e.g., 12 inches) of weed–free soil may inhibit regrowth.
Galinsoga *Galinsoga parviflora*	No information found.	No information found.	Since this plant reproduces only by seed, a burial depth sufficient to prevent seed germination should suffice.	No information found.	No information found.	Plant is an annual and continuously produces seed throughout the growing season The seeds germinate from up to 0.8 inches deep (67) and do not persist long in the soil (52). Seeds can remain viable up to 10 years (67).	Field test[1]: Since reproduction is by seed and seed germination was impacted when the soil depth was 2 inches, burial of plants and seed-infested soil under a shallow amount (e.g., 12 inches) of weed–free soil may inhibit regrowth.

Species	Invasive Species Disposal Methods				Rooting Depth/Excavation Depth	Reproduction	Burial Depth Summary and Suggested Field Tests [1]
	General Disposal Information	Burning / Incineration[2]	Burial/Burial Depth	Composting			
Orange hawkweed *Hieracium aurantiacum*	Dispose of plants and flower heads by burial or by burning or by bagging and bringing to landfill (5).	Plant material may be burned (5)(60)(7). Plant material may be bagged and incinerated (80).	Weed material may be buried deeply below a 24-inch or greater layer of weed free soil or rock fill (88)[3].	Do not compost (5).	Shallow, fibrous root system (33).	Reproduces vegetatively from stolons and rhizomes. Plants can generate from stolon fragments. Also reproduces by seed. Seeds can survive up to 7 years (10).	Bury plant and seed-infested soil below 24 inches of weed-free soil or rock.[3]
Blue-flowering lettuce *Lactuca tatarica, (L. pulchella)*	No information found.	No information found.	No information found.	No information found.	Illustrations indicate rhizomatous root branching is expected to occur within 18 inches of the soil surface (90)(62).	Plant is a perennial and reproduces by seeds and roots (69). Seeds are small (70). It has a deep taproot and extending rhizomes coming from a heavy rootcrown (75).	Field test[1]: If rhizomatous growth is most prolific above 18 inches of soil, a moderate to deep burial depth (e.g., 36 inches) under weed-free soil might be sufficient.
Purple loosestrife *Lythrum salicaria*	Flower spikes should be disposed of onsite (not specific about how to do this) or bagged and removed to an approved facility (35).	Burning is recommended (13) (54).	Acceptable to bury 3 feet below grade (13). Bury 3 feet deep in a pit lined with heavy plastic (53).	Do not place in brush or compost pile directly on the ground (4).	No information found.	Reproduces by seed and by stem fragments (7).	Bury plants and infested soil below at least 36 inches of weed–free soil, preferably in a pit lined with heavy plastic.
Austrian fieldcress *Rorippa austriaca*	Entire plant should be bagged and placed in landfill or burned (43).	Plant can be burned (43).	No information found.	No information found.	Plant has deep, fleshy taproot and extensive creeping lateral roots that produce new shoots (42)(43).	Reproduces from seeds, creeping roots, and rootstalks (7). Roots are the primary means of spread, seeds are rarely viable. New plants can grow from small root fragments (42).	Field test[1]: Examine rooting characteristics in local soils and design appropriate field test. Burial of plants and infested soil below 24-36 inches of weed–free soil may be sufficient.
Horsenettle *Solanum carolinense*	Roots do not regenerate if cut into less than 0.4 inch lengths (42).	Rooting material can be gathered, dried, and then burned (42).	Seedlings can germinate from soil depths of up to 4 inches (42). Roots can resprout from as deep as 12 inches below the soil surface and have been found to be capable of resprouting after 10 years of burial when uncovered (74).	No information found.	Tap roots can grow to 8 feet deep and can spread 4 or more feet horizontally before producing new shoots (74).	Reproduces from seeds and roots (74).	Chop all roots to sizes less than 0.4 inches and bury with a shallow layer (e.g. 12 inches) of weed-free soil or field trials may indicate a moderate burial depth (e.g., 24 inches) is effective even if roots are not fragmented.
Perennial sowthistle *Sonchus arvensis*	No information found.	No information found.	Bury root fragments at least 12 inches below soil surface to prevent resprouting (7). Rhizomes are capable of budding from depths of 24 inches (44). Seeds typically germinate from depths of less than 2.4 inches (44).	No information found.	Roots can spread up to 5 to 10 feet (16) and may resprout from depths of 24 inches (44). Vertical roots can penetrate 10 feet, but horizontal roots are generally within 4 inches of the soil surface (33).	Reproduces by seed and by creeping roots (7) Seed can remain viable for up to 6 years (44).	Field test[1]: Bury plant and infested soil below a moderate to deep (e.g., 36 inches) layer of weed-free soil.

Species	Invasive Species Disposal Methods				Rooting Depth/Excavation Depth	Reproduction	Burial Depth Summary and Suggested Field Tests [1]
	General Disposal Information	Burning / Incineration[2]	Burial/Burial Depth	Composting			
Other Invasive Plants Addressed in Study							
Garlic mustard *Alliaria petiolata*	Plants may be placed into garbage bags and taken to landfill. If in seed, carefully remove seed head and place in bag (5).	Plant may be incinerated (5). Field burning is recommended for flower heads and seedheads (21). Prescribed field burning can be useful early in the growing season due to the plant's early seed production. Only high intensity fires are effective to incinerate the seeds and roots (55).	Bury 3 feet deep in a pit lined with heavy plastic (53).	Prior to flowering, plants can be composted (53).	No information found on rooting depth. Plants may re-sprout from adventitious buds located just below the soil surface (33).	Reproduces by seed; biennial (21). Seeds remain viable in soil for at least 5 years (35) (89). Seeds are small, less than 3mm long, and abundant (up to 7,900/plant) (89).	Bury 3 feet deep in a pit lined with heavy plastic. Or initiate field test[1]: Reproductive characteristics (small seeds and vegetative reproduction only from shallow buds) indicate burial of plants and seed-infested soil under a moderate amount (e.g., 24 inches) of weed–free soil may inhibit re-growth.
Cheatgrass *Bromus tectorum*	No information found.	Prescribed burning is used to control infestations; however this is most effective before plant produces seeds. Field burning may not kill all seeds (33).	Seeds should be buried at least 6 inches to prevent germination (33). Since this plant reproduces only by seed, a burial depth sufficient to prevent seed germination should suffice.	No information found.	Roots can penetrate 34 to 60 inches. Generally rooting is concentrated in the upper 12 inches of soil, and plants may send out far-reaching lateral roots (33).	Cheatgrass is an annual plant. Reproduction is by seed only. Seeds can remain dormant in the soil for two to three years (1).	Field test[1]: Reproductive characteristics (seed reproduction only) indicate burial of plants and seed-infested soil under a shallow amount (e.g., 12 inches) of weed–free soil may inhibit re-growth.
Rampion bellflower *Campanula rapunculoides*	Dispose of all plant parts by bagging and removing to landfill (76).	No information found.	No information found on burial depth for rhizomes. Seed germination occurs in the upper one inch of soil (44).	Never compost or pile this species (76).	Excavate at least 6 inches deep and several inches horizontally from the plant to ensure all of the roots are removed (14).	Reproduces vegetatively by creeping rhizomes and by seed. Seeds are light and may be spread by wind (44).	Field test[1]: The small seeds and shallow excavation recommendation indicate active growth generally occurs in shallow soil layers and burial of plants and seed-infested soil under a shallow amount (e.g., 12 inches) of weed–free soil may inhibit re-growth.
Siberian pea shrub *Caragana arborescens*	No information found.	Repeated field burning can be effective, but plant can resprout (16).	No information found.	No information found.	Root system is dense and spreading (16).	Reproduces by seed and to a lesser extent vegetatively. The root crown is capable of generating shoots (44). How long the seed remains viable is unknown (44).	Field test[1]: Since underground shoots emerge from a shallow root crown, burial of plants and seed-infested soil under a moderate amount (e.g., 24 inches) of weed–free soil may inhibit re-growth. Effectiveness might be increased by mechanically isolating (i.e., cutting) the root crown from the resources stored in roots.

Species	Invasive Species Disposal Methods				Rooting Depth/Excavation Depth	Reproduction	Burial Depth Summary and Suggested Field Tests [1]
	General Disposal Information	Burning / Incineration[2]	Burial/Burial Depth	Composting			
Spotted knapweed *Centaurea stoebe (C. maculosa)*	Small populations may be hand pulled and removed or buried (32).	May be burned (4). Seeds can withstand field burning and still be viable (33). Field fires do not usually affect the taproot of mature plants but propane torching works on seedlings (33). Incineration is a good option for disposing of plant materials (54).	Optimum seed germination occurs at the surface. Little germination occurs below 2 inches (33). Weed material may be buried deeply below a 24-inch or greater layer of weed free soil or rock fill (88)[3].	Do not place in brush or compost pile (4)(5).	Taproots are thick and grow deep (33).	Spreads by seed only, which can germinate for up to 7 years (5). Control measures should be instituted before seed production (13). Spreads mainly by human activities. Check/clean vehicles and equipment (32). Control requires a sustained, site-specific commitment over several years (33).	Bury plant and seed-infested soil below 24 inches of weed-free soil or rock.[3] Or initiate field test[3]: Since seed germination is generally unsuccessful below 2 inches soil depth and this plant does not reproduce vegetatively, field trials may indicate a more shallow burial depth (e.g., 12 inches) would be appropriate.
Bull thistle *Cirsium vulgare*	Bag flowering plants; dispose in trash (landfill) (7). Collect flowering or seeding stems; bag and discard in landfill or controlled disposal site (5)(50). Take care with flowering/seeding plants; seeds may be spread by wind (5).	If flowers or seeds are present, debris may be piled and burned on site (50).	Weed material may be buried deeply below a 24-inch or greater layer of weed free soil or rock fill (88)[3].	Non-flowering plants can be composted (5).	No information found.	Reproduces by seed (5).Seeds are small (70). Biennial herbaceous plant. Reproduces by seeds, does not reproduce vegetatively. Colonizes disturbed areas (7).	Bury plant and seed-infested soil below 24 inches of weed-free soil or rock.[3] Or initiate field test[1]: Since seeds are small and this plant does not reproduce vegetatively, field trials may indicate a more shallow burial depth (e.g., 12 inches) would be appropriate.
Narrowleaf hawksbeard *Crepis tectorum*	Plants should be bagged and removed from site (20) (44).	May be burned (66).	Few seeds germinate when buried more than 2 inches deep (44)	Do not compost flowers or seeds as seeds can remain viable (65).	Excavation should include the shallow tap root, otherwise, it might resprout (66).	Reproduces by seed (19) and has a shallow tap root that can resprout (66).	Field test[1]: Since reproduction is by seed and seeds germination was impacted when soil depth was 2 inches, burial of plants and seed-infested soil under a shallow amount (e.g., 12 inches) of weed–free soil may inhibit regrowth.
Scotchbroom *Cytisus scoparius*	Scotchbroom produces a long lived seed bank, minimal soil disturbance is recommended to minimize germination (42).	May be chipped and incinerated on site. (5). A mild fire may cause seeds to germinate. Field fire can be used in conjunction with other control methods (33).	Seeds can germinate from up to 3 inches deep (42), but seeds buried at or great than 4 inches deep did not germinate. Coarser soil allows less seed germination than finer textured soil (33). Weed material may be buried deeply below a 24-inch or greater layer of weed free soil or rock fill (88)[3].	Do not put in waste piles, brush piles, or compost piles because the seeds will stay viable (5).	Plant has a deep, forked taproot (33).	Seeds can remain viable for many years. In one experiment, 7% of seeds were ungerminated and still viable after 3+ years (33).	Bury plant and seed-infested soil below 24 inches of weed-free soil or rock.[3] Or initiate field test[1]: Since seed germination is generally unsuccessful below 4 inches soil depth, field trials may indicate a more shallow burial depth (e.g., 12 inches) would inhibit re-growth, particularly under coarse-textured soil.

Species	Invasive Species Disposal Methods				Rooting Depth/Excavation Depth	Reproduction	Burial Depth Summary and Suggested Field Tests [1]
	General Disposal Information	Burning / Incineration[2]	Burial/Burial Depth	Composting			
Splitlip hempnettle *Galeopsis bifida*	No information found on this species, but the two species of hempnettle treated in this report (*G. bifida* and *G. tetrahit*) are very similar, sometimes producing hybrids, and are sometimes treated as the same species (44).	No information found.	Seedlings typically emerge from a depth of 0.4-1.6 inches. No specific burial information was found.	No information found.	No information found.	Plant is an annual and reproduces by seed only. Seeds may be viable up to 14 years.	Field test[1]: Since reproduction is by seed and seed germination for the closely-related species, *G. tetrahit*, is generally within 2 inches of the soil surface, burial of plants and infested soil under a shallow amount (e.g., 12 inches) of weed–free soil may inhibit regrowth.
Meadow hawkweed *Hieracium caespitosum*	Dispose of plants and flower heads by burial or by burning or by bagging and bringing to landfill (5).	Plant material may be burned (5).	No information found on burial depth for rhizomes, but seeds failed to germinate at depths greater than 1 inch (33).	Do not compost (5).	Shallow, fibrous root system (33).	Mostly reproduces vegetatively from stolons, rhizomes, and stolon fragments (10)(33). Also reproduces by seed. Seeds can survive up to 7 years (10). Reproduces from adventitious root buds.	Field test[1]: Since reproduction is generally achieved via shallow roots, burial of plants and infested soil under a shallow amount (e.g., 12 inches) of weed–free soil may inhibit regrowth.
Foxtail barley *Hordeum jubatum*	No information found.	No information found.	No information found on burial depth for rhizomes, but seeds germinate at depths of 3 inches or less (44). Burial under at least 2 inches of soil hinders seedling growth (58).	No information found.	Shallow, fibrous roots (58).	Reproduces prolifically by seed and also vegetatively by tillers (33)(58). Reproduction entirely by seed (44). Reproduces by seed and also from vegetative buds which are located on the root crown, slightly below the soil surface.	Field test[1]: Since reproduction is generally achieved via shallow roots, burial of plants and infested soil under a shallow amount (e.g., 12 inches) of weed–free soil may inhibit regrowth.
Hairy catsear *Hypochaeris radicata*	No information found.	Repeated torching can be effective but prescribed burns have had mixed results (49).	No information found, but light is required for seeds to germinate and see rooting depth notes (44)	No information found.	Deep taproots (49), but the plant does not re-sprout from root fragments that do not contain a portion of the root crown (which extends only 1 inch below soil surface) (44).	Reproduces by seed and vegetatively through crown and root sections (10), but see rooting depth notes. Seeds are small (44), easily dispersed by wind and re-infest sites, but only survive briefly in the soil (49).	Field test[1]: Since vegetative reproduction is generally achieved via shallow roots, burial of plants and seed-infested soil under a shallow amount (e.g., 12 inches) of weed–free soil may inhibit regrowth.
Ornamental jewelweed *Impatiens glandulifera*	If plants are flowering, flowers/seed heads should be cut, bagged and disposed of in landfill (5).	Should be incinerated if seeds are present (6).	No information found.	Can be composted on site on a tarp if no seeds are present (5)(6).	These are annual plants with relatively shallow roots (5). Roots extend 4-6 inches deep (72)(78).	Reproduces mainly by seeds, but also spreads vegetatively. Seeds are small (70) and viable for 18 months (5). Does not reproduce vegetatively, reproduces by seed only. Often spreads by seed-contaminated soil (72).	Field test[1]: Since reproduction is generally achieved via small seeds and shallow rhizomes, burial of plants and seed-infested soil under a shallow amount (e.g., 12 inches) of weed–free soil may inhibit regrowth.
Oxeye daisy *Leucanthemum vulgare*	Flowering plants need to be bagged and disposed of in landfill (45)(47).	Plant material may be bagged and incinerated (80).	Mulching with 3-4 inches of compacted straw laid over infested area was successful when mulch was applied at the beginning of the growing season.	No information found.	Root system is shallow (1)(7)(44)(5). One study found that plowing to a depth of greater than 6 inches (15.2 cm) was effective at killing the plants (1).	Shallow-rooted perennial plant. May spread by seed or vegetatively (44)(81) Less than 50% of seeds survive 20 years burial and less than 1% germinate after 39 years (92).	Field test[1]: Since reproduction is generally achieved via small seeds and shallow rhizomes and shallow mulch can inhibit spring growth, burial of plants and seed-infested soil under a shallow amount (e.g., 12 inches) of weed–free soil may inhibit regrowth.

Species	Invasive Species Disposal Methods				Rooting Depth/Excavation Depth	Reproduction	Burial Depth Summary and Suggested Field Tests [1]
	General Disposal Information	Burning / Incineration[2]	Burial/Burial Depth	Composting			
Common toadflax *Linaria vulgaris*	No information found.	No information found.	No information found.	No information found.	Taproots may be up to 3 feet deep. Rhizomes may be several meters long, and can form adventitious buds, which grow into new plants (71). Rhizomes are shallow (84).	Reproduction is from seed and vegetatively by creeping rhizomes. New plants can establish from small root fragments (44)(7). Seeds are small (70) and can remain dormant up to 10 years (71)(81).	Field test[3]: Since reproduction is generally achieved via small seeds and shallow rhizomes, burial of plants and seed-infested soil under a shallow amount (e.g., 12 inches) of weed–free soil may inhibit regrowth.
White sweetclover *Melilotus alba*	Plants may be burned or taken to a landfill (21).	Burn flowering plants (21). Plant material may be bagged and incinerated (80).	No information found.	No information found.	Taproot is extensive, has been measured at 5.5 feet deep. Lateral roots may be 6-8 inches (33).	Reproduction is mainly by seed. Vegetative reproduction is rare. Seedlings generally do not germinate below 2 inches. Plants may sprout again after being cut from large crown buds formed on roots (33). Seeds can stay viable in soil for 30 years (17).	Field test[1]: Since root regrowth only occurs from the shallow root crown, burial of plants and seed-infested soil under a shallow amount (e.g., 12 inches) of weed–free soil may inhibit re-growth. Effectiveness might be increased by mechanically isolating (i.e., cutting) the root crown from the resources stored in the extensive roots.
Reed canarygrass *Phalaris arundinacea*	The best methods for disposal are removing to landfill or burning (54).	Can be burned (7)(54). Plant material may be bagged and incinerated (80).	No information found.	Do not place in brush or compost pile (54).	Rhizomes occur in the upper 8 inches of soil, but roots extend deeper (33). Excavation should be used only if soil can be disposed of, as seed bank will persist in soil (73).	Reproduces by seed and by creeping rhizomes (44). Can also produce roots and grow from the nodes of freshly cut culms (5)(7). Less than 50% of seeds remain viable after 20 years burial and less than 1% after 39 years (92). Germination is best at soil surface, in lab tests few seeds germinated at depths of 0.4 and 2 inches (1 and 5.1 cm) (33). Seeds buried deeper may remain viable for up to 20 years (33)(10).	Field test[1]: Since rhizomes are mostly found within 8 inches of the soil surface, burial of plants and infested soil under a moderate amount (e.g., 24 inches) of weed–free soil may inhibit re-growth.
Japanese knotweed *Polygonum cuspidatum, P. bohemicum*	Plant material should rot if it is left in sealed plastic bags for sufficient duration (83).	Burning is recommended (13)(21)(53)(54).	Bury 16 feet deep and place geotextile fabric over (6)(79). Bury to a depth of 16 feet and cover with geotech or heavy polythene sheeting before filling (36). Burial of stem and root fragments (30 cm and 20 cm long, respectively) to 10 inches deep in sand resulted in generation of approximately three shots/fragment (85). Burial is not recommended (88). Bury 5 feet deep in a pit lined with heavy plastic (53).	Do not place in brush pile or compost pile directly on the ground (4).	Excavate to a depth of 10 feet and to a radius of 23 feet from the edge of the infestation (36).	Reproduces from stem and root fragments (5)(32), seed (13), and from long creeping rhizomes (32). Rhizomes may lie dormant for several years (83). Once exposed to light, rhizomes are stimulated to produce shoots (83). Knotweed is dioecious (38) and does not produce seed in Alaska - only one sex of the plant appears to be in the state (37). *P.cuspidatum* seedlings are rare in the Pacific NW, however *P. bohemicum* seedlings appear to be more common (40).	Treat the area with herbicides (Table C.2) and avoid soil disturbance. If soil disturbance cannot be avoided, excavate the infestation to 10 feet deep and incinerate plants and infested soil, or bury under 5 feet of weed-free soil in a pit lined with heavy plastic. Or initiate field test[1]: Field trials could test intermediate depths of burial with weed-free soil. Additional treatments, such as pre-treating plants with herbicides and irrigating plants fragments with salt water might facilitate successful field trials of shallower soil depths. See table notes.

Species	Invasive Species Disposal Methods				Rooting Depth/Excavation Depth	Reproduction	Burial Depth Summary and Suggested Field Tests [1]
	General Disposal Information	Burning / Incineration[2]	Burial/Burial Depth	Composting			
European bird cherry *Prunus padus*	No information found.	Plant material may be incinerated (80).	No information found.	No information found.	No information found.	Reproduces by seed and root resprouting (44). Seeds are viable up to 1 year (44). Cut trees must be treated with herbicide, because stumps and roots will resprout (68). Other reports suggest seeds may be viable longer than 1 year (68).	Field test[1]: Chip plants and roots into small pieces to separate root buds from resources stored in the roots. Bury chipped plant material and infested soil at moderate depths (e.g., 24 inches) under weed-free soil and monitor one year for regrowth.
Tansy ragwort *Senecio jacobaea*	Bag and dispose of plants (disposal method not specified) (32). Flower heads can be bagged and taken to a landfill (60)(6).	If plants are pulled when flowering, flower heads and buds should be burned immediately onsite to prevent spread (60)(6).	Plants buried 5 inches deep were able to re-sprout through soil (1). Weed material may be buried deeply below a 24-inch or greater layer of weed free soil or rock fill (88)[3].	Do not compost flowering plants; do not leave plants where they may be eaten by livestock (60).	Soft, fleshy roots primarily grow horizontally. Roots extend to a maximum depth of 12 inches (70).	The fibrous roots left after pulling up a plant can produce small shoots (5). Usually reproduces by seed but it can reproduce vegetatively (7)(44). Vegetative regeneration usually occurs in damaged plants. Plants can resprout from fragments of the rootstock (44)(1). Seeds can remain viable for 4-5 years (5).	Bury plant and seed-infested soil below 24 inches of weed-free soil or rock[3] Or initiate field test[1]: Intermediate depths for burial with weed-free soil, such as 18 inches may be field-tested. Additional treatments, such as pre-treating plants with herbicides and irrigating plants fragments with salt water might facilitate successful field trials of shallower soil depths. See table notes.
Common tansy *Tanacetum vulgare*	Flowering plants need to be bagged and disposed of in landfill (5)(14).	If plants are mowed or cut when in flower or seed stage they may be piled and burned (33).	No information found.	Compost non-flowering plants (5).	Roots can extend more than 51 inches in depth, but, another study found most occur within 23 inches of the soil surface (33).	Reproduces by prolific light-weight seeds, rhizomes, and rhizome fragments (35). Seeds germinate near the soil surface (33).	Field test[1]: Since most roots are found within 23 inches of the soil surface, field trials may indicate a moderate to deep burial depth with weed-free soil is effective (e.g., 36 inches).
Western salsify *Tragopogon dubius*	No information found.	No information found.	Seedlings in British Columbia did not emerge if seeds were planted deeper than 2 inches (33). Seeds buried 2 inches or deeper may germinate but did not emerge (51).	No information found.	Roots are described as stout, thick, fleshy, and long (33).	Reproduces only by seed (26)(33). This plant is not particularly aggressive (33).	Field test[1]: Since this plant reproduces only by seed, field trials may indicate burying plant material and infested soil under a shallow layer of weed-free soil (e.g., 12 inches) may inhibit re-growth.
Bird vetch *Vicia cracca*	No information found.	Plant material may be bagged and incinerated (80).	No information found.	No information found.	Taproot is up to 3 feet long (16).	Reproduces primarily by seeds but can also spread through spreading rhizomes (44). Seeds can remain viable up to 5 years (80).	Field test[1]: Seed germination and rhizome reproduction may be inhibited by moderate burial (e.g., 24 inches) under weed-free soil.

Note:

[1] The comments included this table were selected based on a scenario that ground-disturbance cannot be avoided and burial is the preferred method for plant disposal by the AKDOT SE Region. Many agencies, such as the Minnesota Department of Agriculture and Li et al. 2013, caution against disturbing the soil around rhizomatous species or burying material for disposal since either practice, if done incorrectly, may lead to an increase in infestation size. For example, if reproductive plant materials, such as seeds, resprouting stems, stolons, or rhizomes, are not buried to a sufficient depth, the buried material originating from one plant will likely produce multiple shoots. The minimum burial depth required to inhibit regrowth likely will vary with changes in site conditions, such as hydrology, soil type, temperature variation, and compaction, and will vary among species and even among ecotypes within a given species. The burial depths specified in the summary column of this table are based entirely on literature review and should be field tested before implementation. Burial depths suggested in "field tests" are occasionally deeper than might be suggested from the information in preceding columns (e.g., *Leucanthemum vulgare)*. This discrepancy was designed to allow for variation among sites and ecotypes, slight erosion, and/or limited soil settling. To further reduce burial depths or to increase the effectiveness of suggested field test depths, it may be effective to incorporate additional pre-treatments to stress reproductive tissue prior to burial. The examples that follow, particularly fragmentation, may not be suitable for all species: 1) pre-treatment of the area prior to excavation with herbicides or other appropriate methods of control (Table C.2), 2) timing disturbance to target those growth stages when stored resources have been depleted and are less available to fuel regrowth, 3) fragmentation of reproductive material into tiny pieces such that stem and/or rhizome buds are separated from resources otherwise available in storage tissues, 4) soaking (fragmented) plant materials gathered for burial in salt water, and/or 5) desiccation of (fragmented) plant material prior to burial.

[2] Incineration to ash would work for disposal of all plant species.

[3] The authors of the report in which this statement appears, do not reference field tests nor do they support the burial depth statement with a citation, i.e., this burial depth might not have been tested in the field.

Appendix B
Invasive Species Control

Table B.1 Invasive Species Control Matrix

NOTE: Numbers in ( ) cross reference to Section 7.0 Literature Cited and Appendix D.2 Annotated Bibliography

Table B.1
Invasive Species Control Matrix

Common Name	Scientific Name	Control Methods			
		Manual	Mechanical	Chemical	Biological
Prohibited Noxious Weeds					
Russian knapweed	*Acroptilon repens*	Pull by hand and remove as much of the roots as possible (48). Repeated removal of above ground growth either by pulling or cutting can diminish root nutrients and stress plant; suggestion is to pull 3 times yearly (33). Species is light sensitive and can be controlled with a black plastic, sheet metal, straw, or manure (33).	Plowing/tilling is not effective; may spread the weed. Repeated yearly cutting and killing of the top 12 inches (30.5 cm) of the roots can effect up to 3.3 feet (1 meter) of the remaining roots (33).	Herbicides are not very effective when used by themselves (5).	*Subanguina picridis*, a gall-forming nematode, has been approve for biological control but has not been found to be effective (33).
Whitetops and its varieties	*Cardaria draba, C. pubescens, Lepidium latifolium*	*C. draba* may be pulled by hand within 10 days of emergence, definitely before flowering (17). Flooding for three months can kill 90% of plants when submerged to a depth of 6-10 inches (15.2-25.4 cm) (1).	Repeated tilling to remove the root system can be effective. Mowing 2 -3 times per year during the bud stage is also effective at controlling spread but won't reduce the population size (17)(18).	Use 2,4-D on mature plants (17); Metsulfuron and chlorsulfuron on plants before flowering (18).	The mite *Acerea draba* can sterilize *Cadaria draba* (1).
Canada thistle	*Cirsium arvense*	Cutting or hand removal prior to seed production can help suppress populations (8)(81). Dig out the plants (80).	Tilling every 1 to 4 weeks for four years helps manage population, as does mowing before the reproductive stage (7). Mowing must take place several times per year for several years to be effective (5)(14)(35)(80)(81). If tillage is used, care should be taken not to spread root fragments or seeds to new locations (1). When plants have 8-10 leaves, root reserves are depleted. When plants with 8-10 leaves were uprooted and re-buried at 9 inches depth, no shoots had emerged after a 28 day monitoring period (86).	Apply herbicides twice per season, in spring and in fall after mowing (21). Clopyralid, aminopyralid, or metsulfuron-methyl foliar applications can be made as plants bolt, prior to flowering, or in rosette stage. Glyphosate, triclopyr, dicamba, 2,4-D, and clopyralid or clopyralid+2,4-D (1); Clopyralid is the most effective (11). Chemical treatment is most effective after mowing (81).	Biological treatments are under investigation. A stem-mining weevil is available in Minnesota, effectiveness not known (35). No effective insects or fungi are available at this time. Plants may be grazed when they are young (1).
Field bindweed	*Convolvulus arvensis*	Restrict all light for 3 - 5 years with landscape fabric and mulch or bark. However, seeds will still be viable (41). Flooding infected areas with 6-10 inches (15-25 cm) of water for 60-90 days will kill most plants (42). Repeated hoeing every 2-3 weeks can reduce established stands (41).	Mechanical control doesn't work well because plants reproduce from roots and the seeds can sprout even after many years (3). Plowing/tilling is not effective, it may spread the weed. Tillage promotes bud formation and carbohydrate stock recovers in a few weeks (42).	Systemic herbicides including glyphosate, triclopyr, 2,4-D (3).	The bindweed moth (*Tyta luctuosa*) and the bindweed gall mite (*Aceria malherbae*) are both in use in the Great Plains (42).
Quackgrass	*Elymus repens*	Hand pull and hoe small infestations (24). Mowing and subsequent raking reduces biomass in future years (33).	Till area twice per growing season, spring and fall (22). Till before and after herbicide treatment. May be mowed to control spread but this will not result in a population decrease (24). Multiple tillings/mowings can reduce carbohydrate reserves; however immature seeds can still be viable and rhizomes may spread. Tilling/mowing/grazing when plant is about 2 inches (5.1 cm) in spring is most effective (42).	Apply glyphosate in spring and fall (22). Other effective herbicides include atrazine, Roundup, imazapyr, bromacil, Pramitol, simazine, and hexazinone (15).	No information found.

Common Name	Scientific Name	Control Methods			
		Manual	Mechanical	Chemical	Biological
Leafy spurge	*Euphorbia esula*	Suppress growth by mulching with several feet of hay (2). Pulling and digging shoots may cause the shoots to spread more (21). Sheep and goats have been used to control leafy spurge (7).	Plowing/tilling and subsequent planting of competing plants is effective in controlling the spread (7). Mowing before flowers develop can limit seed production (35). Disking or plowing is not effective. Mechanical controls generally are not effective (11).	2,4-D, dicamba, picloram between early bud and bloom stage and repeated in the fall when plants have regrown 4-6 inches (10.2-15.2 cm) (7). Herbicide is the best choice for treatment (21). Repeated applications are likely necessary (35).	Flea beetles, and stem and root boring beetles are used in Minnesota (35). Many insects are available which will reduce but not eliminate populations (11).
Hempnettle	*Galeopsis tetrahit*	Plants reproduce by seed only and are easily pulled. Hand-pulling should be effective; however hand pulling in the Portage Valley in Alaska has not been effective at reducing the population after 5 years of treatment (44).	Control spread by mowing before plants go to seed (20). Plowing early in spring before seedlings develop can control hemp nettle in ag fields (32).	Cannot be controlled with 2,4-D. Dicamba mixed with MCPA is recommended (14). Chlorsulfuron 10 grams per hectare (44).	None are currently available (32).
Galinsoga	*Galinsoga parviflora*	No information found.	Crop rotation can be useful in controlling the spread of *Galinsoga* as well as regular crop rotation in agricultural situations (52). Mechanical control is most effective at the seedling stage (67).	Herbicides which have been proven to be effective are Tillam, atrazine, Goal, Karmex, Lasso, and Lorox; among others (52).	Sudan grass and sorghum have been known to out-compete *Galinsoga* (52).
Orange hawkweed	*Hieracium aurantiacum*	Pull by hand when not in seed to avoid spreading seeds. Make sure to remove all roots from the soil so they don't resprout (5). Control by careful digging of rosette plants. Plants re-grow quickly from broken roots left in the soil, so hand pulling is seldom effective (32). Hand pulling may not be effective, but may be preferable to no control at all (81).	Mowing is not effective, as these are perennial (5). Do not mow; it stimulates rhizomatous growth (37). Mowing can limit seed production, but may promote vegetative spread and flowering. Tilling in conjunction with herbicide has been effective (81).	Triclopyr before flowering; aminopyralid; clopyralid before buds form (5); picloram or picloram + 2,4-D provides very good control (32).	None are currently available (44).
Blue-flowering lettuce	*Lactuca tatarica, (L. pulchella)*	No information found.	No information found.	No information found.	No information found.
Purple loosestrife	*Lythrum salicaria*	Covering plants with black plastic can potentially slow growth. Thick, heavy mulch from mowed plants could possibly kill some roots (7). Small plant populations may be cut or pulled by hand repeatedly over several years (13).	Mowing is not effective when it is the only control mechanism because plants will develop shoots and adventitious roots (7)(13). If cutting plants, the best time is late in the season in order to deplete root reserves (7). Any control measure should be carried out before plant goes to seed (13).	Formulations for use on right-of-ways and near water are likely needed. 2,4-D, glyphosate, imazamox, metsuluron-methyl+aminopyralid, triclopyr, imazapyr, and aminocyclopyrachlor (35).	Two leaf feeding beetles (*Galerucella sp.*) have been very effective in Minnesota (35).
Austrian fieldcress	*Rorippa austriaca*	Dig small populations by hand (7)(23)(43). When hand-pulling, make sure the entire root is removed (23)(43).	Repeated plowing/tilling may be effective (7). Large infestations were controlled in California by draining wetlands and converting infested areas to agricultural fields (42).	2,4-D (7)(8); 2,4-D or glyphosate (42).	No biological controls are currently available (23).
Horsenettle	*Solanum carolinense*	Hand pulling is effective in controlling small outbreaks (8).	Tilling and mowing are not effective (8). Do not till (74). Mechanical techniques spread roots and allow propagation while simultaneously allowing deep growing roots to resprout (42). Mowing at first bloom is effective (74). Mowing weekly can reduce but not eliminate this species (42). The best method was to mow monthly and apply herbicide to summer/fall foliage two weeks before the first frost (74).	Glyphosate and 2,4-d applied to young growing plants, picloram applied at flowering, imazapyr applied during active growth (8).	No biological agents are approved or specifically mentioned (42).

Common Name	Scientific Name	Control Methods			
		Manual	Mechanical	Chemical	Biological
Perennial sowthistle	*Sonchus arvensis*	It is suggested that mowing is less effective than tilling for controlling this species (33).	Tilling the soil can be effective in control when it occurs at the 7-9 leaf rosette stage (7). Treatment must be performed multiple times throughout the growing season (44)(81).	Common herbicides are not highly effective at treating sowthistle (44). However, auxin-type herbicides have been shown to be effective. Some recommended herbicides include: amitrole, dicamba, MCPA amine, and 2,4-D amine (7).	Focused grazing can be used (7). Many insects and nematodes feed on sowthistle, however only a few only feed on the genus *Sonchus*. In Canada, research has been conducted for control using *Tephritis dilacerata, Liriomyza sonchi,* and *Cystiphora sonchi*, but has found limited results. No biocontrol agents are currently available in Washington (7).
Other Invasive Plants Addressed in Study					
Garlic mustard	*Alliaria petiolata*	Cover area where plants were removed with wood chips to prevent sprouting (5). Hand pull second year plants with upper half of root before plant goes to seed (21). Prescribed fire may be used in spring if followed up with herbicide (35).	Do not mow (5). Cutting flowering stems as near to ground level as possible is effective. However, if plants aren't flowering yet they may resprout from the root crown (33).	Herbicides may be applied to foliage-triclopyr, metsulfuron-methyl, or imazapic. Glyphosate or 2,4-D may be used after native plants enter dormancy and garlic mustard is still active (35). There is not a specific herbicide which solely controls garlic mustard. Herbicides which kill garlic mustard are known to kill some field crops (55).	Under investigation, none available at this time (35).
Cheatgrass	*Bromus tectorum*	No information found.	Mowing can help limit but not entirely prohibit seed production (15). Mowing is not recommended unless it is done at regular intervals several times per year for several years. Tilling alone is generally not effective and if used should be done multiple times so that seeds are buried 4-6 inches (10.2-15.2 cm) to prevent seed germination (33). Mature plants may be killed in the spring by tilling or prescribed burn before they go to seed (33).	Atrazine, glyphosate, multiple other herbicides (15); Glyphosate will kill cheatgrass, but should be used in conjunction with other control methods (33).	Grazing in the spring will help control cheatgrass (33).
Rampion bellflower	*Campanula rapunculoides*	Pull or dig out plant, taking care to get all of the roots (14)(76) (81). Cutting flower spikes and bagging can prevent seeding, but plant will resprout from rhizomes (77).	It is almost impossible to control this species mechanically (44). Plowing/tilling is not a control option (77).	Problematic to control by chemical methods, but glyphosate can be effective (44). Glyphosate or dicamba (14); Plant is resistant to 2,4-D (77).	None are currently available (77).
Siberian pea shrub	*Caragana arborescens*	Pull by hand (16).	No information found.	Treat the cut stump with glyphosate or triclopyr (16).	No information found.
Spotted knapweed	*Centaurea stoebe (C. maculosa)*	Can be hand pulled or cut (13). Hand pull and dig plants out along with the root (21). Tarp with black plastic (33).	Can be rototilled or plowed for several years in a row to control. Mowing is not effective because plants can still grow and produce seed (5). Mowing at bud stage and flowering stage reduces the number of plants producing seed (33).	Clopyralid and aminopyralid work well (5)(35). Other good options include clopyralid and 2,4-D or clopyralid and triclopyr (5). Aminopyralid and some amine mixtures of 2,4-D and triclopyr are safe up to the edge of water (5). Apply herbicides on leaves before the stem elongates (21). Glyphosate, imazapyr, aminocyclopyrachlor, or picloram are also effective when applied to foliage (35).	Biological control has been effective in British Columbia. Seed-reducing flies (*Urophora sp.*) have resulted in up to 95% reduction in seed production (32).

Common Name	Scientific Name	Control Methods			
		Manual	Mechanical	Chemical	Biological
Bull thistle	*Cirsium vulgare*	Hand pull and dispose of flowering plants in the trash (7). Digging or hoeing is effective. Plants usually die if the top couple of inches of roots are removed with the main stem (5).	Cutting plants 1 to 2 inches (2.5-5.1 cm) beneath the soil surface when plant is in bud every year or more than once a year is effective for controlling the spread (5). Mowing can be effective. Make sure plants are not flowering. Also, if mowing is done too early plants may re-sprout and flower again that season (7). Mow after plant bolts but before it flowers. May need to mow twice per season. Repeated mowing will prevent flowering and spreading. Plowing/tilling is effective (5). Tillage is effective when properly timed (50).	2,4-D is recommended (7). Glyphosate (5); dicamba, clopyralid, or picloram: either alone or in combination with 2,4-D (50).	Seed production is impacted by the seedhead gall fly (7).
Narrowleaf hawksbeard	*Crepis tectorum*	Hand pull small populations and completely remove roots. Pull plants prior to seed set and follow up for several years to deplete seed bank (20).	No information found.	2,4-D on basal rosettes in fall (19). Glyphosate and metsulfuron-methyl (20). Metsulfuron-methyl should be applied in the spring to cotyledons and again in the fall to weaken the rosettes. An additional 49 foot (15 m) buffer should be treated along with the contaminated site with 70 grams per hectare (66). This species is so widespread in the Anchorage area, AKNHP recommends treating with herbicide be used in conjunction with any other control methods (80).	No information found.
Scotchbroom	*Cytisus scoparius*	Remove all roots so plant doesn't resprout (5). Older plants can be cut before seeds are mature as close to ground as possible. After the plant is removed the area should be revegetated with species that can compete with future scotch broom seedlings (5). Plants may be hand-lopped in the fall, which will kill the plant and not disturb the soil (34).	Plants may be cut mechanically. Plants should be cut between flowering and seed pod maturation to reduce seed spread, but may be cut after the plant has gone to seed to deplete root reserves. Bulldozing is not effective, and cutting is most effective on plants greater than 2 inches (5.1 cm) in diameter. Mowing in the spring and then applying herbicide in the fall to plants that have re-grown can be effective (5).	Glyphosate applied to growing plants in the spring; triclopyr applied on wet, actively growing foliage; herbicide will need to be applied several times over several years (5).	Several insects have been used to control Scotch broom such as *Bruchidius villosus, Exapion fuscirostre,* and *Leucoptera spartifoliella*. In addition, many native insects will attack this species (33).
Splitlip hempnettle	*Galeopsis bifida*	Plants reproduce by seed only and are easily pulled out. Hand-pulling should be effective; however hand pulling in the Portage Valley in Alaska has not been effective at reducing the population after 5 years of treatment (44).	No information found.	Chlorsulfuron 10 grams per hectare (44).	No information found.
Meadow hawkweed	*Hieracium caespitosum*	Pull by hand when not in seed to avoid spreading seeds. Make sure to remove all roots from soil so they don't resprout (5).	Mowing is not effective, as this species is perennial (5). Mowing may also encourage vegetative reproduction (33). Fertilization may eliminate hawkweed by encouraging competition by other plants (33)(5).	Triclopyr before flowering; aminopyralid; clopyralid before buds form (5); Picloram or picloram + 2,4-D provides very good control (32).	Several insects are being studied for use in control of meadow hawkweed but none have been permitted thus far (10).

Common Name	Scientific Name	Control Methods			
		Manual	Mechanical	Chemical	Biological
Foxtail barley	*Hordeum jubatum*	No information found.	Mowing is not effective (10). Plow in fall and cultivate alternate cover in spring to control (10). Seed infested area with native grasses that grow quickly, such as *Calamagrostis canadensis*. (20). Shallow root system allows for easier mechanical management than other perennial grasses (58).	Glyphosate, sethoxydim, fluazifop, trifluralin (10); dalapon (20)(33).	An integrated management approach should be taken; desirable species should be seeded in area after control of foxtail, as it is not highly competitive (59).
Hairy catsear	*Hypochaeris radicata*	Hand pull and make sure to remove root (10). Plowed up material can be covered with black plastic (49).	Plowing/Tilling for a few years can help control (7)(10), but mowing doesn't work (10). It tolerates occasional mowing (84).	Chemical control within the first year when plant is still in rosette stage is most effective using spot treatment with either 2,4-D, MCPA, or clopyralid (49).	No known agents are available (49).
Ornamental jewelweed	*Impatiens glandulifera*	Hand pull before flowering (5)(6).	Mow before flowering and repeat on regrowth. Cut as close to ground as possible (5)(6).	Glyphosate or 2,4-D should be used in early vegetative stages (6).	No biological controls have been identified (5).
Oxeye daisy	*Leucanthemum vulgare*	Mulching with 3-4 inches (7.6-10.2 cm) of compacted straw laid over infested area was successful when mulch was applied at the beginning of the growing season. If plant population is small or widely scattered hand removal may be efficient. Care must be taken to remove all of the roots and rhizomes (1)(80). 3-4 inches of topsoil over controlled area should be re-seeded with fast-growing native grasses, such as *Calamagrostis canadensis* (80). Cut and bag flower heads, dig out plants and rosettes, removing as much of the roots as possible (81).	Can also be controlled by intensive cultivation, which destroys its shallow root system (1)(7)(44)(5). Mowing right as plants flower or are in flower bud stage will limit seed production (5).	Apply herbicides as plants begin to flower: dicamba, imazapyr, picloram, or sulfometuron-methyl (1). One study found that fertilizing with nitrogen reduced daisy and benefitted grass (7). Fertilize or re-seed with native grasses (81).	None have been found (5). Intense grazing by cattle can be an effective means of control (1).
Common toadflax	*Linaria vulgaris*	Cutting, pulling, or spraying prior to seed development will help control the spread of toadflax. Must be repeated every year until seed bank is depleted (71). Dig up plants, removing as much of the rhizome as possible (81).	Plowing/Tilling infested areas every 3 weeks, starting in early summer for at least two years (7). Mowing is generally not recommended, as it does not affect buried seeds or roots (33). Mowing prior to seed set may help control the spread of this species (81).	Dicamba applied in spring or early fall is effective (7). Fertilize or seed with native grasses to compete with toadflax (81).	Several insects have been released in the U.S. and Canada. The most important ones seem to be the flower feeding beetles (*Brachypterolus pulicarius* and *Gymnetron antirrhini*). These insects reduce seed production in toadflax. Grazing by sheep and goats can be used to control toadflax (33).
White sweetclover	*Melilotus alba*	Hand pull the first year stems in late summer (9)(21). Pull second year stems before they reach the flowering stage (21). Burning with a torch has been used to control sweetclover in Alaska. Burning significantly reduced the number of plants and viable seeds (33). Hand pull small populations (80)(81).	Mow in late spring or early summer to reduce seed dispersal (9). Hand pulling, mowing, and cutting have been successful. Cutting first year plants does not kill them but reduces seed production. Cutting second year plants reduces plant density and seed production (33). Mowing several times in the growing season can reduce flowering and seed production (80) and may help control the spread of this species (81).	2,4-D, aminocyclopyrachlor + chlorsulfuron, aminopyralid, chlorsulfuron, clopyralid, dicamba, imazapyr, metsulfuron, picloram, and triclopyr are all excellent for controlling white sweetclover (10). Large populations should be treated with herbicide; including a 50 foot (15.2 m) buffer around the infestation (81).	No biological controls have been released (33). Seed area with native grasses to outcompete sweetclover (81).

Common Name	Scientific Name	Control Methods			
		Manual	Mechanical	Chemical	Biological
Reed canarygrass	*Phalaris arundinacea*	Dig up small populations by hand, carefully digging up all roots. For medium size populations (generally less than 1,076 sq. feet [100 sq. meters]) first mow and then cover with opaque tarps for several growing seasons. This method may be used in conjunction with plastic mulch (12). Prescribed fire can be effective to suppress growth and allow for colonization of native plants (10)(18). Hand dig, mow, or burn. Follow up by tarping controlled area (80).	Mow before seed production twice per year to control spread (7). Mowing and tilling must be repeated consistently or it could lead to the spread of this species (21). Mowing/ cutting multiple times may help control reed canarygrass. It is also sensitive to plowing. Application of herbicide followed by plowing is effective (18). Mowing prior to seed set may help control the spread of this species (81).	Glyphosate can be used when near aquatic areas (7)(12). Apply herbicide in late summer or fall (21). Fertilizer should not be used in areas infested by *Phalaris*, as it will promote further growth of the species (81).	No biological controls are known (44)(10)(81).
Japanese knotweed	*Polygonum cuspidatum, P. bohemicum*	Dig up by hand small populations of less than 50 stems. Cut stems close to the ground at least twice a month during the growing season for three to five years. Pile cuttings where they will dry out and not be moist. After cutting plants and digging up roots, cover area with heavy geotextile fabric or black plastic and leave in place for 3 to 5 years. Crush the regrowth under the covering every two to four weeks (5). Conversely, mowing and tarping has not been effective in some instances (37)(82).	Do not mow, because it can cause the plant to spread from stem and root fragments. (13)(5). If plant must be cut, it should be cut by hand several times per summer and disposed of (13). Root and stem fragments as small as 1/2 inch (1.3 cm) can sprout to form new colonies (40).	2,4-D or glyphosate (36)(5); Glyphosate in the fall in southeast Alaska (37); Glyphosate, triclopyr, picloram, and imazapyr (40); Field trials are underway to test the efficacy of glyphosate or imazapyr application in late summer versus fall in Washington state (83).	Research is ongoing to determine a suitable biocontrol option. The first test-release of a potential biocontrol agent occurred in 2013 in Britain (39).
European bird cherry	*Prunus padus*	No information found.	Cutting trees in conjunction with chemical application is suggested. Specifically applying the herbicide to fresh cut stumps at the end of the growing season (68)(80). Cutting and then rotting the stump is the alternative approach. Rotting can be promoted by fertilizers, creating depressions for water to pool in, and coving with dirt (68).	Glyphosate is effective in controlling this plant (5).	No information found.
Tansy ragwort	*Senecio jacobaea*	Pull plants after bolting and before flowering, then bag and dispose of plants immediately so they don't develop seeds (5). Hand pull before plants go to seed (32). May be controlled by hand digging or pulling (60).	Mowing is not effective because plants can resprout and flower soon after mowing (5). Mowing must be done often and thoroughly to be effective (32).	Glyphosate works well when the area is revegetated after the herbicide application. 2,4-D, triclopyr, and dicamba work well in grassy areas (5). Use 2,4-D in the seedling to young rosette stages (32).	British Columbia has introduced three species of insects to control ragwort, one of them, the ragwort flea beetle, has been used successfully in California and Oregon as well (32).
Common tansy	*Tanacetum vulgare*	Hand pull or dig up in early spring as plants sprout, removing all of the roots (5)(35)(81). Site should be re-visited the following year to remove plants that may have re-sprouted from root fragments (5). Gloves should be worn when hand pulling, this species can cause dermatitis (81).	Mowing is not effective, as plant can resprout and flower. Plowing/Tilling is effective (5). Tilling can actually spread the plant by spreading root fragments. Mowing can be effective if done just prior to flowering (35). Regular mowing before plants go to seed can be effective (44)(81). Mowing prior to seed set may help control the spread of this species (81).	Glyphosate, dicamba, metsulfuron, or chlorsulfuron may be applied before flowering (5).	None are available at this time (5).

Common Name	Scientific Name	Control Methods			
		Manual	Mechanical	Chemical	Biological
Western salsify	*Tragopogon dubius*	Small populations may be pulled or hand dug (61).	Plowing/Tilling is effective (26). Mow when flowers appear and repeat throughout the season (26). Mowing is not effective at controlling western salsify (61).	Picloram or dicamba (51); dicamba combined with 2,4-D applied at the rosette stage (61).	Livestock grazing may be effective (33). Grazing in conjunction with herbicide use can provide effective control (51).
Bird vetch	*Vicia cracca*	Pull plants (25)(16). Cover the area with plastic or geotextile fabric to prevent regrowth (25). Hand dig early in the growing season, and repeat every six weeks throughout the growing season (80). The Alaska Natural Heritage Program (AKNHP) recommends manual control for 5 years; if bird vetch is not eradicated by this time herbicide is recommended (80). Small populations may be hand pulled; care should be taken to remove roots and rhizomes (81).	Mow plants through growing season until seed pods mature (25). Mowing prior to seed set may help control the spread of this species (81). Mechanical control is effective for bird vetch, as plants will not resprout after cutting and cannot tolerate repeated cutting (81).	In early summer spray clopyralid, triclopyr, or 2,4-D. Then let plants sit as herbicide makes its way into the root system (25). Clopyralid should be effective and should be used if manual treatment is ineffective (80).	No information found.

Appendix C
Invasive Species Project Plant List

Table C.1 Invasive Species Project Plant List Organized Alphabetically by Latin Name

Table C.1
Invasive Species Project Plant List Organized Alphabetically by Latin Name

Latin Name	Common Name
Prohibited Noxious Weeds - Alaska Department of Natural Resources	
Acroptilon repens	Russian knapweed
Cardaria draba, C. pubescens, Lepidium latifolium	Whitetops and its varieties
Cirsium arvense	Canada thistle
Convolvulus arvensis	Field bindweed
Elymus repens	Quackgrass
Euphorbia esula	Leafy spurge
Galeopsis tetrahit	Hempnettle
Galinsoga parviflora	Galinsoga
Hieracium aurantiacum	Orange hawkweed
Lactuca tatarica, (L. pulchella)	Blue-flowering lettuce
Lythrum salicaria	Purple loosestrife
Rorippa austriaca	Austrian fieldcress
Solanum carolinense	Horsenettle
Sonchus arvensis	Perennial sowthistle
Other Invasive Plants Addressed in this Study	
Alliaria petiolata	Garlic mustard
Bromus tectorum	Cheatgrass
Campanula rapunculoides	Rampion bellflower
Caragana arborescens	Siberian pea shrub
Centaurea stoebe (C. maculosa)	Spotted knapweed
Cirsium vulgare	Bull thistle
Crepis tectorum	Narrowleaf hawksbeard
Cytisus scoparius	Scotchbroom
Galeopsis bifida	Splitlip hempnettle
Hieracium caespitosum	Meadow hawkweed
Hordeum jubatum	Foxtail barley
Hypochaeris radicata	Hairy catsear
Impatiens glandulifera	Ornamental jewelweed
Leucanthemum vulgare	Oxeye daisy
Linaria vulgaris	Common toadflax
Melilotus alba	White sweetclover
Phalaris arundinacea	Reed canarygrass
Polygonum cuspidatum, P. bohemicum	Japanese knotweed
Prunus padus	European bird cherry
Senecio jacobaea	Tansy ragwort
Tanacetum vulgare	Common tansy
Tragopogon dubius	Western salsify
Vicia cracca	Bird vetch

Appendix D
Project Contacts Summary & Bibliography

Table D.1 Interview Contact Summary

Table D.2 Annotated Bibliography

Table D.1
Interview Contact Summary

Name	Association	State Affiliation	Contact phone	Contact email
Alaska				
Brian Maupin	Alaska Association of Conservation Districts	Alaska	315-1795	aacdpm@mtaonline
Brett Nelson	Alaska Department of Transportation	Alaska	451-2238	brett.nelson@alaska.gov
James Sowerwine	Alaska Native Plant Society	Alaska	334-2542	james.sowerwine@gmail.com
Danielle Verna	Copper River Watershed Project	Alaska	424-3334	danielle@copperriver.org
Blythe Brown	Kodiak Soil and Water Conservation District	Alaska	539-5372	blythe.brown@kodiaksoilandwater.org
Genelle Winter	Metlakatla Indian Community	Alaska	886-1560	mic_landscaping@yahoo.com
Pam Randles	Takshanuk Watershed Council	Alaska	766-3542	pam.randles@takshanuk.org
Ruth Gronquist	U.S. Bureau of Land Management	Alaska	474-2377	ruth_gronquist@blm.gov
Laurie Thorpe	U.S. Bureau of Land Management	Alaska	267-1208	lthorpe@blm.gov
John Hudson	U.S. Fish and Wildlife Service	Alaska	780-1169	john_hudson@fws.gov
Trish Wurtz	U.S. Forest Service, State & Private Forestry	Alaska	451-2799	twurtz@fs.fed.us
David Lendrum	University of Alaska	Alaska	796-6513	dwlendrum@uas.alaska.edu
Gino Graziano	University of Alaska Cooperative Extension Service	Alaska	786-6315	gagraziano@alaska.edu
Phil Kaspari	University of Alaska Cooperative Extension Service	Alaska	895-4215	fnpnk@uaf.edu
Lindsey Flagstad	Alaska Natural Heritage Program	Alaska	786-6386	laflagstad@uaa.alaska.edu
Brianne Blackburn	Alaska Division of Agriculture	Alaska	745-8785	brianne.blackburn@alaska.gov
Canada & the Lower 48				
Normand Boulet	Municipal District of Smoky River Number 130	Alberta	780-837-2221	asb@mdsmokyriver.com

Name	Association	State Affiliation	Contact phone	Contact email
Greg Czernick	British Columbia Ministry of Transportation and Infrastructure	British Columbia	250-387-7557	greg.czernick@gov.bc.ca
Scott Bockness	Center for Invasive Species Management	Montana	406-208-7657	scott.bockness@montana.edu
Phil Johnson	Montana Department of Transportation	Montana	406-444-7657	phjohnson@mt.gov
Patti Caswell	Oregon Department of Transportation	Oregon	503-986-3008	patti.caswell@odot.state.or.us
Will Lackey	Oregon Department of Transportation	Oregon	503-986-3010	william.lackey@odot.state.or.us
Mike Shippey	Oregon Department of Transportation	Oregon	541-484-7336	mike.shippey@odot.state.or.us
Emilie Holland	Rhode Island Department of Transportation	Rhode Island	401-222-2023	emilie.holland@dot.ri.gov
Sally Nickelson	Cedar River Watershed, Seattle Public Utilities	Washington	206-233-1564	sally.nickelson@seattle.gov
Sandy Salisbury	Washington Department of Transportation	Washington	360-705-7245	salisbs@wsdot.wa.gov
Ray Willard	Washington Department of Transportation	Washington	360-705-7865	willarr@wsdot.wa.gov
Wendy DesCamp	Washington State Noxious Weed Board	Washington	360-725-5764	wdescamp@agr.wa.gov
Tim Miller	Washington State University Cooperative Extension Service	Washington	360-848-6138	twmiller@wsu.edu
Jennifer Andreas	Washington State University Cooperative Extension Service	Washington	253-445-4657	jandreas@wsu.edu
Julie Kraft	Sublette County Weed & Pest District	Wyoming	307-367-4728	N/A

Notes:
[1] Not all interviews are cited in the document text, annotated bibliography (Table D.2, Appendix D), or invasive species management matrices (Table A.1, Appendix A & Table B.1, Appendix B).

Table D.2
Annotated Bibliography of Sources Cited in Invasive Species Management Matrix Disposal Method[1] & Invasive Species Management Matrix Control Method[2]

Matrix Tables A.1 & B.1 Reference	Author / Title / Source / Access Date	Summary	Disposal Information	Control Information
1	Bossard, C.C., J.M. Randall, and M.C. Hoshovsky, Editors. 2000. Invasive Plants of California's Wildlands. University of California Press. Berkeley, California, USA. Available at: http://www.cal-ipc.org/ip/management/ipcw/online.php (September 27, 2013)[3]	• Provides life history information, distribution, and control measures for many species of invasive plants occurring in California. • This is an online version of the book *Invasive Plants of California's Wildlands*. Sections exist for each of the following plants which are found on the Project Plant List[4]: *Euphorbia esula, Cirsium arvense, Cardaria draba, Lapidium latifolium, Lythrum salicaria, Cirsium vulgare, Bromus tectorum, Leucanthemum vulgare, Cytisus scoparius,* and *Senecio jacobaea.*		☑
2	Tu, M., C. Hurd, and J.M. Randall. 2001. The Global Invasive Species Team: *Weed Control Methods Handbook.* The Nature Conservancy. Available at: http://www.invasive.org/gist/handbook.html (September 10, 2013)	• Provides detailed information about the tools and techniques available for controlling invasive plants in natural areas. • The focus is on providing information regarding herbicide action and recommendations. The handbook provides practical advice on the application of many herbicides to many invasive species, including some that are on the Project Plant List. • Biocontrol methods are discussed in depth. • Includes limited information on mechanical control, but there are some notes on the efficacy of burning to control species on the Project Plant List. These species include: *Cirsium vulgare, Cirsium arvense, Phalaris arundinacea, Lythrum salicaria, Alliaria petiolata, Centaurea maculosa (C. Stoebe), Euphorbia esula,*and *Melilotus alba.* • Appendix 5.1 contains contact information for land managers that provided information for the report.		☑
3	King County Noxious Weed Control Program. 2007. King county noxious weed control program weed alert: field bindweed (aka morning glory) *Convolvulus arvensis.* King County Department of Natural Resources and Parks, Water and Land Resources Division, Noxious Weed Control Program. Available at: http://your.kingcounty.gov/dnrp/library/water-and-land/weeds/Brochures/Bindweed_factsheet.pdf (September 27, 2013)	• Noxious weed program flyer for King County, Washington. Contains information on identification, biology, distribution, prevention, and control of *Convolvulus arvensis.* • Provides limited information on disposal of plant material. • King County Noxious Weed Control Program contact number: (206) 296-0290	☑	☑
4	Connecticut Department of Energy and Environmental Protection and University of Connecticut. 2011. Guidelines for disposal of terrestrial invasive plants. Available at: http://www.hort.uconn.edu/CIPWG/pdfs/Invasive_plant_disposal_guide_8-2011.pdf (October 1, 2013)	• General guidelines for disposal of invasive plant materials. Covers broad categories such as woody plants, herbaceous plants, and grasses and sedges; and various methods of disposal such as air drying, composting, and incinerating. Some plants which reproduce by rhizomes are addressed specifically. • Species addressed that are on the Project Plant List: *Centaurea stoebe, Cirsium arvense, Euphorbia esula,* and *Lythrum salicaria.* • Other resources suggested by this document include the Connecticut Invasive Plant Working Group (www.hort.uconn.edu/cipwg) and the Connecticut Department of Energy and Environmental Protection. Contact number: (860) 424-3589. • This document drew on several previous documents, including a non-native plant disposal document from the University of New Hampshire Cooperative Extension (January 2010), a New Hampshire Department of Transportation BMPs[5] (2008) document, and an aquatic plant disposal document from the Invasive Plant Atlas of New England.	☑	
5	King County Noxious Weed Control Program. 2013. Noxious weeds; weed identification photos; index for identification and control of noxious weeds. Available at: http://www.kingcounty.gov/environment/animalsAndPlants/noxious-weeds/weed-identification.aspx (October 1, 2013)	• Contains plant profile pages that include identification, control methods, disposal, and other information relevant to that specific plant. Some additional links are present on the profile page; some species have BMP files attached, which provide additional information. • Species addressed that are on the Project Plant List: *AIIiaria petiolata, Centaurea stoebe, Cirsium arvense, Cirsium vulgare, Cytisus scoparius, Hieracium aurantiacum, Hieracium caespitosum, Impatiens glandulifera, Senecio jacobaea,* and *Tanacetum vulgare.*	☑	☑

Matrix Tables A.1 & B.1 Reference	Author / Title / Source / Access Date	Summary	Disposal Information	Control Information
6	National Roads Authority. 2010. The management of noxious weeds and non-native invasive plant species on national roads. National Roads Authority. Available at: http://www.nra.ie/environment/environmental-construction-guidelines/Management-of-Noxious-Weeds-and-Non-Native-Invasive-Plant-Species-on-National-Road-Schemes.pdf (October 22, 2013)	• Document provides guidance on the management of noxious weeds and invasive plants on national roads in Ireland. Provides information on identification, growth habits, control measures, and herbicides used for several species of plants that are problematic in Ireland. • Species addressed that are on the Project Plant List: *Cirsium vulgare, Cirsium arvense, Senecio jacobea, Impatiens glandulifera,* and Japanese knotweed (*Polygonum cuspidatum, P. bohemicum*).	☑	☑
7	Washington State Noxious Weed Control Board. 2010. Home page Washington State Noxious Weed Control Board. Available at: http://www.nwcb.wa.gov/default.asp (October 1, 2013)	• Washington State Noxious Weed Control Board home page. Includes plant profile pages with information on identification, habits, reproduction, and control. • Provides link to written findings. Clicking on the link connects to a more detailed description of the plant with references. • Website refers to the *Pacific Northwest Weed Management Handbook* for herbicide control. This handbook is available online at http://pnwhandbooks.org/weed/ • Species addressed that are on the Project Plant List: *AIIiaria petiolata, Centaurea stoebe*, Whitetops and its varieties *(Cardaria draba, C. pubescens, Lapidium latifolium), Cirsium arvense, Cytisus scoparius, Euphorbia esula, Hieracium aurantiacum, Hieracium caespitosum, Hypochaeris radicata, Impatiens glandulifera, Leucanthemum vulgare, Linaria vulgaris, Lythrum salicaria, Phalaris arundinacea, Polygonum cuspidatum, Rorippa austriaca, Senecio jacobaea, Sonchus arvensis, and Tanacetum vulgare*. • Contact information available at: http://www.nwcb.wa.gov/nwcb_contact.htm		☑
8	Nevada Department of Agriculture noxious weed program. Horsenettle (*Solanum carolinense*). Available at: http://agri.nv.gov/Noxious_Weed-Horsenettle/ (October 2, 2013)	• Nevada Department of Agriculture profile page for horsenettle; includes information on plant identification, habits, and control methods. • Nevada Department of Agriculture noxious weed list is located at http://agri.nv.gov/Plant/Noxious_Weeds/Noxious_Weed_List/ • Species on the noxious weed list each have a profile page. Project Plant List species on this list include: *Rorippa austriaca, Cirsium arvense, Cardaria draba, Solanum carolinense, Euphorbia esula, Lepidium latifolium, Sonchus arvensis, Lythrum salicaria, Acroptilon repens,* and *Linaria vulgaris.*		☑
9	Southeast Exotic Pest Plant Council. Yellow and white sweet clover *Melilotus officinalis* and *Melilotus alba*. Available at: http://www.se-eppc.org/pubs/musk_clover_treatment.pdf (October 2, 2013)	• Profile page for yellow and white sweet clover. Includes information on plant identification, habits, and control methods. • Does not include contact information.		☑
10	University of California Cooperative Extension and Agricultural Experiment Station. 2013. Weed Research and Information Center. Weeds in natural areas. Available at: http://wric.ucdavis.edu/information/crop/natural_areas_common_C.htm (October 22, 2013)	• Extensive list of weeds occurring in natural areas. Profile pages contain some information on plant habit, distribution, and identification, but are mostly related to control methods. Each page contains recommendations for non-chemical and chemical control. • Good site for control methods and herbicide use. • Weed profile pages are excerpts from the book *Weed Control in Natural Areas in the Western United State* (J. M. DiTomaso and G.B. Kyser et al. 2013. Weed Research and Information Center, University of California. 544 pp). • Species addressed that are on the Project Plant List*: Convolvulus arvensis, Elymus repens, Cirsium vulgare, Acroptilon repens, AIIiaria petiolata, Cardaria draba, C. pubescens, Lepidium latifolium, Cirsium arvense, Bromus tectorum, Centaurea stoebe (Centaurea maculosa -* synonym*), Euphorbia esula, Hypochaeris radicata, Tanacetum vulgare, Leucanthemum vulgare, Hordeum jubatum, Senecio jacobaea, Linaria vulgaris, Cytisus scoparius, Hieracium caespitosum, Hieracium aurantiacum, Melilotus alba, Phalaris arundinacea, Lythrum salicaria, Polygonum cuspidatum,* and *P. bohemicum.*		☑
11	Donaldson, S. and G. Bowers. Weed Identification and Control Guide. Educational Bulletin 98-01. University of Nevada Cooperative Extension. 32 pp. Available at: http://www.unce.unr.edu/publications/files/nr/other/eb9801.pdf (October 2, 2013)	• Handout contains profiles for a number of weeds which are of concern in Nevada. Profile pages provide description of plant and control methods. • Species addressed that are on the Project Plant List: *Acroptilon repens, Centaurea maculosa (C. stoebe), Euphorbia esula, Cirsium arvense, Cardaria draba, Lythrum salicaria, Lepidium latifolium, Convolvulus arvensis,* and *Hordeum jubatum.* • For more information contact: University of Nevada Cooperative Extension, PO Box 11130, Reno NV 89520. Telephone: (775) 784-4848. www.extension.unr.edu		☑

Matrix Tables A.1 & B.1 Reference	Author / Title / Source / Access Date	Summary	Disposal Information	Control Information
12	Homer and Kenai Soil and Water Conservation Districts. 2007. Managing invasive plants in wetlands of the Kenai Peninsula: developing a management program for reed canary grass infestations. FY2007 Progress Summary. Available at: http://www.homerswcd.org/invasives/FY07RCGsummary.pdf (October 3, 2013).	• Summary of study conducted on Kenai Peninsula which surveyed and documented infestations of reed canary grass. Sites were evaluated by experts, who gave recommendations for control and site restoration. • Good source for control methods of reed canary grass (*Phalaris arundinacea*). • Does not include specific contact information. Report prepared by Caleb Slemmons, Homer Soil and Water Conservation District. Telephone: (907) 235-8177.		☑
13	New Hampshire Department of Transportation. 2008. BMPs for roadside invasive plants. Available at: http://www.fws.gov/northeast/cpwn/pdf/activities/InvasiveSpecies/BMPsforRoadsideInvasivePlantsNH.pdf (October 23, 2013).	• Document provides general BMPs for dealing with invasive plants in New Hampshire. Goes into more detail for a few priority species and gives preferred control methods for those species. Includes disposal and control of invasive plants and general guidelines for avoiding the spread of invasives. • Species addressed that are on the Project Plant List: Knotweed (*Polygonum cuspidatum, Reynoutria bohemicum*) and purple loosestrife (*Lythrum salicaria*). • Contacts: Christine Perron, Senior Environmental Manager, cperron@dot.state.nh.us , 271-3717. Contact for information on: plant identification, BMPs, and control methods ; Marc Laurin, Senior Environmental Manager, mlaurin@dot.state.nh.us , 271-4044. Contact for information on: plant identification, BMPs, and control methods; Guy Giunta, Landscape Specialist Supervisor, ggiunta@dot.state.nh.us ,271-6476, Contact for information on: herbicides; Doug Cygan, Invasive Species Coordinator, dcygan@agr.state.nh.us ,271-2561, Contact for information on: plant identification, control methods	☑	☑
14	Wisconsin Department of Natural Resources. Terrestrial invasive species-regulated plants. Available at: http://dnr.wi.gov/topic/Invasives/species.asp?filterBy=Terrestrial&filterVal=Y&catVal=PlantsReg#RegSelect (October 3, 2013).	• Provides profiles for many species of invasive plants which occur in Wisconsin. Includes information on distribution, life history, and control methods. • Species addressed that are on the Project Plant List: Garlic mustard (*AIliaria petiolata*), spotted knapweed (*Centaurea stoebe*), Canada Thistle (*Cirsium arvense*), Scotchbroom (*Cytisus scoparius*), Hempnettle (*Galeopsis tetrahit*), Purple Loosestrife (*Lythrum salicaria*), Japanese Knotweed (*Polygonum cuspidatum*), and Common Tansey (*Tanacetum vulgare*).	☑	☑
15	Rutledge, C. R., and T. McLendon. 1996. An Assessment of Exotic Plant Species of Rocky Mountain National Park. Department of Rangeland Ecosystem Science, Colorado State University. Jamestown, ND: Northern Prairie Wildlife Research Center Online. Available at: http://www.npwrc.usgs.gov/resource/plants/explant/index.htm (October 23, 2013).	• Provides brief descriptions of invasive plants found within Rocky Mountain National Park. Describes plant distribution, reproduction, impacts, and control methods. • Species addressed that are on the Project Plant List: *Elymus repens (Agropyron repens), Bromus tectorum, Centaurea stoebe (C. maculosa), Leucanthemum vulgare (Chrysanthemum leucanthemem), Cirsium arvense, Cirsium vulgare, Convulvulus arvensis, Euphorbia esula, Linaria vulgaris, Lythrum salicaria, Melilotus alba, Phalaris arundaceae*, and *Sonchus arvensis*.		☑
16	Minnesota Department of Natural Resources factsheets. Available at: http://www.dnr.state.mn.us/invasives/terrestrialplants/ (October 3, 2013).	• Brief factsheet describing plant identification, ecological threat, and control methods. • Information from invasive plant factsheets was taken from the booklet *Minnesota Invasive Non-native Terrestrial Plants, An Identification Guide for Resource Managers.* • Minnesota invasive plant profiles are available at http://www.dnr.state.mn.us/invasives/terrestrialplants/index.html. • Species addressed that are on the Project Plant List: Bull thistle (*Cirsium vulgare*), Canada thistle (*Cirsium arvense*), common tansy (*Tanacetum vulgare*), bird vetch (*Vicia cracca*), Japanese Knotweed (*Polygonum cuspidatum*), Leafy Spurge (*Euphorbia esula*), garlic mustard (*AIliaria petiolata*), Orange Hawkweed (*Hieracium aurantiacum*), Perennial Sowthistle (*Sonchus arvensis*), Oxeye Daisy (*Leucanthemum vulgare*), Siberian Pea Shrub (*Caragana arborescens*), Purple Loosestrife (*Lythrum salicaria*), Reed Canarygrass (*Phalaris arundinacea*), White Sweetclover (*Melilotus alba*), and Spotted Knapweed (*Centaurea stoebe*).	☑	☑
17	U.S. Department of Agriculture Forest Service, Forest Health Staff. 2006. Weed of the week: whitetop (*Cardaria draba).* U.S. Department of Agriculture Forest Service, Forest Health Staff, Newtown Square, PA. Available at: http://na.fs.fed.us/fhp/invasive_plants/weeds/whitetop.pdf. (October 23, 2013)	• Provides plant description, habitat, distribution, impacts, and control and management information for *Cardaria draba.*		☑

Matrix Tables A.1 & B.1 Reference	Author / Title / Source / Access Date	Summary	Disposal Information	Control Information
18	Colorado State Parks. 2005. Colorado State Parks; BMPs; weed profile whitetop/hoary cress (*Cardaria draba*). Available at: http://parks.state.co.us/SiteCollectionImages/parks/Programs/ParksResourceStewardship/Whitetop.pdf (October 4, 2013).	• Factsheet describing plant identification, distribution, biology, and control. • Additional species profiles from Colorado Department of Natural Resources may be found at: http://www.parks.state.co.us/NaturalResources/ParksResourceStewardship/NoxiousWeeds/SpeciesProfiles/Pages/ResourceStewardshipSpeciesProfile.aspx • Species addressed that are on the Project Plant List include: Canada Thistle (*Cirsium arvense*), Russian Knapweed (*Acroptilon repens*), Whitetops and its varieties (*Cardaria draba, C. pubescens, Lapidium latifolium*), Bull Thistle (*Cirsium vulgare*), Russian Knapweed (*Acroptilon repens*), Common Toadflax (*Linaria vulgaris*), and Oxeye Daisy (*Leucanthemum vulgare*).		☑
19	Montana State University Cooperative Extension. July 2013. Narrow leaf Hawk's beard (*Crepis tectorum).* Available at: *http://www.msuextension.org/invasiveplantsMangold/documents/Weed_Posts/2013/post/narrowleaf_hawksbeard_July.pdf* (October 3, 2013*)*	• A short synopsis on the identification, habitat, spread and management priorities of *Crepis tectorum*. • Removing the species by hand is most effective when found in small quantities. If present in a larger area herbicides can be used to diminish the spread of the invasive. Herbicides effective on dandelions have proved to work for *Crepis tectorum;* however, these herbicides may be detrimental to crops such as peas, lentils, canola, and flax.		☑
20	The Alaska Natural Heritage Program. March 11, 2010. Tracking weeds along the Iditarod National Historic Trail. Available at: http://aknhp.uaa.alaska.edu/wp-content/uploads/2010/11/Flagstad_Cortés_2010.pdf (October 8, 2013)	• This article reviews the control recommendations of Narrowleaf hawk's beard (*Crepis tectorum)*, Field mustard (*Brassica rapa*), Hempnettle (*Galeopsis tetrahit*), Flixweed (*Descurainia Sophia*), Foxtail barley (*Hordeum jubatum*) and Common timothy (*Phleum pretense*). • Each species has a section on its biography as well as control and management recommendations. The most common disposal method is to bag and remove picked plants for small infestations. For large infestations, application of herbicides is recommended. In both cases, monitoring is advised to ensure the problem doesn't persist. • Along the Iditarod Historic Trail, invasive species are concentrated in cities, cabins, and places frequented by humans. The most common transportation method for these species is uncertified weed-free straw used for dog bedding. • Species addressed that are on the Project Plant List include: Narrowleaf hawk's beard (*Crepis tectorum)*, Hempnettle (*Galeopsis tetrahit*), and Foxtail barley (*Hordeum jubatum*).	☑	☑
21	Michigan State University Extension. December 2009. An Identification Guide to Invasive Plants in Michigan's Natural Communities. Available at: http://mnfi.anr.msu.edu/invasive-species/InvasivePlantsFieldGuide.pdf (October 8, 2013)	• This document on invasive species organises species by trees, shrubs, woody vines, herbaceous plants and aquatic plants. Each plant has a short description of its habitat, growing tendencies, identifying features, and monitoring to management strategies • Guide reviews many management techniques. • Burning is the most common means of disposal, but is dependent on the amount of infestation and means of seed dispersal. Some species are fire resistant. • Species addressed that are on the Project Plant List include: Garlic mustard (*AIliaria petiolata*), Spotted Knapweed (*Centaurea stoebe*), Leafy Spurge (*Euphorbia esula*), White Sweetclover (*Melilotus alba*), Japanese Knotweed (*Polygonum cuspidatum*, *P. bohemicum*), Reed Canarygrass (*Phalaris arundinacea*), Purple Loosestrife (*Lythrum salicaria*), and Canada Thistle (*Cirsium arvense*).	☑	☑
22	U.S. Department of Agriculture Forest Service, Forest Health Staff. 2005. Weed of the week: quackgrass (*Elymus repens)*. U.S. Department of Agriculture Forest Service, Forest Health Staff, Newtown Square, PA. Available at: http://na.fs.fed.us/fhp/invasive_plants/weeds/quackgrass.pdf (October 23, 2013)	• Provides plant description, habitat, distribution, impacts, and control and management information for *Elymus repens.*		☑
23	University of Wyoming Cooperative Extension Service. 2006. Weed alert: Austrian fieldcress or Austrian yellowcress (*Rorippa austriaca)* synonym: (*Nasturtium austriacum*). Available at: http://www.uwyo.edu/capsweb/_files/docs/pest-alerts/weed-alert-austrian-fieldcress.pdf (October 24, 2013)	• Weed alert which provides brief overview of information on Austrian fieldcress (*Rorippa austriaca)*. Provides a plant description, distribution, reasons for concern, and control methods.		☑

Matrix Tables A.1 & B.1 Reference	Author / Title / Source / Access Date	Summary	Disposal Information	Control Information
24	Penn State University College of Agricultural Sciences Agricultural Research and Cooperative Extension. Quackgrass Management: An Integrated Approach. Available at: http://pubs.cas.psu.edu/freepubs/pdfs/uc041.pdf (October 9,2013)	• Quackgrass (*Elytrigia repens*) is a species which reproduces by rhizomes and is common in areas under cultivation. This publication reviews prevention techniques as well as cultural, mechanical, and chemical control methods in different crops.		☑
25	Graziano, G., A. Grant, and T. Wurtz. 2012. University of Alaska Fairbanks Cooperative Extension Service. Control of bird vetch (*Vicia cracca*). September. Available at: http://www.uaf.edu/files/ces/publications-db/catalog/anr/PMC-00341.pdf (October 9, 2013)	• A short review of control methods for bird vetch *(Vicia cracca*). • *V. cracca* is characterized as very aggressive and able to spread rapidly. • For more information regarding invasive plants is available at UAF Cooperative Extension Service, Telephone (877) 520-5211 or www.uaf.edu.ces		☑
26	Donaldson, S. and W. Hanson Mazet. 2011. University of Nevada Cooperative Extension. A Northern Nevada Homeowner's Guide to Identifying and Managing Western Salsify. Available at http://www.unce.unr.edu/publications/files/ho/2011/fs1162.pdf (October 9, 2013).	• A brief review of Western Salsify (*Tragopogon dubius*). Most commonly found in disturbed areas. Preventing seed production and dispersal is vital with this biennial invasive.		☑
27	Kansas Department of Agriculture. 2006. Plant protection and weed control – Quackgrass. Available at: http://www.ksda.gov/plant_protection/content/349/cid/583 (October 4, 2013)	• Describes quackgrass, how to control it and prevent its spread. • Provides information on effective herbicides. • Provides links to control of other species including Canada Thistle, Field Bindweed, Bull Thistle, and Russian Knapweed.		☑
28	Raleigh, S.M., T.R. Flanagan, and C. Veatch. 1962. Life history studies as related to weed control in the Northeast. Number 4 – Quackgrass. Agricultural Experiment Station, University of Rhode Island, Kingston. Available at: http://www.caf.wvu.edu/~forage/library/forglvst/bulletins/bul365.pdf (October 4, 2013)	• Describes the biology and growth of quackgrass. • Contains a literature cited section but no other contact information.		
29	Duval, J. 2006. Controlling Quackgrass. Available at: http://www.cog.ca/documents/ControlQuackgrassSU06.pdf (October 4, 2013)	• Provides information on quackgrass control. • Discusses quackgrass biology, how to prevent spread and destroy. • Contains an additional reference for more information.		☑
30	Clark, J.C. 2003. *Invasive Plant Prevention Guidelines.* Center for Invasive Plant Management, Bozeman, MT. Available at: http://www.weedcenter.org/store/docs/CIPM_prevention.pdf (September 15, 2013)	• Describes basic BMPs with a focus on preventing establishment of invasive species in new areas. • Recommendations are not species-specific		☑

Matrix Tables A.1 & B.1 Reference	Author / Title / Source / Access Date	Summary	Disposal Information	Control Information
31	Barker, A.V. and R.G. Prostak. 2008. *Herbicide Alternatives Research.* Prepared for: the Executive Office of Transportation and Public Works, Boston, MA. Prepared by: Plant Soil and Insect Sciences Univ of Mass. Available at: http://www.mhd.state.ma.us/downloads/vmp/Herbicide_Alternatives.pdf (September 7,2013)	• Compares the efficacy of two conventional herbicides (Roundup and Finale) against several alternative treatments to provide recommendation for the control of roadside weeds. Includes a detailed literature review. • Alternative methods evaluated: "Natural" herbicides, corn gluten meal, introduction of a competitive cover crop (*Trifolium repens*), thermal treatments with steam, flame, or hot water; application of mulch (bark or woodchips). • Includes a price comparison of control techniques. • Includes a list of DOT weed specialists the authors contacted for information regarding current DOT weed control practices (pg. 15). • Recommends: mulch applied 2-3 inches thickness after site preparation (i.e., thermal treatment) was highly effective although may need to re-treat some re-sprouts in the second growing season; consider clove oil or pelargonic acid when herbicide treatment is needed, but site is near water (but re-application will be necessary). • Does not recommend: mowing prior to herbicide application (reduces the effect); thermal treatments alone (re-growth occurs); general use of citric acetic acid, corn gluten meal, or introducing a *Trifolium repens* as a competitive cover crop (all were ineffective). • Cautions: burning alone is insufficient over the long-term; steaming (Aquacide) and foam/steam (Waipuna) alone were only slightly more effective than burning.		☑
32	British Columbia Ministry of Agriculture. Weed management. Available at: http://www.agf.gov.bc.ca/cropprot/weeds.htm#IWM (October 8, 2013)	• Web page includes links to weed management factsheets, weed alerts, field guides, and invasive plant management in British Columbia. • Weed management factsheets are available for spotted knapweed (*Centaurea stoebe, C. maculosa*), orange hawkweed (*Hieracium aurantiacum*), and Tansy Ragwort (*Senecio jacobaea*). A few additional species have pages containing limited information.		☑
33	U.S. Department of Agriculture Forest Service. Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available at: http://www.fs.fed.us/database/feis/plants/ (October 8, 2013)	• Database contains detailed species specific plant profiles. Includes sections on distribution, biology, fire ecology, and management. Control methods are addressed in the management section. • Includes a references section, in which many references are cited. This is a detailed report, but the reference page would be a good place to start if further information on a species is needed. • Species addressed that are on the Project Plant List: *Acroptilon repens, AIliaria petiolata, Cardaria draba, C. pubescens, Lepidium latifolium, Centaurea maculosa, Cirsium arvense, Cirsium vulgare, Convolvulus arvensis, Euphorbia esula, Hieracium aurantiacum, Hieracium caespitosum, Linaria vulgaris, Lythrum salicaria, Melilotus alba, Polygonum cuspidatum, Sonchus arvensis, Tragopogon dubius, Bromus tectorum, Elymus repens, Hordeum jubatum*, and *Phalaris arundinacea*.		☑
34	U.S. Department of Agriculture Forest Service. Dangerous travelers: controlling invasive plants along America's roadways. Available at: http://www.fs.fed.us/invasivespecies/prevention/dangeroustravelers.shtml (October 8, 2013)	• Video produced primarily for work crews and land managers of public lands and roads. Provides general strategies for control and prevention for spreading invasive plants along roadways. Provides a few specific examples of invasive species control, e.g. Scotchbroom (*Cytisus scoparius*). • Provides some general information on disposal of plant material, equipment cleaning, etc.	☑	☑
35	Minnesota Department of Transportation. 2013. Minnesota noxious weeds. Available at: http://www.dot.state.mn.us/roadsides/vegetation/pdf/noxiousweeds.pdf (October 8, 2013)	• Noxious weed information booklet from Minnesota DOT. Provides species specific information on weed identification, life history, and management. • Species addressed that are on the Project Plant List: *Centaurea stoebe, Alliaria petiolata, Cirsium arvense, Euphorbia esula, Lythrum salicaria*, and *Tanacetum vulgare.* • Booklet compiled by Dave Hanson, Telephone: (651) 366-3632; e-mail: David.L.Hanson@state.mn.us		☑
36	Devon County Council, United Kingdom. Japanese knotweed advice for developers and haulers. Available at: http://www.devon.gov.uk/index/environmentplanning/natural_environment/biodiversity/japanese_knotweed/advice_dev_and_haul.htm (October 10, 2013)	• Describes how to deal with knotweed at construction sites in the United Kingdom including legal requirements. • Discusses excavation depths, burial depths and treatments, herbicides to use, and transportation of infested soil. • Contains a citation and links to more information.	☑	☑

Matrix Tables A.1 & B.1 Reference	Author / Title / Source / Access Date	Summary	Disposal Information	Control Information
37	Maupin, Brian. 2013. Alaska Association of Conservation Districts. Telephone conversation with JD Mason, 3PPI, Inc. Subject: Invasive species disposal and management in southeast Alaska (October 9 and 10, 2013)	• Reference the report for more details.	☑	
38	Nice, G. 2007. Japanese knotweed in Indiana. Available at: https://ag.purdue.edu/btny/weedscience/documents/japaneseknotweed07.pdf (October 11, 2013)	• Describes reproductive biology of Japanese knotweed. • Briefly describes the introduction of Japanese knotweed, and spread and control options. • Has a reference section with potentially useful sources.		☑
39	Royal Horticulture Society. 2013. Japanese knotweed. Available at: http://apps.rhs.org.uk/advicesearch/profile.aspx?pid=218 (October 11, 2013)	• Mentions release of biocontrol agent for Japanese knotweed in the United Kingdom. • Describes Japanese knotweed, its invasiveness, control options. • Does not contain any other very useful links.		☑
40	Soll, J. 2004. Controlling knotweed in the Pacific Northwest. Available at: http://www.invasive.org/gist/moredocs/polspp01.pdf (October 14, 2013)	• Describes knotweed control in the Pacific Northwest. • Describes knotweed manual, mechanical, and chemical control. • Contains information on additional resources and information.		☑
41	University of California Agriculture and Natural Resources. UC Integrated Pest Management Program. 2011. Available at: http://www.ipm.ucdavis.edu/PMG/menu.weeds.html (October 22, 2013)	• Describes *Convolvulus arvensis* habit, description, and management controls such as prevention, cultural control, and chemical methods. • Species addressed that are on the Project Plant List: *Convolvulus arvensis*, *Cytisus scoparius,* and *Lepidium latifolium.*		☑
42	California Department of Food and Agriculture. Plant Health and Pest Prevention Services. Integrated Pest Control. Available at: http://www.cdfa.ca.gov/plant/ipc/weedinfo/winfo_table-sciname.htm (October 22, 2013)	• Contains detailed species specific plant profiles. Includes sections on general descriptions, seedling and root information, and characteristics, habitat, and control methods. • Describes control options such as prevention, mechanical, fire, biological, grazing, use of competitive species, chemicals, and integrated management. Integrated Pest Control can be reached at (916) 654-0768; website ipcinfo@cdfa.ca.gov • Species addressed that are on the Project Plant List: *Convolvulus arvensis, Cirsium vulgare, Acroptilon repens, Cardaria draba, C. pubescens, Lepidium latifolium, Cirsium arvense, Centaurea stoebe (Centaurea maculosa - synonym), Euphorbia esula, Senecio jacobaea, Linaria vulgaris, Cytisus scoparius, Sonchus arvensis, Lythrum salicaria, Polygonum cuspidatum, Rorippa austriaca,* and *Solanum carolinense*		☑
43	University of Nevada Cooperative Extension. Managing Austrian fieldcress. University of Nevada Cooperative Extension. Factsheet 04-11. Available at: http://www.unce.unr.edu/publications/files/nr/2004/FS0411.pdf (October 24, 2013)	• Factsheet describing identification, habitat, impact, prevention, and control methods for Austrian fieldcress.	☑	☑
44	University of Alaska Anchorage. Alaska Natural Heritage Program. Alaska Exotic Plants Information Clearinghouse. 2013. Available at: http://aknhp.uaa.alaska.edu/botany/akepic/non-native-plant-species-list/#content (October 24, 2013).	• Contains detailed species specific plant profiles. Profiles include a description, ecological impacts, biology, invasive potential, and distribution. Management techniques such as mechanical, chemical and biological potential are addressed but to varying levels of details. Some information, such as seed germination depths, may be useful for development of disposal strategies. • Species addressed that are on the Project Plant List: *Convolvulus arvensis, Crepis tectorum, Elymus repens, Cirsium vulgare, Acroptilon repens, Alliaria petiolata, Lepidium latifolium, Caragana arborescens, Cirsium arvense, Bromus tectorum, Centaurea stoebe, Hypochaeris radicata, Galeopsis tetrahit, G. bifida, Tragopogon dubius, Tanacetum vulgare, Leucanthemum vulgare, Hordeum jubatum, Senecio jacobaea, Linaria vulgaris, Cytisus scoparius, Vicia cracca, Sonchus arvensis, Prunus padus, Hieracium caespitosum, H. aurantiacum, Melilotus alba, Impatiens glandulifera, Phalaris arundinacea, Lythrum salicaria, Polygonum cuspidatum,* and *Lactuca pulchella (L. tatarica).* The Chippindale and Milton (1934) study cited regarding seed longevity of *Leucanthemum vulgare*, however, is based on an experimental design that did not definitlively establish the year of seed burial.	☑	☑

Matrix Tables A.1 & B.1 Reference	Author / Title / Source / Access Date	Summary	Disposal Information	Control Information
45	Colorado Department of Agriculture. 2008. Oxeye daisy identification and management. Colorado Department of Agriculture, Conservation Services Division. Lakewood, CO, USA. Available at: http://www.colorado.gov/cs/Satellite?blobcol=urldata&blobheader=application%2Fpdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1191397772841&ssbinary=true (October 17, 2013)	• Factsheet describes characteristics and basic management techniques for oxeye daisy.	☑	☑
46	Lancaster City Council. 2013. Home composting. Available at: https://www.lancaster.gov.uk/community-and-living/sustainable-living/the-great-outdoors/home-composting-advice/ (October 24, 2013)	• Composting advice that includes a short list of invasive species that must be killed prior to composting. • Includes information on composting as a disposal method. • Species addressed that are on the Project Plant List: Quackgrass (*Elymus repens*) and field bindweed (*Convolvulus arvensis*).	☑	☑
47	University of Nevada Cooperative Extension. Oxeye daisy. Nevada weeds project factsheet 06-23. Available at: http://www.unce.unr.edu/publications/files/ag/2006/fs0623.pdf (October 17, 2013)	• Factsheet describing features and some basic management techniques for oxeye daisy. • University of Nevada Cooperative Extension contact number: (775) 784-1334.	☑	☑
48	U.S. Department of Agriculture Forest Service. 2012. Field guide for managing Russian Knapweed in the southwest. U.S. Department of Agriculture Forest Service Southwestern Region TP-R3-16-13. Available at: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5410125.pdf (October 22, 2013)	• Describes plant characteristics, management, and control such as manual, mechanical, fire, cultural, biological, and chemical methods.	☑	☑
49	Garry Oak Ecosystems Recovery Team. 2013. Field manual: Invasive species in Garry Oak and associated ecosystems in BC. Available at: http://www.goert.ca/publications_resources/invasive_species.php#GDP (October 22, 2013)	• Contains detailed species specific plant profiles. Includes sections on general descriptions, habitat, and control methods such as physical, biological, chemical, and other techniques. • Species addressed that are on the Project Plant List: *Convolvulus arvensis*, *Centaurea biebersteinii (C. maculosa), Hypochaeris radicata, Leucanthemum vulgare, Senecio jacobaea,* and *Cytisus scoparius*		☑
50	U.S. Department of Agriculture Forest Service. 2012. Field guide for managing annual and biennial invasive thistles in the southwest. U.S. Department of Agriculture Forest Service Southwestern Region TP-R3-16-8. Available at: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5410130.pdf (October 15, 2013)	• Describes management, control, and disposal methods for four species of invasive thistles found in the southwestern United States. • Species addressed that are on the Project Plant List: Bull thistle (*Cirsium vulgare*).	☑	☑
51	Upadhyaya, M.K., M.Q. Qi, N.H. Furness, and R.S. Cranston. 1993. Meadow salsify and western salsify - two rangeland weeds of British Columbia. Rangelands 15: 148-150. Available at: https://journals.uair.arizona.edu/index.php/rangelands (October 24, 2013)	• Describes the problem of salsify as a weed in general, and provides information on the biology, distribution, habitat, and management of western salsify.		☑

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52	Kagima, D.2002. Bibliography and biology outline of *Galinsoga* spp. April. Available at: http://agron-www.agron.iastate.edu/~weeds/weedbiollibrary/517%20student%20pages/2000/Galinsogad..htm (October 16,2013)	• Reviews seed production, dispersion, and resiliency. Also covers reproduction and management options for several species within the genus *Galinsoga*.		☑
53	University of New Hampshire Cooperative Extension. 2010. Methods for disposing non-native invasive plants. Available at: http://extension.unh.edu/resources/files/Resource000988_Rep1720.pdf (October 17, 2013)	• Factsheet describing the different disposal methods generally used for disposing of invasive plant materials. Provides descriptions of disposal methods and makes recommendations for properly disposing of woody and non-woody plants; places plants into categories based on their method of reproduction. • Species addressed that are on the Project Plant List: *Alliaria petiolata, Centaurea maculosa, Lepidium latifolium, Lythrum salicaria*, and *Polygonum cuspidatum.* • States all species considered in the pamphlet may be buried to three feet deep if the pit is lined first with plastic except Japanese knotweed which requires five feet • Contact University of New Hampshire Cooperative Extension via by Telephone: (877) 398-4769 or email at answers@unh.edu or	☑	
54	Door County Soil and Water Conservation Department and Door County Invasive Species Team. Compost with care: how to dispose of invasive plants responsibly. Available at: http://map.co.door.wi.us/swcd/invasive/Get%20EDUCATED_files/Compost.pdf (October 17, 2013)	• Factsheet that includes a table listing several types of invasive plants, and guidelines for disposing of plant material for each type of plant based on how the plant reproduces and spreads. • Species addressed that are on the Project Plant List: garlic mustard *(AIliaria petiolata),* Japanese knotweed (*Polygonum cuspidatum, P. bohemicum*), reed canarygrass (*Phalaris arundinacea*), purple loosestrife (*Lythrum salicaria*), spotted knapweed (*Centaurea stoebe*), and leafy spurge (*Euphorbia esula*). More detailed sections exist for Japanese knotweed and garlic mustard. • The Door County Invasive Species Team can be contacted at (920) 746-5955.	☑	
55	Nuzzo Victoria, Fell George, Kennay Jill. 2013. Vegetation Management Guideline Garlic Mustard. Illinois Natural History Survey. Available at: http://wwx.inhs.illinois.edu/research/vmg/gmustard/ (October 16, 2013)	• Brief overview of garlic mustard and management techniques for control.		☑
56	University of Nevada Reno Cooperative Extension. Leafy spurge. Nevada weeds project factsheet 98-68. Available at: http://www.unce.unr.edu/publications/files/ho/other/fs9868.pdf (October 16, 2013)	• Factsheet describing identification, management, and disposal for leafy spurge (*Euphorbia esula*). • Contact Nevada Cooperative Extension contact number: (775) 784-1334.	☑	☑
57	Messersmith, C.G., R.G. Lym, and D.S. Galitz. 1985. Biology of leafy spurge *in* Watson, A.K. Ed. Leafy spurge, monograph series of the Weed Society of America. Weed Science Society of America. Available at: http://wssa.net/ pp 42-56. Available at: http://lib.ndsu.nodak.edu/repository/bitstream/handle/10365/3196/475MES85.pdf?sequence=1 (October 17, 2013)	• Scientific article describing the biology of leafy spurge.		
58	Oregon State University Rangeland Ecology and Management. 2005. Foxtail barley *Hordeum jubatum* L. Available at: http://oregonstate.edu/dept/range/sites/default/files/Foxtail_20Barley.pdf (October 18, 2013)	• Factsheet describing characteristics and management techniques for foxtail barley.		☑

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59	Ristau, R.J. 1994. Foxtail barley: biology and management. Colorado State Cooperative Extension. No. 3.109. Available at: http://www.co.laplata.co.us/sites/default/files/departments/weed/documents/education/Foxtailbarleymgmt.pdf (October 18, 2013)	• Factsheet describing biological characteristics, reproduction, and management of foxtail barley.		☑
60	Whatcom County Noxious Weed Board. Whatcom County Noxious Weed Fact Sheets. Available at: http://www.co.whatcom.wa.us/publicworks/weeds/factsheets.jsp (October 18, 2013)	• Site contains factsheets which provide descriptions, management, and disposal information for many invasive weed species. • Species addressed that are on the Project Plant List: purple loosestrife, bull thistle, Canada thistle, common tansy, garlic mustard, Japanese knotweed, orange hawkweed, oxeye daisy, perennial pepperweed (*Lepidium latifolium*), reed canary grass, scotch broom, spotted knapweed, and tansy ragwort. • Whatcom County Noxious Weed Control Board can be contacted at: (360) 715-7470.	☑	☑
61	Montana State University Extension. Weeds. Available at: http://store.msuextension.org/Departments/Agriculture-Topic-Categories/Weeds.aspx (October 24, 2013)	• Montana State University Extension Montguides. Guides describe range, identification, biology, impacts, and management for many species of weeds occurring in Montana. • Species addressed that are on the Project Plant List: *Centaurea stoebe, Acroptilon repens, Cardaria draba, C. pubescens, Bromus tectorum, Euphorbia esula, Tragopogon dubius, Tanacetum vulgare, Leucanthemum vulgare, Hieracium caespitosum, Hieracium aurantiacum,* and *Polygonum cuspidatum.*		☑
62	Whitson , T.D. Editor 1996. Weeds of the West. University of Wyoming, 630 pp	• Photographs and characteristics of many common western weeds • Some comments regarding species control		☑
63	Wiese, A. F., J. M. Sweeten, B. W. Bean, C. D. Salisbury, and E. W. Chenault. 1998. High temperature composting of cattle feedlot manure kills weed seeds. American Society of Agricultural Engineers Vol. 14(4): 377-380. Available at: http://amarillo.tamu.edu/files/2010/11/bean6_High-Temperature-Composting.pdf (October 22, 2013)	• Research outlines amount of heat and duration it took to kill field bindweed in compost and with dry air.		☑
64	Asgharipour, M. R. 2011. Effects of planting depth on germination and the emergence of field bindweed (*Convolvulus arvensis* L.). Asian Journal of Agricultural Sciences 3(6):459-461. Available at: http://maxwellsci.com/print/ajas/v3-459-461.pdf (October 22, 2013)	• Research outlines the relationship between seed depths and rate of germination.		☑
65	Narrowleaf hawksbeard (*Crepis tectorum*). 2007. Peninsula Clarion. Weekly Weeder. Available at: http://peninsulaclarion.com/stories/071307/outdoors_2948.shtml (October 23, 2013)	• Newspaper article describing the characteristics of *Crepis tectorum*. Gives information on rooting system and discourages composting.	☑	
66	Cortés-Burns, H., T. Nawrocki, E. Johnson, and D. Collet. 2011.Unalakleet wild river invasive plant management plan. The Alaska Natural Heritage Program, University of Alaska Anchorage. Available at: http://aknhp.uaa.alaska.edu/big-files/Botany/Publications/2011/Unalakleet_Wild_River_Invasive_Plant_Management_Plan.pdf (October 23, 2013).	• Report outlines invasive plant species monitoring and management along the Unalakleet River. Species specific information such as diagnostic traits, biology, and control methods such as manual, mechanical, and chemical techniques. • Does not include information on disposal other than to bag and remove plants. • Species addressed that are on the Project Plant List: *Crepis tectorum* and *Hordeum jubatum*		☑

Matrix Tables A.1 & B.1 Reference	Author / Title / Source / Access Date	Summary	Disposal Information	Control Information
67	Crop Compendium: Weeds. Bayer CropScience, Global Internet Portal. 2012. Available at: http://www.cropscience.bayer.com/en/Crop-Compendium/Pests-Diseases-Weeds/Weeds.aspx (October 23, 2013)	• Database gives species specific information on plant characteristics such as seed germination depths and viability, and control options that are primarily developed for agricultural settings. • Species addressed that are on the Project Plant List: *Bromus tectorum, Cirsium arvense, Convolvulus arvensis, Galensoga parviflora,* and *Galeopsis tetrahit.*		☑
68	Cortés-Burns, H., and L. A. Flagstad. 2010. Invasive plant inventory and bird cherry control trials. The Alaska Natural Heritage Program, University of Alaska Anchorage. Available at: http://anchoragecreeks.org/media/publications/Final%20Bird%20Cherry%20Report.pdf (October 23, 2013)	• Report documents the extent of *Prunus padus* on Anchorage trail networks and outlines strategies for controlling the species.		☑
69	Cooperative Extension Service, University of Alaska Fairbanks. Noxious weed identification and prevention. FGV-00144. 2006. Available at: http://uaf.edu/files/ces/aiswg/resources/FGV-00144-noxiousweed-IDprevention.pdf (October 23, 2013)	• Report lists noxious weeds, their identification, and a few non-species specific prevention measures.		☑
70	Natural Resources Conservation Service. NRCS plants database, fact sheets and plant guides. Available at: http://plants.usda.gov/ (October 18, 2013)	• Plant database contains information for many species of plants. Contains descriptions, distribution, seed size, habitat, life history, and management information for many species of plants. Not specifically geared toward invasive species. • Species addressed that are on the Project Plant List*: Caragana arborescens, Bromus tectorum, Centaurea stoebe, Impatiens glandulifera, Senecio jacobaea, Phalaris arundinacea*, and *Lythrum salicaria*.		☑
71	Colorado Weed Management Association. Noxious weed information. Available at: http://www.cwma.org/noxweeds.html#list (October 18, 2013)	• Website contains profiles for many species of invasive plants found in Colorado. Profiles contain information on identification, habitat, biology, and control and management for many species of invasive plants. • Species addressed that are on the Project Plant List: orange hawkweed, purple loosestrife, tansy ragwort, bull thistle, Canada thistle, common tansy, hoary cress (*Cardaria draba*), leafy spurge, oxeye daisy, perennial pepperweed (*Lepidium latifolium*), quackgrass, Russian knapweed, spotted knapweed, and yellow (common) toadflax.		☑
72	Invasive Species Specialist Group. Global Invasive Species Database. Available at: http://www.issg.org/database/welcome/ (October 23, 2013).	• Searchable database archives numerous invasive species. Database has information on description, habitat, impacts, biology, and management of invasive species. Species addressed that are on the Project Plant List: *Cirsium vulgare, Acroptilon repens, Lepidium latifolium, Cirsium arvense, Bromus tectorum, Euphorbia esula, Hypochaeris radicata, Senecio jacobaea, Linaria vulgaris, Cytisus scoparius, Hieracium aurantiacum, Melilotus alba, Impatiens glandulifera, Phalaris arundinacea, Lythrum salicaria,* and *Polygonum cuspidatum.*		☑
73	Wisconsin Reed Canary Grass Management Working Group. 2009. Reed canary grass (*Phalaris arundinacea*) management guide: recommendations for landowners and restoration professionals. U.S. Department of Agriculture Cooperative State Research, Education, and Extension Service PUB-FR-428 2009. Available at: ftp://ftp-fc.sc.egov.usda.gov/WA/Tech/RCG_management_0509.pdf (October 23, 2013)	• Information on the impacts, biology, and management of reed canary grass. Multiple methods for control are listed and situations where they should or should not be used.	☑	☑
74	Penn State Extension. Weed Identification. 2013. Available at: http://extension.psu.edu/pests/weeds/weed-id (October 23, 2013)	• Bulletins contain species specific biology, natural history, and control options such as mechanical and chemical techniques. • Species addressed that are on the Project Plant List: *Convolvulus arvensis, Cirsium arvense, Solanum carolinense*	☑	☑

Matrix Tables A.1 & B.1 Reference	Author / Title / Source / Access Date	Summary	Disposal Information	Control Information
75	U.S. Geological Survey Northern Prairie Wildlife Research Center. 2013. Native wildflowers of the North Dakota grasslands. Available at: http://www.npwrc.usgs.gov/resource/plants/wildflwr/species/lactoblo.htm (October 24, 2013).	• Information on the growth habits and vegetative characteristics of *Lactuca oblongifolia* which is a synonym to *Lactuca pulchella*.	☑	
76	The City of Calgary. 2013. Creeping bellflower. Available at: http://www.calgary.ca/CSPS/Parks/Pages/Planning-and-Operations/Pest-Management/Creeping-bellflower.aspx (October 25, 2013)	• Provides brief description with recommendations for control and disposal of *Campanula rapunculoides*.	☑	☑
77	Alberta Invasive Plants Council. Invasive alien species: creeping bellflower (*Campanula rapunculoides*). Available at: https://www.invasiveplants.ab.ca/factsheets/FS-CreepingBellflower.pdf (October 25, 2013)	• Provides information on identification, prevention, and control of *Campanula rapunculoides*.		☑
78	U.S. Department of Agriculture Forest Service. 2007. Invasive plant treatment guide-summer home lots. Available at: https://fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_036467.doc (October 25, 2013)	• Provides descriptions of plants, including reproduction, root characteristics, and control methods. • Species addressed that are on the Project Plant List: *Cirsium vulgare, Cirsium arvense, Tanacetum vulgare, Convulvulus arvensis, Alliaria petiolata, Polygonum cuspidatum, Hieracium aurantiacum, Leucanthemum vulgare, Impatiens glandulifera, Phalaris arundinacea, Cytisus scoparius, Centaurea biebersteinii (C. stoebe),* and *Senecio jacobaea.*		☑
79	United Kingdom Environment Agency. 2013. Japanese knotweed. Available at: http://www.environment-agency.gov.uk/homeandleisure/wildlife/130079.aspx (November 5, 2013)	• Contains United Kingdom government guidelines on knotweed management. • Provides identification tips, control, and disposal options. • Contains a link to more information.	☑	☑
80	Cortés-Burns, H., and L. Flagstad. 2013. Non-native plant management plan for Campbell Tract, Anchorage, Alaska. Prepared for the Bureau of Land Management-Anchorage Field Office. Alaska Natural Heritage Program, University of Alaska, Anchorage, Alaska. 74 pp.	• Management plan for non-native plant species along the Campbell Tract in Anchorage, Alaska. Includes recommendations for prioritizing management tasks, prevention, control, and disposal of non-native plant species. This report recommends that all manual or mechanical management practices be conducted prior to seed set. • This report recommends that all invasive plant materials collected by control efforts be bagged and incinerated in the Campbell Tract incinerator. This recommendation is based on the fact that some species may reproduce vegetatively, and therefore should not be left on-site.	☑	☑
81	Klein, H., C. Greenstein, M. Phelps, L. Flagstad, H. Cortés-Burns, and M. Carlson. 2012. Municipality of Anchorage Non-native Plant Survey: a survey of non-native plants along major and secondary roads in the Municipality of Anchorage, Alaska. Prepared for the Anchorage Park Foundation and Municipality of Anchorage. Alaska Natural Heritage Program, University of Alaska Anchorage, Alaska. 144 pp.	• Reports the results of a non-native plant survey of the Anchorage, Alaska area. This report contains recommendations for control and prioritizes specific sites and species for invasive species management. Contains recommendations for a mowing program, and contains profiles for many of the high priority species. • Contains limited information on disposal of plant material. • Species addressed that are on the Southeast Alaska DOT&PF Project Invasive Plant List: *Campanula rapunculoides, Cirsium arvense, Hieracium aurantiacum, Lepidium latifolium, Leucanthemum vulgare, Linaria vulgaris, Melilotus alba, Phalaris arundinacea, Sonchus arvensis, Tanacetum vulgare*, and *Vicia cracca.*	☑	☑
82	Nickelson, Sally. 2013. Cedar River Municipal Watershed, Seattle Public Utilities. Telephone conversation with JD Mason, 3PPI, Inc. October 17.	• Interview subject: Use of geotextiles to control invasive species.		☑

Matrix Tables A.1 & B.1 Reference	Author / Title / Source / Access Date	Summary	Disposal Information	Control Information
83	Miller, Tim. 2013. Washington State University. Webinar sponsored by UAF Cooperative Extension. Subject: Knotweed Control, November 20, 2013. Presentation posted at: http://www.uaf.edu/ces/pests/cnipm/k12/webinars/	• Webinar lecture on control of Japanese knotweed sponsored by University of Alaska Fairbanks Cooperative Extension • Some comments cited in the ISMM were made during the discussion that followed the presentation		☑
84	Weedy Wildflowers of Illinois. Available at: http://www.illinoiswildflowers.info/weeds/weed_index.htm (February 10, 2014)	• Contains morphology and phenology information for many weedy species	☑	
85	Francis, R.A., K.A. Riley, and S.P.G Hoggart 2008. Vegetative regeneration of *Fallopia japonica* (Houtt.) Ronse Decraene (Japanese knotweed) at varying burial depths. Weed Biology and Management 8:69-72.	• Stem fragments (10cm and 30cm) and root fragments (30cm) of Japanese knotweed were buried up to 10 inches deep in sand. Fewer of the smaller stem fragments produced shoots than the bigger ones, but both the 30 cm stem and 10 cm root fragments produced an average of almost 3 shoots each at 10 inches depth	☑	
86	Gustavsson, A.D. 1997. Growth and regenerative capacity of plants of Cirsium arvense. Wed Research Volume 37: 229-236.	• Field and greenhouse experiments demonstrated that when *Cirsium arvense* plants have 8-10 leaves, root reserves are depleted. When plants with 8-10 leaves were uprooted and re-buried to 8 inches depth, no shoots had emerged after a 28 day monitoring period	☑	☑
87	Sciegienka, J.K, E.N Keren, and F.D. Menalled 2011. Impact of root fragment dimension, weight, burial depth, and water regime on Cirsium arvense emergence and growth.	• Field and greenhouse experiments tested the effects of *Cirsium arvense* root fragment length (up to 16 inches) and biomass, burial depth (up to 8 inches), and water stress on production of new shoots.	☑	
88	Smayda Environmental Associates, Inc. 2009. Noxious Weed Management Plan for the Henry M. Jackson Hydroelectric Project (FERC No. 2157) Prepared for the PUD No 1 of Snohomish County, Everett, WA. Available at: http://www.snopud.com/Site/Content/Documents/relicensing/License/NWMP.pdf	• Includes statement that, with the exception of Japanese knotweed, the weeds found at this site in western Washington may be disposed of by burying under at least two feet of weed free soil or rock fill. The statement is not supported with a citation or description of a field trial. Six of the species treated in this report were found at this site.	☑	
89	Pyle C. 2006 Invader of the month - Garlic Mustard - *Alliara petiolata* (Bieb.) Cavara & Grande. Connecticut Invasive Plant Working Group. Available at: http://www.hort.uconn.edu/cipwg/invader_month/invader_of_the_month_Mar06_alliaria.pdf	• Summary of garlic mustard characteristics, methods of control, and, assessment of effectiveness of solarization of plant parts as disposal	☑	☑
90	U. S. Department of Agriculture. 1970. Common Weeds of the United States Agricultural Research Service. Illustrations are available through the Robert W. Freckmann Herbarium website http://wisplants.uwsp.edu/scripts/detail.asp?SpCode=LACPUL	• Botanical illustrations		
91	Whitson, T.D. Editor 1996. Weeds of the West. University of Wyoming, 630 pp.	• Photographs and characteristics of many common western weeds • Some comments regarding species control		☑
92	Toole, E.H. and E. Brown. 1946. Final results of the Duvel buried seed experiment. J of Agricultural Research Volume 72: 201-201	• Seeds of 107 species were buried in porous containers at 8, 22, and 42 inches depth and then excavated and re-planted under controlled conditions at several intervals up to 39 years after burial. Species tested include *Phalaris arundinacea, Elymus repens,* and *Leucanthemum vulgare*	☑	

Notes: [1] Table A.1: Invasive Species Management Matrix by Disposal Method (Appendix A)
[2] Table B.1: Invasive Species Management Matrix by Control Method (Appendix B)
[3] Date web site was accessed.
[4] Project Plant List: Alaska DOT&PF Southeast Region Invasive Species Management Plan Plant List detailed in the Statement of Services
[5] BMP: Best management practice

perennial sowthistle

Sonchus arvensis ssp. *uliginosus* (Bieb.) Nyman

Synonyms: *Sonchus arvensis* var. *glabrescens* Guenth., Grab.& Wimmer, *S. uliginosus* Bieb.
Other common name: field sowthistle, marsh sowthistle, moist sowthistle, perennial sowthistle, sowthistle
Family: Asteraceae

Invasiveness Rank: **73** The invasiveness rank is calculated based on a species' ecological impacts, biological attributes, distribution, and response to control measures. The ranks are scaled from 0 to 100, with 0 representing a plant that poses no threat to native ecosystems and 100 representing a plant that poses a major threat to native ecosystems.

Description

Perennial sowthistle is a succulent, rhizomatous, perennial plant that grows up to 122 cm tall with extensive root systems that grow down to 3 m deep. All parts of the plant contain a white, milky juice. Leaves are alternate, lanceolate, and 6 ½ to 40 ½ cm long with clasping bases and soft-prickly margins that vary from deeply toothed to nearly entire. Flower heads are bright yellow and 2 ½ to 5 cm wide. Involucral bracts and flower stalks are covered with yellow gland-tipped hairs. Seeds are dark brown, prominently ridged, and wrinkled with tufts of soft, white bristles (Royer and Dickinson 1999, Whitson et al. 2000).

Glabrous involucral bracts of *Sonchus arvensis* ssp. *uliginosus* (Bieb.) Nyman. Photo by R. Old.

Similar Species: Sonchus arvensis ssp. *uliginosus* is similar to *S. arvensis* but lacks glandular hairs on the involucral bracts and flower stalks. Its involucral bracts are green with white margins. Perennial sowthistle is common on disturbed soils (Royer and Dickinson 1999, Whitson et al. 2000).

Foliage of *Sonchus arvensis* ssp. *uliginosus* (Bieb.) Nyman. Photo by Ohio State Weed Lab Archive.

Ecological Impact

Impact on community composition, structure, and interactions: At high densities, perennial sowthistle drastically reduces water resources and possibly decreases the number of plant species in communities (Butterfield et al. 1996). It is a known host for a number of plant pests. Perennial sowthistle is acceptable feed for rabbits and other foraging animals (Noxious Weed Control Board 2003).

Impact on ecosystem processes: Perennial sowthistle may modify or retard the successional establishment of native species (Butterfield et al. 1996).

Biology and Invasive Potential

Reproductive potential: Perennial sowthistle reproduces sexually by seeds and vegetatively from rhizomes. Each plant can produce 4,000 to 13,000 seeds. Seeds can remain dormant in the soil for up to six years; usually, however, less than 40% of the seeds are viable (Royer and Dickinson 1999). Perennial sowthistle can produce new plants from rhizome buds at depths of down to 61 cm. Spreading rootstocks are the primary means of invasion into new areas (Rutledge and McLendon 1996, Royer and Dickinson 1999).

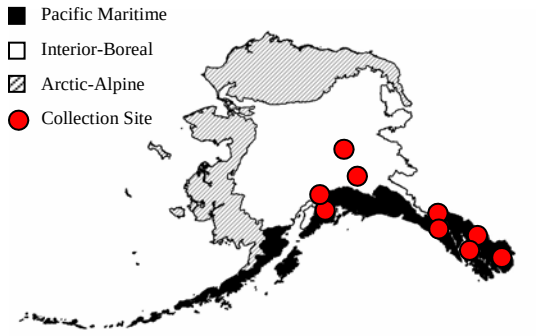
Potential for long-distance dispersal: Each seed has a pappus and can be spread by wind (Rutledge and McLendon 1996, Royer and Dickinson 1999). Seeds can become attached to animals (Butterfield et al. 1996).
Potential to be spread by human activity: Seeds can be moved on vehicles and farm equipment. They have been documented as contaminants in commercial seeds and hay (Butterfield et al. 1996, Noxious Weed Control Board 2003).
Germination requirements: Seeds germinate at depths of 6 to 31 ½ mm in the soil. The optimal temperature for germination is between 25°C and 30°C. Vegetation cover and litter promote germination (Butterfield et al. 1996, Rutledge and McLendon 1996, Royer and Dickinson 1999).
Growth requirements: Although perennial sowthistle is adapted to a variety of soils, it grows best on rich, non-compacted, moist, fine-textured soils with pH between 5.2 and 7.2. Perennial sowthistle can survive temperatures as low as -16°C (Butterfield et al. 1996, Rutledge and McLendon 1996).
Congeneric weeds: Spiny sowthistle (*Sonchus asper*) and common sowthistle (*S. oleraceus*) are non-native weeds known to occur in Alaska. All *Sonchus* species are considered noxious weeds in Ontario. Common sowthistle is considered a noxious weed in Alberta, British Colombia, Manitoba, Quebec, and Saskatchewan (Whitson et al. 2000, Invaders 2010).

Legal Listings

- ☐ Has not been declared noxious
- ☒ Listed noxious in Alaska
- ☒ Listed noxious by other states (AZ, CO, CT, HI, IA, ID, IL, IN, MA, ME, MI, MN, ND, SD, VA, VT, WA, WY)
- ☐ Federal noxious weed
- ☒ Listed noxious in Canada or other countries (AB, BC, MB, QC, SK)

Distribution and Abundance

Perennial sowthistle commonly grows in gardens, cultivated areas, roadsides, and fertile waste areas (Rutledge and McLendon 1996, Whitson et al. 2000). It can also grow in disturbed sites in prairies, woods, meadows, lawns, stream banks, and lake shores (Gubanov et al. 1995, Butterfield et al. 1996, Noxious Weed Control Board 2003).
Native and current distribution: Perennial sowthistle is native to Europe, western Asia, and Iceland. It has spread widely throughout the northern United States and southern Canada and has also established in South America, Australia, and New Zealand (USDA 2002, Noxious Weed Control Board 2003). *Sonchus arvensis* has been documented from the Pacific Maritime and Interior-Boreal ecogeographic regions of Alaska (AKEPIC 2010).



Distribution of perennial sowthistle (*Sonchus arvensis*) in Alaska

Management

Biological, chemical, and mechanical control methods have been used on perennial sowthistle. Mechanical treatments must be repeated several times per growing season for multiple, consecutive years to reduce seed production and root reserves. Perennial sowthistle is relatively resistant to many common broadleaf herbicides (Butterfield et al. 1996, Rutledge and McLendon 1996).

References:

AKEPIC database. Alaska Exotic Plant Information Clearinghouse Database. 2010. Available: http://akweeds.uaa.alaska.edu/

Alaska Administrative Code. Title 11, Chapter 34. 1987. Alaska Department of Natural Resources. Division of Agriculture.

Butterfield, C., J. Stubbendieck, and J. Stumpf. 1996. Species abstracts of highly disruptive exotic plants. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/plants/exoticab/index.htm (Version 16JUL97).

eFloras. 2008. Published on the Internet http://www.efloras.org [accessed 18 October 2010]. Missouri Botanical Garden, St. Louis, MO & Harvard University Herbaria, Cambridge, MA.

Gubanov, I.A., K.B. Kiseleva, B.C. Novikov, B.N. Tihomirov. 1995. Flora of vascular plants of Center European Russia. Moscow. Argus. 558 pp.

Invaders Database System. 2010. University of Montana. Missoula, MT. http://invader.dbs.umt.edu/

ITIS. 2010. Integrated Taxonomic Information System. http://www.itis.gov/

Noxious Weed Control Board. Washington State. 2003. Perennial sowthistle (*Sonchus arvensis* L. ssp.

arvensis). Available: http://www.nwcb.wa.gov/INDEX.htm [Oct 7, 2004].

Royer, F. R. Dickinson. 1999. Weeds of the Northern U.S. and Canada. The University of Alberta press. 434 pp.

Rutledge, C.R., and T. McLendon. 1996. An Assessment of Exotic Plant Species of Rocky Mountain National Park. Department of Rangeland Ecosystem Science, Colorado State University. Jamestown ND: Northern Prairie Wildlife Research Center Online. http://www.npwrc.usgs.gov/resource/plants/exp lant/index.htm (Version 15DEC98).

USDA (United States Department of Agriculture), NRCS (Natural Resource Conservation Service). 2002. The PLANTS Database, Version 3.5 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

Whitson, T. D., L. C. Burrill, S. A. Dewey, D. W. Cudney, B. E. Nelson, R. D. Lee, R. Parker. 2000. Weeds of the West. The Western Society of Weed Science in cooperation with the Western United States Land Grant Universities, Cooperative Extension Services. University of Wyoming. Laramie, Wyoming. 630 pp.

bird vetch
Vicia cracca L.

Synonyms: *Ervum cracca* (Linnaeus) Trautvetter; *Vicia cracca* f. *canescens* Maximowicz; *V. cracca* var. *canescens* (Maximo wicz) Franchet & Savatier; *V. cracca* ssp. *heteropus* Freyn; *V. cracca* var. *japonica* Miquel.
Other common names: cow vetch
Family: Fabaceae

Invasiveness Rank: **73** The invasiveness rank is calculated based on a species' ecological impacts, biological attributes, distribution, and response to control measures. The ranks are scaled from 0 to 100, with 0 representing a plant that poses no threat to native ecosystems and 100 representing a plant that poses a major threat to native ecosystems.

Description
Bird vetch is a climbing or trailing, perennial plant that grows 40 to 150 cm tall. Stems are weak and hairy or glabrous, and they cling to structures. Leaves consist of eight to ten pairs of narrow leaflets and have coiling, branched tendrils at the ends. Leaflets are linear to oblong, 11 to 30 mm long, and 2 to 4 mm wide with round or acute tips. Flowers are blue-violet and are borne on one-sided, many-flowered racemes. Pods are narrow, lanceolate, and 20 to 25 mm long with beaked apexes (Hultén 1968, eFloras 2008).

Racemes of *Vicia cracca* L.

Similar species: There are a number of other climbing, blue-flowered legumes in Alaska. Bird vetch can be distinguished from similar species by the presence of fully developed inflorescences that are longer than the subtending leaves, many-flowered, one-sided racemes, entire stipules, leaflets with sparse, unobvious lateral veins, gradually rounded calyxes, and lance-attenuate teeth on the lower calyxes (Cody 1996).

Ecological Impact
Impact on community composition, structure, and interactions: Bird vetch overgrows herbaceous vegetation and can climb over shrubs, such as alder and willow. It forms symbiotic relationships with *Rhizobium* bacteria, allowing it to fix nitrogen. This species is highly palatable to grazing and browsing animals. Flowers are visited by native bees, and their presence may alter the pollination ecology of the surrounding area (Klebesadel 1980, Aarssen et al. 1986).
Impact on ecosystem processes: Bird vetch alters soil conditions by fixing atmospheric nitrogen (Aarssen et al. 1986).

Leaf of *Vicia cracca* L. with coiling, branched tendrils.

Biology and Invasive Potential
Reproductive potential: Bird vetch reproduces sexually by seeds and vegetatively from spreading, underground roots (Aarssen et al. 1986). Each plant produces a copious amount of seeds. Seeds remain viable for a number of years, and large seed banks are common.
Role of disturbance in establishment: Bird vetch establishes in disturbed, grassy areas and roadsides.
Potential for long-distance dispersal: Seeds are large

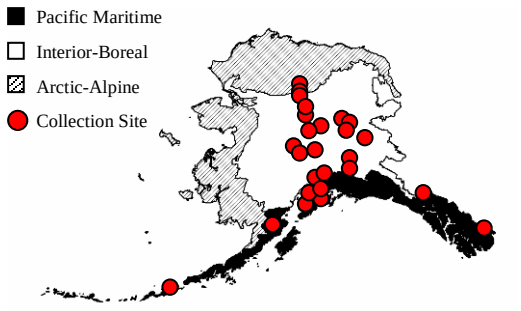
and not easily dispersed (Densmore et al. 2001).
Potential to be spread by human activity: Bird vetch is used as a cover and forage crop, and it frequently escapes cultivation. It can be introduced with topsoil. Seeds can be carried in tangled vegetation clinging to maintenance or construction equipment (Densmore et al. 2001).
Germination requirements: Seeds germinate underground. Cold stratification is not required for germination, but scarification significantly increases germination rates (Aarssen et al. 1986).
Growth requirements: Bird vetch is adapted to all soil textures with pH levels from 4.9 to 7. It is somewhat tolerant of shade and highly tolerant of drought, fire, and high calcium carbonate ($CaCO_3$) content. This species can withstand temperatures down to -36°C. It requires 110 frost-free days to grow and reproduce successfully (USDA 2002).
Congeneric weeds: *Vicia benghalensis*, *V. disperma*, *V. hirsuta*, *V. lathyroides*, *V. pannonica*, *V. sativa*, *V. tetrasperma*, and *V. villosa* are known to occur as non-native weeds in North America (Hultén 1968, Whitson et al. 2000, USDA 2002).

Legal Listings

☐ Has not been declared noxious
☒ Listed noxious in Alaska
☐ Listed noxious by other states
☐ Federal noxious weed
☐ Listed noxious in Canada or other countries

Distribution and Abundance

Bird vetch grows in waste places, old fields, and roadsides.
Native and current distribution: Bird vetch is native to Europe. It can be found throughout Canada and through much of the U.S. This species was introduced to Alaska as a forage crop in Fairbanks and Palmer, and it has spread relatively slowly from these urban centers. Bird vetch has been documented from all three ecogeographic regions of Alaska (AKEPIC 2010).



Distribution of bird vetch in Alaska

Management

This species is very difficult to eradicate once established.

References:

Aarssen, L.W., I.V. Hall, K.I.N. Jensen. 1986. The biology of Canadian weeds. 76. *Vicia angustifolia* L., *V. cracca* L., *V. sativa* L., *V. tetrasperma* (L.) Schreb. and *V. villosa* Roth. Canadian Journal of Plant Science. 66 (3):711-737.

AKEPIC database. Alaska Exotic Plant Information Clearinghouse Database. 2010. Available: http://akweeds.uaa.alaska.edu/

Alaska Administrative Code. Title 11, Chapter 34. 1987. Alaska Department of Natural Resources. Division of Agriculture.

Cody, W. 1996. Flora of the Yukon Territory. National Research Council of Canada Monograph Publishing Program. Ottawa, ON. 634 p.

Densmore, R.V., P.C. McKee, C. Roland. 2001. Exotic plants in Alaskan National Park Units. Report on file with the National Park Service – Alaska Region, Anchorage, Alaska. 143 pp.

eFloras. 2008. Published on the Internet http://www.efloras.org [accessed 19 October 2010]. Missouri Botanical Garden, St. Louis, MO & Harvard University Herbaria, Cambridge, MA.

Hultén, E. 1968. Flora of Alaska and Neighboring Territories. Stanford University Press, Stanford, CA. 1008 pp.

Invaders Database System. 2010. University of Montana. Missoula, MT. http://invader.dbs.umt.edu/

ITIS. 2010. Integrated Taxonomic Information System. http://www.itis.gov/

Klebesadel, L.J. 1980. Birdvetch. Forage crop, ground cover, ornamental, or weed? Agroborealis. January/1980: 46-49.

USDA (United States Department of Agriculture), NRCS (Natural Resource Conservation Service). 2002. The PLANTS Database, Version 3.5 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

Whitson, T.D., L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, R. Parker. 2000. Weeds of the West. The Western Society of Weed Science in cooperation with the Western United States Land Grant Universities, Cooperative Extension Services. University of Wyoming. Laramie, Wyoming. 630 pp.