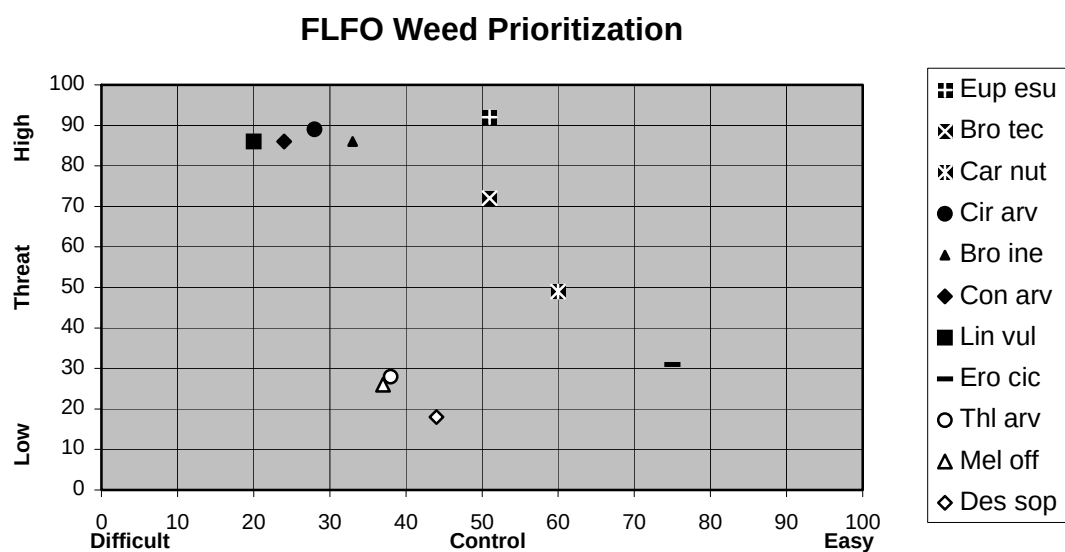


Assessment and Management Plan for Weeds and Exotic Plants on Florissant Fossil Beds National Monument



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September 1999

Preface

Non-native species are a threat to our natural heritage and to natural values. Invasive and noxious species are an especially serious threat to natural resources. Thus, the purpose of this document is to lay the foundation for an integrated weed management program that Monument biologists and managers can refer to as they carry out the important and necessary work of battling our invasive plants.

Chapter 1 serves to illustrate why we should be concerned about noxious weeds and provides a prioritization of weed control efforts for the Monument. Chapter 2 provides abstracts for those species reported at FLFO which are on the Colorado Noxious Weed List and a few other selected species. This is followed in chapter 3 by recommendations specific to the Monument for selected species, and gives a summary of what control measures were used in 1999. Chapter 4 contains guidelines for spraying operations. Monitoring and evaluation procedures are outlined in chapter 5. Recommendations for future work are given in chapter 6. Cited literature can be found in appendix A, the Colorado Noxious Weed list in appendix B, the completed Exotic Species Ranking forms in appendix C, appendix D contains a map showing where 1999 spraying operations were conducted, and appendix E provides information on the equipment used in the boom spraying operation.

Table of Contents

1. Introduction
2. Abstracts for Noxious Weeds and Other Selected Species
3. Specific Recommendations for Species of Concern
4. Guidelines for Spraying Operations
5. Monitoring and Evaluation
6. Future Work

APPENDIX A - Literature Cited

APPENDIX B – Colorado Noxious Weed List

APPENDIX C – Completed Exotic Species Ranking Forms

APPENDIX D - Map Showing Areas Treated with Herbicide in 1999

APPENDIX E – Literature for Boom Sprayer, Tank, Pump, and Nozzle

CHAPTER 1
INTRODUCTION

Secretary of the Interior, Bruce Babbitt states, “Exotic invaders have played a significant role in the listing of nearly half of all federal threatened and endangered species.”¹ Non-native species can alter ecosystem processes, degrade wildlife habitat, decrease biological diversity, and cause economic loss. Edward O. Wilson has stated, “Alien species are the stealth destroyers of the American environment.”² Following habitat destruction, impacts from invasive species are the greatest cause of species decline.²

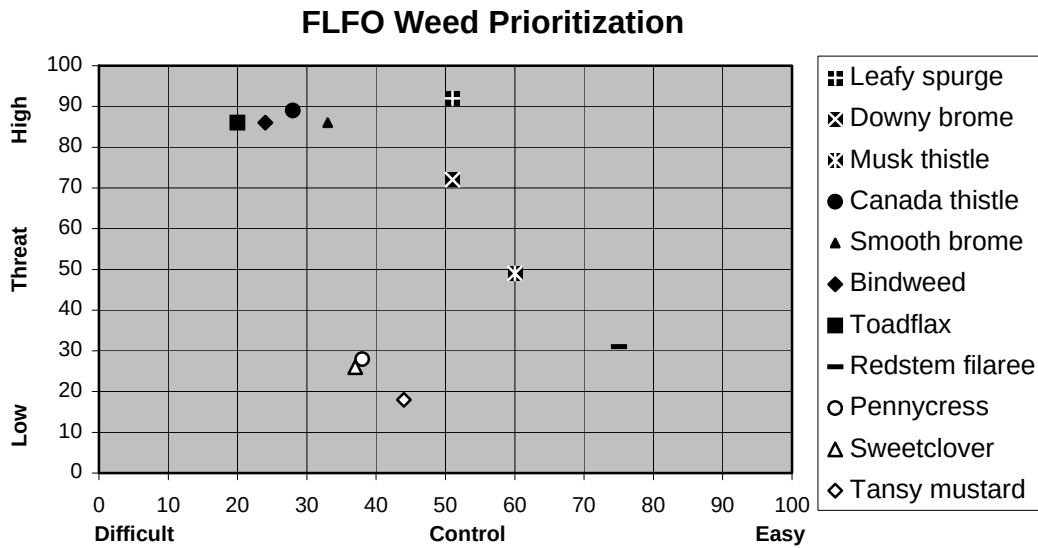
An estimated 4600 acres of federal lands are colonized each *day* by non-native plants.³ This is an area the size of Delaware. Noxious weeds are increasing on Bureau of Land Management (BLM) lands at a rate of about 2300 acres per day.³ More than 250,000 acres of National Forest Service (USFS) land in Colorado are infested with noxious weeds, out of an estimated 6-7 million acres of USFS land nationwide. Infestations are spreading at a rate of 8-12% per year on USFS lands.⁴ The National Park Service is not immune. An estimated seven million acres of National Park lands are infected by invasive plants.³

Preliminary data shows that Florissant Fossil Beds National Monument (FLFO) has at least 30 acres of state classified noxious weeds.⁵ Since 1999 data from the weed mapping project is currently being corrected and combined with 1998 data, the only information currently available are polygon and line data for the seven species mapped in 1998. Line data were converted to areas.⁵ Since the ranking used to generate the graph in Figure 1 uses classes of areas instead of actual areas, it is unlikely the final data will change the priority for control measures. Those species partially mapped in 1998 were *Bromus inermis*, *Carduus nutans*, *Cirsium arvense*, *Convolvulus arvensis*, *Linaria vulgaris*, *Melilotus officinalis*, and *Thlaspi arvense*. They occupy an estimated combined area exceeding 465 acres.⁵

These seven species plus *Euphorbia esula*, *Bromus tectorum*, *Erodium cicutarium*, and *Descurainia sophia* were evaluated using adopted NPS methodology⁶. The outcome is summarized in the Figure 1.

Note that the first and eighth species listed (leafy spurge and redstem filaree) have been reported but not recently confirmed on the Monument. Of the confirmed species, Canada thistle presents the greatest threat to native communities, with yellow toadflax, field bindweed, and smooth brome tied for second place. However, when considering both threat and ease of control, the priority should first be placed on eradicating downy brome (the 5th threat), and musk thistle (the 6th threat). Only after these six species are contained, should resources be directed on controlling the remaining species (pennycress, yellow sweetclover, and tansy mustard). However, by then a new assessment should be undertaken to include all non-native species, which will likely result in a reordering of priorities. Note that the ranked species are state listed noxious weeds except for smooth brome, yellow sweetclover, and pennycress.

Figure 1. Priority of Exotic Species for Control at FLFO.



With 3 exceptions, time and priority constraints allowed evaluation of only those species found at FLFO which were on the Colorado Noxious Weed List. The exceptions were smooth brome, yellow sweetclover, and pennycress. This is only twenty-two percent (eleven out of the reportedly fifty) of the non-native species occurring on the Monument.

After control efforts are firmly established and underway, attempts should be made to incorporate the remaining non-noxious, non-native flora into a comprehensive weed management plan by providing species abstracts similar to those found in chapter 2.

Table 1. NON-NATIVE FLORA REPORTEDLY FOUND AT FLFO.

Scientific Name	Common Name	State Noxious Weed	Non-Native	Verified at FLFO*
<i>Agropyron cristatum</i>	Crested Wheatgrass		Y	Y
<i>Agropyron repens</i>	Quackgrass		Y	Y
<i>Agrostis gigantea</i>	(Redtop)		Y	Y
<i>Amaranthus retroflexus</i>	Redroot Pigweed		Y	
<i>Armoracia rusticana</i>	Horseradish		Y	
<i>Artemisia biennis</i>	Biennial Wormwood		Y	
<i>Avena fatua</i> var. <i>sativa</i>	Wild Oat		Y	Y
<i>Axyris amaranthoides</i>			Y	
<i>Bouteloua simplex</i>			Y	
<i>Bromus inermis</i>	Smooth Brome		Y	Y, M
<i>Bromus tectorum</i>	Cheatgrass	Y	Y	Y
<i>Camelina microcarpa</i>	Smallseed False Flax		Y	
<i>Cardaria draba</i>	Hoary Cress		Y	Y
<i>Carduus nutans</i>	Musk Thistle	Y	Y	Y, M
<i>Chamaesyce erpyllifolia</i>	Thymed Leafed Spurge		Y	
<i>Chenopodium album</i>	Lamb's Quarters		Y	Y
<i>Chenopodium capitatum</i>	Strawberry blight		Y	
<i>Chenopodium foliosum</i>			Y	
<i>Cirsium arvense</i>	Canada Thistle	Y	Y	Y, M
<i>Convolvulus arvensis</i>	Field Bindweed	Y	Y	Y, M
<i>Descurainia sophia</i>	Tansy Mustard	Y	Y	Y
<i>Draba nemorosa</i>	Yellow Whitlowort		Y	
<i>Elymus juncea</i>			Y	Y
<i>Erodium cicutarium</i>	Redstem filaree	Y	Y	

Table 1. NON-NATIVE FLORA REPORTEDLY FOUND AT FLFO Continued.

Scientific Name	Common Name	State Noxious Weed	Non-Native	Verified at FLFO*
<i>Euphorbia esula</i>	Leafy Spurge	Y	Y	N
<i>Fallopia convolvulus</i>	Black Bindweed		Y	Y
<i>Juncus bufonius</i>	Toad Rush		Y	
<i>Linaria vulgaris</i>	Yellow Toadflax	Y	Y	Y, M
<i>Lolium perenne</i>	Perennial Rye Grass		Y	Y
<i>Medicago lupulina</i>	Black Medic		Y	
<i>Medicago sativa</i>	Alfalfa		Y	
<i>Melilotus officinalis</i>	Yellow Sweetclover		Y	Y, M
<i>Phalaroides rundinacea</i>	Reed Canary Grass		Y	Y
<i>Phleum pratense</i>	Timothy		Y	Y
<i>Plantago lanceolata</i>	Buckhorn Plantain		Y	Y
<i>Plantago major</i>	Broadleaf Plantain		Y	Y
<i>Poa compressa</i>	Canada Bluegrass		Y	Y
<i>Poa pratense</i>	Kentucky Bluegrass		Y	Y
<i>Polygonum lapathifolia</i>	Pale Smartweed		Y	Y
<i>Polygonum renastratum</i>	Devils Shoestrings		Y	Y
<i>Ranunculus clerata</i>	Blister Buttercup		Y	Y
<i>Rumex acetosella</i>	Sheep Sorrell		Y	Y
<i>Taraxacum officinale</i>	Dandelion		Y	Y
<i>Thlaspi arvense</i>	Field Pennycress		Y	Y, M
<i>Tragopogon dubius</i>	Western Salsify		Y	Y
<i>Trifolium hybridum</i>	Alsike Clover		Y	
<i>Trifolium repens</i>	White Clover		Y	Y
<i>Triticum aestivum</i>	Wheat		Y	Y
<i>Ximenesia encelioides</i>			Y	

*Y means this species has been sighted on FLFO by the author. N means it has been searched for and has not been seen. M denotes this species has been mapped. Blank means it has not been seen with casual observations.

CHAPTER 2
SPECIES OF CONCERN ABSTRACTS

***Bromus inermis* Leyss. (*Bromopsis inermis*)**
Smooth Brome (Poaceae - Graminae)⁷

Current level of Impact

Known locations in FLFO: Terraced fields south, south-east of Cusack's Potato Barn, In fields near and around Nelson Ranch, and in terraced field west of Hornbek Homestead, and seeded along pipeline easement, among other places. Extensively planted in old agricultural and hay fields prior to becoming a National Monument.

Assessment: It is not believed to be expanding. Populations cover an area greater than 430 acres. Is inhibiting natural succession processes.

Distribution Origin: Eurasia

Geographic distribution: Within the U.S. smooth brome has been introduced in the northeastern Great Plains states as far south as Tennessee, New Mexico, California and north to Alaska. Distributed throughout Colorado, mostly western two-thirds of state from 4500 to 10,000'.

Ecological distribution: Along roads, waterways, in fallow fields, and other waste places. Found in openings in mountain brush, pinyon juniper, aspen, spruce fir, ponderosa pine, lodgepole pine, and meadow communities. High moisture requirement, and generally found in areas with minimum annual precipitation of 38 cm or more.

Soils: Adapted to sandy, loamy soils. Prefers clays and loams, but will grow on sands. Found to have better root growth on sandy soils than silty soils. Has a high mortality rate on organic soils. Moderately tolerant to flooding (can tolerate up to 24 days) and saline conditions.

Reproduction

Perennial cool season grass. Reproduces by rhizomes and seeds, capable of forming sod. A self-compatible species. Starts growth in early spring and flowers May to July. Plants may regrow and reflower in fall if moisture is sufficient. Rhizome production begins between 3 and 6 months following germination.

Seed production: Estimates range from 156 to 10,080 viable seeds per plant.

Longevity of seeds: Most studies report a range of 2 to 10 years.

Seed dispersal: Seeds may be transported short distances by wind. Seeds may also be transported by ants, resulting in new brome patches on anthills.

Competition Highly competitive and may displace more desirable vegetation. In some cases, appears to be invading native prairie areas in plains region from roadsides.

Response to shade: Tolerates shade, grows well in shade or sun. However, seed production, number of shoots and rhizomes, and dry weight of plant parts are all reduced

by shade.

Level of impact: Somewhat invasive, capable of forming a dense sod that may exclude other species.

Control

Smooth brome can be a good target for selective control because it often occurs in single stands, or growing along with *Poa pratensis*. An important consideration is that it is an aggressive plant that reproduces vegetatively and by producing a large number of seeds. Also, control efforts are likely to be ineffective if there are insufficient species to colonize the area following treatment.

Mechanical: One close mowing when the plants are 18-24" (45-60 cm) tall, while the flowering head is still closed (followed ideally by three repetitions) is recommended. The best conditions for mowing are hot moist weather, followed by a dry period. Sather (1988) recommends that park managers may try repeated lawn mowing of brome beginning in late May and mowing at least 4 times during the season where brome patches are contiguous and pure.

Chemical: Rayburn et al. (1981) found that Roundup, or glyphosate (at rates of 3.4 to 9.0 kg/ha) are more effective than dalapon and pronamide. Rates of glyphosate as low as 0.5 kg/ha produced some effect, but control was better when rates approached 2.0 kg/ha. Other chemicals that have been used to control smooth brome include Kerb (pronamide), Arsenal (imazapyr), Bromax or Hyvar (bromacil), Princep (simazine), Aatrex (atrazine), and Spide (tebuthiuron).

Other: A well timed burn that treats brome in the early boot stage may be more effective than mowing at the same susceptible period. Recent research indicates that repeated prescribed burning in late May-early June reduces the number of tillers produced, and favors the regrowth of native warm season grasses. Generally tolerant to grazing.

Notes

Cultivated as a forage grass. Considered a good forage for both livestock and wildlife. However, quality and palatability rapidly decline after inflorescence develops.

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***Bromus tectorum* L. (*Anisantha tectorum*)**
Downy brome, downy chess, cheatgrass (Poaceae)⁷

Current level of impact

Known locations in FLFO: Scattered, small populations throughout Monument. A few individuals were found in and around dam #9, primarily on the southeast side. This species needs to be mapped.

Assessment: This species is expected to spread, especially into recently disturbed areas. Covers an estimated area of less than one acre. Populations are widespread and scattered. As this species increases, it will likely inhibit natural secondary succession.

Distribution

Origin: Mediterranean region and Eurasia, introduced in packing materials first found near Denver, Colorado.

Geographic distribution: Widely distributed throughout North America. Abundant in Great Basin and Columbia Basin of the U.S. Very common in western states and in Colorado from 4000 to 9000'.

Ecological distribution: Common along roadsides, waste areas, misused pastures, rangelands, and cultivated crop areas. Open slopes, salt desert shrub, sagebrush, pinyon juniper, and less commonly in aspen and conifer communities. Found primarily in the 15-56 cm precipitation zones' although is found in many climatic areas.
Soils: Sandy or gravelly soils, does not grow well on heavy soils, or soils with high salts.

Reproduction

Annual or winter annual, reproduces by seeds. Germinates in fall, overwinters as a seedling and flowers in the spring (from April-June). Plants are self-fertile.

Number of seeds/plant: Capable of producing in excess of 300 seeds/plant, and plants as small as 2.5 cm are capable of producing seed.

Seed longevity: Seeds may remain viable in soil for 2 to 5 years.

Seed dispersal: Seeds may be dispersed by wind, attachment to animal fur, or by small rodents. Seed is often a contaminant in hay, grain, and straw and is difficult to separate from crop seed.

Germination: Germination is increased by moistening of stratum. Litter also promotes germination and establishment of seedlings. Seeds will germinate regardless of whether they are in contact with soil. However, germination is enhanced when in contact with soil. Seeds germinate best in dark or diffuse light. Adequate fall or spring moisture seems to be primary factor which inhibits germination.

Competition

Competes for soil moisture with perennial grasses because of its early spring growth habit. An excellent competitor for soil moisture and is capable of reducing soil moisture levels to permanent wilting point in upper soil layers. Capable of invading perennial bunchgrass communities that have been protected from grazing and fire in the Columbia Basin.

Response to shading: Although a competitive plant, generally does not tolerate shading. Level of impact Strong invader, has potential to inhibit natural succession processes. Can become a fire hazard after plants have reached maturity. Although considered an invader, cheatgrass is an important forage on certain inter-mountain ranges.

Control

An important consideration for control is that cheatgrass produces a large amount of seed which remains viable for 2-5 years.

Mechanical: Mowing can help to reduce seed production. However, plants continue to develop during growing season, and late developing plants may be capable of producing seed after mowing. Grazing may also help to reduce plant numbers, but is not an effective method of control.

Chemical: Most chemical control methods developed have been related to control in agricultural crops. Herbicides that have been used to control cheatgrass include: AAtrex (atrazine), Hyvar (bromacil), cynazine, chloropropham, diclofop, Roundup (glyphosate), metribuzin, Cyclone (paraquat), promamide, propham, simazine, terbacil and trifluralin. Research on chemical control in natural area (prairies) has been primarily limited to atrazine. Young (1991) found that atrazine applied at 1.1 kg/ha over one year-old bitterbrush seedlings controlled cheatgrass and promoted the establishment of big sagebrush and bitterbrush seedlings.

Biological: There is limited information on the potential of biological control of cheatgrass. Animals such as rabbits and mice will feed on cheatgrass, as will some migratory grasshoppers.

Other: Prescribed burns could be a useful method of control. However, the prescribed burn should occur in early spring to kill seedlings. Burning may also help to reduce the surface seed bank. Caution should be exercised with the timing of prescribed burns because fires later in the growing season may only reduce competition from other warm season species and promote re-establishment of cheatgrass. Young and Evans (1978) found that fire reduced the number of seeds, but those that survived the fire produced seed more vigorously and more prolific plants. McLendon and Redente (1992) reported that sucrose treatments may also be an effective method for controlling annual plants such as cheatgrass. In this study, soils that received sucrose treatments of 1600 kg C/ha/yr had significantly higher amounts of shrubs and perennial grasses than plots that received nitrogen treatments or no treatments.

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Carduus nutans L.
Musk thistle, plumeless thistle (Asteraceae)⁷

Current level of impact

Known locations in FLFO: This species has been mapped. It is common along the roadside leading to Cusack's potato barn and in meadow to the east of barn. It is also found south of the Teller 1 and Lower Twin Rock Road junction, and along the roadside of Teller 1, especially in the area where the dam in the drainage below the cemetery used to be.

Assessment: Thought to be increasing in FLFO. If added together, all populations would cover an estimated area of less than 1 acre. Populations are defined to narrow occurrences with a patchy distribution.

Distribution

Origin: Introduced from Europe, native to southern Europe and western Asia.
Geographic distribution: Widespread throughout U.S. and Canada. Northeastern and north central states south to Missouri.

Ecological distribution: Disturbed sites along roads, fields, and pasture land. Spreading into sagebrush, pinyon juniper, and mountain brush communities. Meadows and waste places, an abundant weed in overgrazed or neglected fields and roadsides. Does not appear to have any specific climatic requirements other than a cool period of vernalization for flowering.

Soils: Mostly on dry gravelly soils. Abundant on fertile soils, but may also be found in poorer soils. Occurs on soils with a pH range of 6.0 to 8.9.

Reproduction

Biennial forb, reproduces by seeds. Does not reproduce vegetatively, but if severed at the taproot, will produce a plant capable of flowering. Musk thistle dies after it produces seed. Flowers June to October, usually requires a vernalization period of 40 days below 10 C to produce flowers.

Seed production: Average productivity is approximately 4000 seeds/plant; however, a single plant can produce up to 20,000 seeds.

Seed longevity: Musk thistle seeds appear to remain viable in the soil for at least 10 years.

Seed dispersal: Seeds are dispersed primarily by wind. The majority of seeds remain within 50 m of the plant and very few seeds are carried further than 100 m from plant. Seeds can also be dispersed by water, and seeds may attach to animals, farm machinery, and vehicles.

Germination: Seeds germinate in fall, forming a rosette of leaves. Germination usually begins 14-21 days after seed is dispersed in fall.

Competition

Spreads rapidly and forms extensive stands which forces out desirable forage. Invades pasture, range, and forest lands along with roadsides, waste areas, and stream banks. A highly competitive plant. However, vigorous growing grasses can compete with musk thistle. Level of impact: Has a "high potential for becoming a troublesome weed in the Park" (Weber 1988). May retard natural secondary succession processes and invade undisturbed prairie. Response to shade: Shading may reduce seedling establishment.

Control

Because of the long seed-viability, removal of the living plants may not totally eliminate the plant. The key to controlling musk thistle is to prevent seed production. Most control methods will have a detrimental effect on other plants and may cause a disturbance that will favor reinvasion by other exotic species. Natural areas should be monitored for the presence of musk thistle. Dense musk thistle stands along roadsides and in degraded areas can be treated by spot use of herbicides and in high quality areas by a persistent program of hand chopping.

Cultural: Maintaining pastures in good condition (by not over-grazing or fertilizing) is one important component to successfully managing musk thistle (Beck, 1991).

Mechanical: Repeated hand grubbing and mowing can be used to help control musk thistle. Musk thistle will not tolerate tillage and can be removed easily by severing its root below the ground surface with a shovel or hoe. Mowing can also reduce seed output if plants are cut when the terminal head is in the late flowering stage (Beck 1991). The crown must be completely removed because removing only the head will result in a multi-stemmed plant. Repeated treatments are necessary, and heads should be deeply buried or burned because seeds can mature and become viable after cutting.

Chemical: 2,4-D is the most common herbicide and should be applied during the rosette stage (1014 days prior to bolting). Banvel (dicamba at 0.5 to 2.0 lbs. ai/A) has provided good control. Tordon (at 0.125 to 0.25 lbs. ai/A) can be used during cool dry periods with less effect on non-target species. **Biological:** A number of insects have been introduced worldwide to help control musk thistle. The weevil *Rhinocyllus conicus* has in some cases reduced populations to less than 10% pre-release levels. However, Beck (1991) reports that the musk thistle seed head weevil, if used alone, is not a successful management tool. Herbicides or mowing can be used in conjunction with the seed head weevil during late flowering stages. This allows weevils to complete their life cycles and insures their presence in subsequent growing seasons (Beck 1991). Other weevils (such as *Trichosiromus horridus*) and fungi have also been used with some success.

Other: Fire is not an effective method of control. Spring burns do not reach a high enough temperatures to kill crowns. However, burns may increase warm season grasses and their competitive effects on musk thistle.

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Cirsium arvense (L.) Scop. (*Serratula arvensis* L., *Cirsium incanum*)
Canada thistle, creeping thistle (Asteraceae) ⁷

Current level of impact

Known locations in FLFO: This species has been mapped. Primarily located within the Monument in the meadow behind the red barn, near, in and around the Barksdale picnic area, and in wet meadow east of Hornbek Wildlife loop. Common in wet meadows throughout Mounument and along roadsides.

Assessment: Occurs throughout FLFO occupying 22 acres known from over 30 locations.

Distribution

Origin: Introduced from Eurasia and North Africa.

Ecological distribution: Throughout northern half of U.S., north into Canada from Quebec to British Columbia. Distributed in Colorado from 4000 to 9500'.

Ecological distribution: Common in open meadows, including wetlands, ponderosa pine savannas, roadsides, fields, pastures, meadows, and other disturbed areas, but also invading native plant communities. Tolerates temperatures of -35 to 40 C, optimal annual precipitation is 400-750 mm.

Soils: Mostly on rich, heavy soils. Can tolerate saline soils (up to 2% salt) and wet or dry soils, but grows best in dry soils. Does not tolerate water-logged or poorly aerated soils.

Reproduction

Perennial forb, reproduces by seeds and creeping roots. Roots may also remain dormant for many years if deeply buried. Flowers July to October. Insects or weather conditions may prevent maturation of seed. However, some insects are attracted to Canada thistle and may pollinate different patches up to 200' apart (Beck 1991).

Vegetative: Horizontal roots may extend up to 15', and may grow 6-15' deep in soil. By asexual reproduction, it is possible for a colony of entirely male plants to maintain itself. Generally, reproduction from root system contributes to localized spread, while seeds contribute to spread over longer distances.

Seed production: One plant has the potential to produce up to 5200 seeds in a season, but the average is about 1500 seeds/plant.

Seed longevity: Most studies indicate that seeds do not remain viable after 3 years of burial. However, some studies have found seeds remain viable up to 21 years and up to 4 months in water.

Seed dispersal: Dispersed by wind, contaminated crop seed, feed, manure, packing straw and irrigation water. Some studies indicate that the feathery pappus may break off, leaving the seed attached to the parent plant.

Germination: Seeds mature July-September. Seeds germinate most readily in mid-spring. Seeds do not tolerate drought stress or moist, poorly aerated soils, optimal pH range is 5.8-7.0.

Competition

Disturbance, minimal competition, and adequate light is required for initial establishment. However, once established Canada thistle may readily spread by rhizomes and seed to form single stands. One plant can occupy an area of 3-6' in diameter in two years.

Response to shade: Not generally shade tolerant. Growth is reduced when light falls to 60-70% of full daylight, and death occurs when light falls to 20% of full sun.

Level of impact: Currently listed as noxious in Colorado. Semi-colony forming.

Control

Every piece of the root system is capable of forming a new plant. Because of root stocks, breaking up roots may only lead to more plants. Seeds also have the potential to remain viable in the soil for up to 20 years. In general, Canada thistle is able to recover from most stress by utilizing its root reserves. However, Beck (1991) pointed out that the key to controlling perennials such as Canada thistle is to stress the plant to reduce the plant's nutrient reserves.

Cultural: Grasses and alfalfa can compete with Canada thistle if moisture and fertility are at optimal levels. However, cultural control generally is insufficient to adequately control Canada thistle.

Mechanical: Frequent mowing over a number of years will help control Canada thistle. However, mowing by itself is not effective unless it is done with a high frequency. Mowing at two week or monthly intervals may be needed to keep root reserves low. Fall herbicide treatments that follow mowing can be effective management system (Beck 1991).

Chemical: Research at Colorado State indicates that the effectiveness of herbicides is best when combined with cultural or mechanical methods. Beck (1991) recommends the following methods for chemical control of Canada thistle. Tordon (0.5 lb. ai/A) is effective whenever Canada thistle is actively growing. However, fall applications are especially effective. Tordon can be used in permanent grass pastures, rangeland, and non-crop areas. Banvel (2.0 lb. ai/A) and 2,4 D (2.0 lb. ai/A) can also be used together to help control this plant. 2,4-D should be applied in spring when Canada thistle is 10-15" tall (in pre-bud to early bud stages). Banvel applications in the fall can then be applied to areas of re-growth. Both 2,4-D and Banvel can be used in pastures, rangelands, and non-crop areas.

Biological control: A few species have some potential for biological control. However because of the presence of native thistles in the RMNP biological control is likely not a feasible option. The four biological control agents with the greatest threat are two beetles, one fly and the painted lady butterfly. *Ceutorhynchus litura* is a weevil currently used as a biological control agent in Colorado. This weevil can stress Canada thistle, and may cause death of the plant if populations are large enough. However, Beck (1991) points out that use of the weevil alone is not enough to control Canada thistle. Another biological control agent which shows some promise is a fungus (*Puccinia*) that is used in conjunction with 2,4-D.

Other: Canada thistle is capable of surviving flooding, but subsequent root and shoot growth is reduced.

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Convolvulus arvensis L. (*Convolvulus ambigens*, *Convolvulus incanens*)
Field bindweed, morning glory (Convolvulaceae)⁷

Current level of impact

Known locations in FLFO: This species has been mapped. Scattered populations are found throughout the Monument. The largest pockets are found in the disturbed area where dam was removed along the Hornbek Wildlife loop (on the east side of Teller 1) and upstream where the channel starts narrowing, near and around the A-frame, and south of Lower Twin Rock Road near the Monument's border.

Assessment: A few scattered populations totaling more than one acre. Plants may affect succession processes.

Distribution

Origin: Introduced from Europe, thought to have been introduced to North America in 1870 in wheat, from Turkey.

Geographic distribution: Widespread throughout U.S. and southern Canada. Throughout all of U.S. except extreme southern border. In Colorado, found from 4000 to 10,000'.

Ecological range: Weed on roadsides, railroads, gardens, fields (especially in dry farming areas). Able to grow under most cultivated conditions. Because of its ability to adapt to environmental conditions, may be found at altitudes as high as 10,000'.

Soils: On rich somewhat sandy or gravelly soils. Common on more basic soils and those of heavier texture. Dry to moderately moist soils, capable of surviving periods of drought.

Reproduction

Perennial herb, reproduces by seeds and creeping roots. Even small root fragments may give rise to new plants. Roots system is extensive and may go down 6-9 meters (Holm et al. 1977). Flowers from June to September and occasionally until first frost in fall. Plant biotypes appear to be self-incompatible.

Seed production: Number of seeds produced per plant varies from 25-300, although one individual may produce 600 seeds.

Seed viability: Seeds generally remain viable for 20 (up to 50 years) in soil.

Seed dispersal: Somewhat large seed size inhibits dispersal potential, but increases likelihood of successful germination. Seeds generally fall near plant, but may be dispersed by mammals and birds, water, and as a contaminant of crop seed. Germination: Normally seeds germinate in autumn and the following spring. Chilling enhances germination by increasing seed coat porosity.

Competition

Bindweed can pose a threat to native plant communities because of its high capacity for germination. High rate of seed production and long-term seed viability allow this plant to spread and persist. Field bindweed is also tolerant of a variety of environmental conditions which makes it highly competitive for resources. Due to bindweed's extensive root system, it is capable of rapidly colonizing areas.

Response to shading: Does best in open communities with annual, biennial, and short lived weeds.

Level of impact: The Nature Conservancy recommends that even small infestations be viewed as serious because of plant's high potential for regeneration from roots, high seed production, long-lived seed viability, and highly competitive potential. Infested areas in park should be closely monitored for abundance and aerial extent. Seed sources in areas adjacent to park should be identified and managed if possible.

Control

Troublesome and difficult species to eradicate due to its very extensive root system and seed longevity. Nearby agricultural lands can provide a continuous source of reinvasion from seed dispersal.

Mechanical: Difficult to control mechanically. Some studies indicate that some 20 to 25 cultivations, spread over a period of two to three years may be necessary to control this plant. Mechanical control is not a likely option because plants are able to reproduce from roots, and seed remain viable in soil for long periods.

Chemical: Most options that exist for chemical control of bindweed will likely damage desirable plants in areas of treatment. Glyphosate and dicamba provide best control when applied repeatedly at moderately high rates. Application of glyphosphate can provide good control, but only when applied at high rates (3.5-5.0 kg/ha). The most successful time of application is during the early flowering period when moisture levels are low. Even at high rates of application, repeated applications may be necessary for adequate control. Dicamba applied at a rate of 4.5 kg/ha can also provide control of bindweed. However, at these high application rates, dicamba has been observed to damage crop plants. 2,4-D (4 kg/ha) has also been used on bindweed, but is generally less effective than glyphosate and dicamba.

Biological: Currently, there are no available biological control agents for bindweed control.

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Descurainia sophia (L.) Webb ex Prantl (*Sisymbrium sophia*)
Tansy Mustard, Flixweed, Pinnate tansy mustard. (Brassicaceae)

Current level of impact

Known locations in FLFO: Scattered populations throughout Monument.

Assessment: This species is patchy within the Monument, and although it may be locally abundant in disturbed patches it does not appear to be invading undisturbed areas. Estimated to occupy less than one acre.

Distribution

Origin: Introduced from Europe.

Geographic Distribution: Widely established throughout the U.S. and Canada. In Colorado found from 4000 – 8000 feet.

Ecological Distribution: Found in waste places, fields, roadsides, and other disturbed sites.

Reproduction

Annual or winter annual, reproduces by seeds from early to late summer. Overwintered rosettes begin to flower near the end of May. Plant emerging in the spring usually start flowering in mid-June.

Number of seeds per plant: Produces large numbers of seeds. By one estimate, a large plant produced about 700,000 seeds.

Seed longevity: Can remain viable in soil for long periods of time, at least 3 years.

Competition

Overwintered rosettes are strong competitors since they use spring moisture to grow rapidly. Individuals emerging in spring do not compete as well. Can be a severe problem in perennial forage crops grown for seed.

Control

Prevent seed production and control fall rosettes.

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***Erodium cicutarium* (L.) L'her**
Redstem filaree, Storksbill, Cutleaf filaree (Geraniaceae)

Current level of impact

Known locations in FLFO: In 1988 three individuals were collected near the visitor center for herbarium specimens. Since the specimens are small, and the flowers inconspicuous, it is likely this species is present but has gone undetected.

Assessment: This species is likely not a threat to the Monument's natural areas since it has gone undetected except for a floristic inventory conducted in 1988. However, since it is on the state noxious weed list, efforts should be made to adequately survey the area around the visitor center and control measures taken if it is found.

Distribution

Origin: Introduced from Europe. Native to Mediterranean region. Some suggest plant may be native, others argue it was introduced into the U.S. by early Spanish settlers than became naturalized in the southwest.

Geographic Distribution: This species is found worldwide. It is widespread across North America, abundant on Pacific Coast. Scattered over Colorado, except in extreme east, from 4500 to 7500 feet.

Ecological Distribution: Widely distributed in open sites and in numerous plant communities. A weed in fields and waste places, sometimes lawns and pastures on dry soils. Prefers open areas. It is tolerant of a broad range of climates. It will grow in shade, but vigor is reduced.

Soils: Grows well in well-drained, clayey, loamy, or sandy soil.

Reproduction

Annual or winter annual. Reproduces by seeds. Seeds typically germinate in late fall, reach early leaf stage by December and overwinters as a rosette, blossoming in early spring after it resumes growth. One of the earliest flowering plants in spring – March to June.

Number of seeds per plant: At least 25 seeds/plant based on photographs. Seed production is likely to be much greater than that. For ranking purposes I estimated it produced between 11 and 1,000 seeds/plant.

Seed longevity: Unknown. For ranking purposes I estimated seed were viable in the soil for 2-3 years.

Seed dispersal: Fruit is 5-lobed and long-beaked, with each lobe splitting away at maturity such that each seed is wedge shaped with a long, humidity sensitive, tail that coils into a tight spring when it is wet and uncoils when it is dry.

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Euphorbia esula L. *Tithymalus esula*
Leafy spurge (Euphorbiaceae)⁷

Current level of impact

Known locations in FLFO: A specimen was collected in 1986 during a floristic survey of FLFO. The population was noted to be common locally, occurring in “large patches in wet open meadows”, in NW1/4 section 19, T13S, R70W. This puts it in the drainages associated with grape creek near the Cusak potato barn. This area has been searched in 1999 with no individuals found.

Assessment: Although the herbarium shows specimens taken from within the Monument, no individuals of this species have been found within our borders. Since leafy spurge has potential to aggressively invade and modify native plant communities, we must always be on the look out for it. It must be controlled immediately if found. Caution must be used not to confuse it with the native spurge (*Tithymalus robusta*) which is scattered throughout the Monument. The native is much shorter in height, usually one foot or less, and its individuals more scattered within a given population.

Distribution

Origin: Naturalized from Europe, brought to the U.S. as a seed impurity in 1827.

Geographic distribution: Widely scattered throughout U.S. Throughout most of the northern half of the U.S., north into Canada from Nova Scotia to Alberta. In Colorado, found in cultivated soil from 5000 to 6500'.

Ecological distribution: Weedy species of open habitats. Waste areas, pastures, roadsides, cultivated fields. Infests irrigation ditches, roadsides, fields, woodlands, shelter beds, disturbed sites, rangelands, and especially sub-irrigated meadows.

Soils: Tolerant of a wide range of soils, and may occur in rich damp soils such as the bank of rivers or on dry nutrient poor soils common to the western U.S. Grows most rapidly on coarse-textured soils.

Reproduction

Perennial herb, reproduces by extensive slender rootstocks and seeds. Flowers May to September. Flowers are insect pollinated. On heavy soils, about 60% of new shoots are produced from seed, while on lighter soils plants mainly spread by vegetative propagation.

Seed production: 129,714 seeds/plant.

Seed longevity: Seeds may remain viable in soil for at least 5-8 years. In addition, both the crown buds and root buds can remain viable in soil for a number of years.

Seed dispersal: Seeds are contained in a dry capsule which explodes when dry, projecting seeds up to 15'. Seeds can float, and may also be spread by animals such as birds.

Germination: Seeds often have a rather high germination rate, ranging from 60-80%. The majority of seeds germinate within the first two years, usually in May or June.

Competition

Generally spreads most rapidly in semi-arid situations and infestations are common on hillsides, dry prairies, or rangelands. Once established, leafy spurge is capable of crowding out desirable native species. A good competitor for resources because of its early spring emergence. May also exhibit allelopathy toward other species.

Level of impact: A serious weed because of its spreading nature and persistence. For example, between 1973 and 1983, leafy spurge more than doubled its acreage infested in North Dakota. This rapid rate of spread can be attributed to leafy spurge's high seed production and rapid vegetative growth.

Control

An extensive roots system containing large nutrient reserves makes leafy spurge extremely difficult to control.

Cultural: Grasses can compete with leafy spurge; however, over-grazing will limit the ability of grasses to compete. In some cases, fertilization and irrigation may also help to improve grass growth and competition. However, these conditions may also favor other weedy species. The most effective control methods will likely combine a number of management techniques to reduce root reserves and stress the plants.

Mechanical: Because leafy spurge can reproduce rapidly from roots, cultivation or shallow removal can actually cause a net increase in shoots and number of stems.

Chemical: Herbicides can be used to kill the upper portions of the plant, but resource reserves in the roots will allow new shoots to regenerate. Timing of application is critical when using herbicides to control leafy spurge. Research at North Dakota State indicates that picloram (Tordon 22K), 2,4-D, and dicamba (Banvel) are most effective when applied in spring when the true flowers emerge. Picloram is most effective for leafy spurge control, and has yielded control as high as 80% for two years after a single application. Picloram may also be mixed with 2,4-D to provide control. When a mixture of 0.25 to 0.375 pound ai/A picloram mixed with 1 to 1.5 pounds ai/A of 2,4-D is applied for three to five consecutive years, shoot may be controlled 80-90%. Roundup (glyphosate) applied in the fall has relatively good control if followed in spring with pretreatment of Roundup or 2,4-D.

Biological control: Grazing can be used to help deplete root reserves. Using sheep or goats to graze leafy spurge, followed by fall herbicide applications may be one integrated method of control. Several insects are currently being investigated for biological control and may be especially useful in areas where herbicide use is difficult or risky. The spurge hawkmoth (*Hyles euphorbiae* L.) lays eggs on the plants and the larvae emerge and feed on the plant. Two beetles (*Apthona nigriscutis* and *A. flava*) also show some promise as biological control agents.

Notes

Leafy spurge has been reported to cause severe irritation to mouth and digestive tract in cattle which may result in death.

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***Linaria vulgaris* P. Mill**

Butter and eggs, yellow toadflax, wild snapdragon (Scrophulariaceae)⁷

Current level of impact

Known locations in FLFO: This species has been mapped. Scattered patches throughout the Monument. Often found in alongside roads, and appears to be moving up and down drainages. Patches found in and around dam #9, and dams # 6 and #7, all along Teller 1, and near Hornbek Homestead, among other places.

Assessment: Several widespread and occasionally dense populations in park. When added together, populations cover over seven acres. Found in high quality areas and expanding. Potential to invade and modify/replace existing native communities.

Distribution

Origin: Eurasia, escaped ornamental.

Geographic distribution: Throughout most of temperate North America. In Colorado found from 6000' to 8500', mostly on western slope but also found on eastern slope.

Ecological distribution: Waste places, pastures, and roadsides. Cultivated fields, meadows, gardens. Locally abundant and often found around sites of former homesteads. Occurs in a wide variety of habitats, but is generally limited in wet or dark conditions.

Soils: Occurs on mostly sandy or gravelly soils. Common on chalky soils.

Reproduction

Perennial herb, reproduces by seeds and creeping rhizomes. Extensive, creeping rhizomes. Production from shoots can be large, and may begin at seedling stage. Plant is self-incompatible and insect pollinated. Flowers June-August.

Vegetative: Vegetative reproduction is important because of low seed viability. Vegetative reproduction may begin as soon as 2-3 weeks after germination, and is possible from root fragments as short as 1 cm.

Seed production: Range from 1,500-30,000 seeds/individual, but it is often difficult to define an individual because of colony forming habits.

Seed dispersal: Seeds are winged which may allow for long distance dispersal. Seeds may also be dispersed by water and ants.

Seed longevity: Seeds may remain dormant for periods up to 8 years.

Germination: Germination success is often below 10%, although it is highly variable.

Competition

In North America, *Linaria vulgaris* is generally considered a strong competitor, but is considered a weak to moderate competitor in Europe. *Linaria vulgaris* is able to quickly colonize open habitats, and is capable of adapting growth form to a wide range of conditions. Generally does well in moist areas with high fertility but will be displaced by other species when growing in less favorable conditions. Plants growing in dry soils tend to be stunted, but are relatively persistent.

Level of impact: Persistent, aggressive invader and is capable of forming colonies through adventitious buds from creeping root system. Seeds generally germinate in the top 2-3 cm of soil, and also at the soil surface.

Competition

Once established, high seed production and ability to reproduce vegetatively allow for rapid dispersal and high persistence.

Control

Extensive root system makes this species difficult to control.

Chemical: According to some studies, permanent long term control cannot be achieved by herbicide treatments. *L. vulgaris* is resistant to many chemicals such as 2,4-D amine and MCPA salt. Glyphosate, amitrole, diquat, and picloram can be used for spot treatment. Glyphosate applied at early bloom provided some current season control, but was followed by abundant regrowth the following spring.

Mechanical: Generally the keys to controlling *Linaria vulgaris* are to prevent seed production and promote root starvation which can be accomplished by mowing and tillage (Saner et al. 1995). Tillage has been somewhat successful in controlling *L. vulgaris* in crops. Tillage should begin on summer fallow in June and continued at 3-4 week intervals. In post season cultivation, tillage could begin as soon as crops are harvested and should continue at 3-4 week intervals until shoots are killed by first frost. Mowing may also be used to help decrease seed production but generally will not eliminate *L. vulgaris* stands.

Cultural: Grasses can be used to compete with *L. vulgaris*. Disturbed areas can be seeded with vigorous, well adapted grasses.

Biological: Biological control has been relatively successful for *Linaria vulgaris*. In general, the root system seems to be the most promising target that is susceptible to damage. Weevils (*Gymnetron antirrhini*) larvae develop inside of the fruit, and adults feed on leaves, buds and stems. Harris (1961) concluded that *G. antirrhini* is the most important agent for biological control of *L. vulgaris* in the eastern provinces of Canada, British Columbia, and the northwestern U.S. Other species that may be used to help control *L. vulgaris* include another weevil (*Mecinus janthinus*), leaf feeding moths (*Calophasia lunula*), and root mining moths (*Eteobalea serratella*). *Mecinus janthinus* larvae bore in stems, and the adults feed on shoots. *Celophasia lunula* has become established in Ontario, but other more northern releases have failed. *Eteobalea serratella*

winter as larvae in roots and damage plants throughout the growing season.

Other: Fire is not a recommended method of control for *L. vulgaris*.

Notes: Generally considered only moderately poisonous to livestock.

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Melilotus officinalis (L.) Pall Yellow sweetclover (Fabaceae)
Melilotus alba Medic. White sweetclover, Honey clover⁷

Current level of impact

Known locations in FLFO: Found on road shoulders throughout FLFO. Also found along the pipeline easement.

Assessment: A number of patchy distributed populations are found in FLFO. Plants currently do not appear to be invading native plant communities except on localized disturbances (e.g. ground squirrel holes) near established populations. White sweetclover and yellow sweetclover have very similar biology, ecology, and control methods. Occupies about 3 acres on the Monument.

Distribution

Origin: Introduced from Eurasia. Introduced as forage plant in some areas, now widespread.

Geographic distribution: Widespread throughout the U.S.

Ecological distribution: Neglected fields, pastures, roadsides, and waste places. Adapted to irrigation or mean annual precipitation of 10" or higher. Lowland sites of mountain brush and aspen woodlands. Have a broad habitat range, and are drought and cold tolerant.

Soils: Gravely or sandy soils. Commonly found growing on calcareous soils, and are most abundant in rich loams and clay loams having a pH of 6.5 or higher.

Reproduction

Annual or biennial, reproduces by seeds. Plants flower and die during the second year of growth. Flowers from June to October.

Seed dispersal: Seeds are distributed by the wind (short distances), and water.

Seed production: 14,000 to 350,000 seeds/plant.

Seed longevity: Long lived seeds, may remain viable in the soil for 11-50 years.

Germination: Only about 1/2 to 3/4 of seeds will germinate at once, the remaining seeds remain dormant until the seed coat becomes permeable. Germination occurs in March (although some germination can occur in summer), and is enhanced by temperatures > 15 C.

Competition

Level of impact: Sweet clovers readily invade open areas, and have the potential to inhibit natural succession processes.

Response to shade: Grows well in direct sunlight and partial shade, but does not tolerate dense shade.

Control

The key to controlling sweetclover is to prevent seed production. Spread of sweetclover can be halted by interrupting the flowering stage.

Mechanical: Hand pulling is effective for small to moderate infestations if done when the ground is moist and if most of the root can be removed. In general, the best times to pull sweetclover are in the late fall after the first-year plants develop root crown buds' or any time in early spring before second year plants develop flower buds. In large, dense colonies, cutting first and second year stems close to the ground with a hand held scythe is effective if done after the leaves on the lower stems have died.

Chemical: Spot application should be used to avoid contacting non-target plants with solution. 2,4-D can be used to hand spray individual seedlings following fall burns or when the plants are in the cotyledon stage. An amine formulation of 2,4-D is generally recommended to reduce spray drift. A 1% solution of Mecamine (2,4-D plus Dicamba) applied to the foliage is effective.

Biological control: Biological control options for sweetclover has not been investigated because of the plants value as an agricultural crop. However, heavy grazing has been observed to reduce sweetclover densities.

Other: Prescribed burning can control sweetclover. A burn in April combined with a burn in May the following year is most successful in eradicating an even aged stand of sweetclover. In uneven aged stands, a combination of other procedures such as later spring burns, or follow up with an early burn and hand pulling may be necessary.

Notes

White and sweet clover are grown extensively for forage, pasture, green manure crops in some regions. An excellent source of honey for domestic bees.

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Thlaspi arvense L.
Field Pennycress, fanweed (Brassicaceae)

Current level of impact

Known locations in FLFO: Scattered patches throughout the Monument. Appears to be contained to recently disturbed sites such as burrow holes.

Assessment: Small populations associated with recent disturbances. Does not appear to threaten established native communities.

Distribution

Origin: Native to Asia, introduced from Europe.

Geographic Distribution: Troublesome in prairie provinces of Canada and especially prevalent in northwestern U.S. Found in Colorado from 4000 to 9500 feet.

Ecological Distribution: Found as a weed in grain fields, waste places, roadsides, and other disturbed areas. Ubiquitous. Found in wide range of climatic conditions, in both dry and wet habitats.

Soils: Found on a wide variety of soils, but more common on heavier soils.

Reproduction

Annual or winter annual, reproducing by seeds. Fruit is a pod, circular in outline, winged, rounded, and deeply notched at the top with 2 or more seed in each chamber. Flowers from late spring to early summer (May to June, maturing in July), and is self compatible.

Number of seeds per plant: Average yield is 2000/plant, although may produce 1600-15,000 seeds/plant. Normal germination is 80%.

Seed longevity: Six to 20 years, depending upon depth in the soil.

Seed dispersal: Primarily wind dispersed, although seeds float and thus water may aid in dispersal. Low dispersal potential due to seed weight and size.

Germination: Enhanced with temperature alterations from 10-25 C, and exposure to light. Most emerge by mid May, although some may emerge throughout growing season, overwintering as a seedling and continuing growth in the spring. Most seeds germinate within the first four growing seasons.

Competition

Can compete for moisture and nutrients, especially in nutrient poor areas.

Control

Focus should be on controlling seed production. Control of fall rosettes will reduce the following spring's seed crop.

Mechanical: Mowing prevents seed production. Short plants may escape cutting.

Chemical: Susceptible to 2,4-D applications throughout the year. Also susceptible to MCPA salt, bromoxynil-MCPA-dicamba, 2,4-D mecoprop, linuron-MCPA, and dichlorprop-2,4-D.

Notes: Adds a bad flavor to milk if eaten by cows. Presence of seed in flour makes it undesirable. May cause gastric distress in livestock.

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CHAPTER 3

SPECIFIC RECOMMENDATIONS

***Bromus inermis* (Smooth Brome)**

This species is ranked 5th out of 11 species for control. No control actions were taken in 1999. However, I suggest integrating management of this species into the fire management plan. Since smooth brome is a cool season grass which begins growth around mid March, a late spring burn followed by reseeding the area with native species – especially warm season species -, over a period of years, should be an effective control strategy. If funds are available, plowing and reseeding with natives would likely accelerate the return to a more natural community. If plowing is done, early spring prescribed burns in following years after the natives have established should be effective in reducing the brome and aided in the establishment of native species. Those areas where terracing was installed should be considered first if plowing becomes an option, thus reclaiming the natural topography and hydrology also.

***Bromus tectorum* (Downy Brome)**

This species is ranked 2nd out of 11 species for control. No control measures were taken in 1999. This species should be mapped and control measures taken as soon as possible to prevent widespread successional changes. Since existing populations are assumed to be small, I recommend spot herbicide treatments. Since this is a cool-season annual, a late spring prescribed burn may also provide control if the infested areas are large.

***Carduus nutans* (Musk Thistle)**

This species is ranked 3rd out of 11 species for control. In 1999 most individuals were hand dug ensuring each root crown was removed. It appears most of the mature musk thistles were removed. However, some individuals, especially seedlings, were undoubtedly missed. I found this species on only three main sites: around Cusak's potato barn, 5 individuals about half way up the A-frame road on the north side, and a stand just off of to the east side of Teller one in the drainage leading adjacent to the cemetery where the old dam used to be. There were a few isolated individuals along the Teller 1 roadside too.

Musk thistle begins flowering at FLFO around late July and continues into late August. It begins seeding in late August through September. Removal of the root crown is the best removal method.

***Cirsium arvense* (Canada Thistle)**

This species is ranked 4th out of 11 species for control. Canada thistle begins flowering at FLFO around mid August and begins seeding by early September. I recommend mowing at least once during the growing season, around mid June. For the most effect, this should be followed with a herbicide operation beginning in early August. Note that if the thistle is not mowed, then it will be several feet high, difficult to spray, and spray effectiveness will be reduced. Mowing is necessary to deplete the vast root reserves and retard seeding. If spraying operations are started too late, after seeding has begun, spraying will increase dispersal of seeds.

In 1999 FLFO had 2.5 gallons of Rodeo and 0.5 gallons of Stinger left over from last year. Thus I used Stinger – a *specific* broadleaf herbicide – to spray the Canada thistle. In 2000, I recommend using up the remaining Rodeo – a non specific herbicide - to boom spray the *dense monocultural* stands of Canada thistle. This should be followed by spreading native grass seed mixes in those areas where Rodeo was used, about a week or more after the last spraying operation. I suggest the use of picloram in future years since it is a specific broadleaf herbicide which is effective on Canada thistle, field bindweed, and yellow toadflax. Using such a specific herbicide will allow for graminoid survival. This will give the graminoids a competitive advantage while maintaining some ground cover and a seed source. Reseeding with natives should also be considered in all sprayed areas, especially in the dense stands.

In 1999, for the dense stands of Canada thistle, I *intended* to use Rodeo in the boom sprayer at a rate of 4.5 pints/acre (labeled recommendation). However, major spraying operations were started too late in the season (September), when most individuals began seeding. This combined with a series of wet and cold days prevented a full assault. However I did use Stinger in the boom sprayer at a rate of 2/3 pints/acre (labeled recommendation) for some areas. The patch located south of the Visitor Center was hit with both Stinger (2/3 pints/acre) and Rodeo (4.5 pints/acre). This is the only area where Rodeo was used in 1999. See the map in appendix D for more information. A few areas were also mowed once during the season prior to spraying operations.

***Convolvulus arvensis* (Field Bindweed)**

This species is ranked 6th out of 11 species for control. In 1999 *consideration* was given to using the backpack sprayer with a 1.5% solution of Rodeo for spot treatment of bindweed. However, the bindweed patches are relatively small, and are entwined in areas of high native diversity. Thus the better option was hand pulling followed by a squirt of 1.5% Rodeo from a small bottle sprayer aimed directly at where the plant stem entered the ground. It should be noted that a 1.5% Rodeo solution is the labeled recommendation for backpack sprayers, even though it is 9 pints/acre. The literature supports 6-7.5 pints/acre for bindweed. Bindweed begins flowering at FLFO around mid July and continues throughout August.

***Descurainia sophia* (Tansy Mustard)**

This species is ranked 11th out of 11 species for control. Since this species appears confined to disturbed areas and doesn't seem to inhibit secondary successional processes, it is presumed to have little impact on our native communities.

***Erodium cicutarium* (Redstem filaree)**

This species is ranked 8th out of 11 species for control. There are no known occurrences of this species on the Monument except for 3 herbarium specimens collected near the visitor center in 1988. Thus, this species is likely not a threat to the Monument's natural areas. However, since it is on the state noxious weed list, efforts should be made to adequately survey the area around the visitor center and control measures must be taken if it is found.

***Euphorbia esula* (Leafy Spurge)**

This species is ranked 1st out of 11 species for control. The Monument is fortunate in not having this highly invasive and disruptive species present aside from herbarium specimens collected in 1986 in the drainages near Cusak's potato barn. Therefore at the first appearance, this species should be promptly eradicated by all available means.

***Linaria vulgaris* (Yellow Toadflax)**

This species is ranked 7th out of 11 species for control. Toadflax begins flowering at FLFO around early August and continues through mid September. Populations are patchy and usually moderately dense, but not so dense as to justify a *non-specific* herbicide. In 1999 we did not have a specific herbicide effective for Toadflax, and thus resorted primarily to handpulling except for one test area that was dense and monocultural enough to justify spraying with the available *non-specific* herbicide. The backpack sprayer was used with a 4.5 pints/acre concentration of Rodeo to treat the dense patch west of the Teller 1 and Lower Twin Rock Road junction. It should be noted that a 1.5% concentration is the labeled recommendation for backpack sprayers, even though it is 9 pints/acre. The literature supports 6-10 pints/acre for toadflax even though Rodeo is *not* labeled for toadflax.

In the future, for small stands, isolated individuals, and areas where toadflax is interspersed with native species such as shrubby cinquefoil, I recommend hand pulling followed by a squirt of herbicide from a small bottle sprayer aimed directly at where the plant stem enters the ground. In areas of denser toadflax, a boom or backpack application of picloram should be used. Note that while hand pulling will reduce stand vigor and prevent seed dispersal, it is not an effective control. Since hand pulling is time and labor intensive, treating *all* patches of toadflax with picloram or some other effective herbicide should be considered.

***Melilotus officinalis* (Yellowsweet Clover)**

This species is ranked 10th out of 11 species for control. Although yellow sweetclover is a nitrogen fixer and therefore may influence secondary successional processes, it does not appear to invade undisturbed areas and is not a threat to our natural communities nor a priority for control. Personal observations, however, suggest that ants tend to colonize areas around sweetclover populations more than other areas. This is likely due to the tending of aphids which feed on the sweetclover plants. If this is true, sweetclover may indeed have community effects which haven't been considered.

***Thlaspi arvense* (Field Pennycress)**

This species is ranked 9th out of 11 species for control. This species does not appear to invade undisturbed areas and is not a threat to our natural communities nor a priority for control. Actions should focus on preventing seed production, which makes this a good candidate for hand pulling prior to setting seed.

***Cardaria draba* (Hoary Cress)**

This species was not ranked nor was an abstract completed. This species is not a state noxious weed. It is included here since I found two stands of Hoary Cress on the monument by casual observations. However I believe there are others. The first stand was hand pulled and was found on the north side of the A-frame road just before the telephone poles and dam. The other stand consisted of two individuals I found and pulled on the north side of the Cusak barn road. These sites should be monitored in future years. At FLFO Hoary Cress begins flowering in late July and is seeding by mid to late August.

CHAPTER 4
SPRAYING OPERATIONS

DECIDING ON THE CONCENTRATION OF PESTICIDE

NOTE: Always read the label and follow the manufacturer's recommendations. Concentrations will vary based on the chemicals used and the pesticide brand. The information provided in this chapter is for illustrative purposes only.

The manufacture's label should list recommended application rates for a given species in a rangeland setting. This could be supplemented with what the literature also suggests. Most of the abstracts in chapter 2 have herbicide recommendations, while chapter 3 provides application rates for the 3 main candidates for spraying: canada thistle, bindweed, and yellow toadflax. I have also compiled literature for each of the ranked species that often recommends application rates. This literature is available in a binder located in the library.

In 1999 Rodeo was available from a previous year's purchase and approval to use it was obtained. The label states to use 3-4.5 pints/acre for Canada thistle and 6-7.5 pints for Bindweed. It is not labeled for use on toadflax. However, the literature supports 6-10 pints/acre for toadflax. Note that the average for all 3 species is about 6 pints/acre.

However, the label also states that for *backpack* sprayers the concentration of Rodeo should be 0.75% to 2.0% mixed with water and a nonionic surfactant. A 1.5% mixture works out to about 9 pints/acre, and is what would normally be used for spot treatments on Canada thistle, bindweed, and toadflax. However, a more reasonable concentration for use with the *boom sprayer* mounted on the back of the gator would be around 6 pints/acre if all three species are expected to be sprayed from the same mix. If canada thistle only is being treated, then a concentration of 4.5 pints/acre for the dense stands is recommended, while 3 pints/acre should be used in more sparse populations.

USE OF THE BOOM SPRAYER MOUNTED ON THE GATOR

The boom sprayer was purchased primarily for use on the (mowed) Canada thistle stands that are large, dense, and fairly monotypic. Most of these patches occur in the meadow behind the red barn.

According the literature obtained with the boom sprayer (appendix E), the nozzles are designed to have about 50% overlap. They came from the store on thirty-inch centers which I did not alter. The boom height was adjusted such that each nozzle's spray pattern overlapped with the next by about 50%. This overlap is an assumption inherent in the following calculations and necessary to ensure proper application.

The distance from end nozzle to end nozzle is 90 inches. The gator is 60 inches from outer edge to outer edge of the back tires. Thus, to get a 50% overlap on the ends, the gator should begin its next spray pass one-hundred and twenty inches from the previous spray pass. The easiest way to accomplish this thus to ensure all areas are sprayed, is to put the inside tire on the previously outside tire track (see figure X), *SPRAYING ON ALL ODD PASSES BUT NOT ON THE EVEN PASSES* (figure X). That is, the operator simply sprays on every other pass. This means the gator will pass through areas already

sprayed. Thus, proper decontamination procedures must be used when spraying operations are completed.

Do not spray on windy days. However, a light breeze *may* be acceptable. Use your own judgment and follow the label recommendations. Stop spraying operations if drift is noticeable. If spraying in a breeze, to avoid drift contamination onto the driver and gator, the gator should *never* be driven *with* the wind, but rather should always be driven *into* the wind when the boom is spraying.

After spraying operations are completed for the day, to avoid contaminating storage areas, the gator should be parked with the other heavy equipment off of the A-frame road or other designated area. Upon completion of final operations, the pressure sprayer should be used to wash the gator and all equipment down, before storage.

At the end of the spray season, the tank should be rinsed according to the directions on the label for the herbicide used. If none are given, then rinse the tank and boom nozzles out three times with water. Then wash everything down on the outside with soap and water and make sure the pump is *dry* before placing in storage for the winter. Store it in Cusak's potato barn or other designated area over the winter.

CALIBRATION OF THE BOOM SPRAYER⁹

1. According to the literature provided with the boom nozzles (appendix E), they are extended range 100 degrees and work best between 15 and 60 psi. However at 40 to 60 psi the spray may drift onto non-target vegetation. The sprayer ran at around 20-30 psi for me, which is where I left it. If needed, you may lower the pressure in one of 3 ways:
 - a. Use an Allen wrench to loosen the screw on the front of the pump one turn or so. This lowers the "On" pressure to 30 psi and the "Off" pressure to 50 psi. (the standard set by the pump manufacturer is 40 and 60).
 - b. Crack the hand valve slightly toward off until desired spray consistency is obtained. Your gauge will no longer be a reliable indication of nozzle tip pressure. (Not recommended).
 - c. Get larger tips from your dealer – probably #3 – 110 degrees LFR (or XR). The gauge is still reliable using this method.
2. Confirm that the width covered by the spray at ground level is about 100 inches or 8.33 feet. This is your effective spray width.
3. Divide the effective spray width into 43,560 ft², to get the linear feet the sprayer must travel to cover 1 acre. This is your linear feet. Thus, 43,560/8.33 equals about 5,229 feet, or 51 feet short of one mile.

4. In field conditions similar to the area to be sprayed, measure and mark out a line equal to the linear feet obtained in step 3. For my calculations it was 5,229 feet long.
5. Fill the spray tank with water at the visitor center as close as possible to the 26 gallon mark. Note the water level. I marked it with a grease pencil.
6. Spray the linear feet line (e.g. 5,229 feet long), using the same speed you plan to use during the spraying operation *and* note the pressure.
7. Note how much water it takes to refill the tank to the previous level. This is the application rate in acres. Note that it is desirable to make more than one run and take the average for a more accurate calibration.
8. Divide the tank capacity (26 gals or the capacity to which you plan on filling the tank). Divide this by the application rate. This gives you the number of acres one tank (or the given capacity) will spray.
9. Ex: I filled the tank with 26 gallons of water. While running the gator as consistently slow as possible I *twice* sprayed 25.5 feet short of ½ a mile on the A-frame. This was equivalent to the 5,229 linear feet. I visually estimated that it took about 16.5 gallons. I did the first ½ mile in 5 minutes and 25 seconds, the second ½ mile in 6 minutes and 20 seconds for a total time of eleven minutes and 45 seconds. The pressure gauge read about 28 psi on the first trip and 23 on the second, for an average of about 26 psi. Next I divided 26 gallons (the tank capacity) by 16.5 (the application rate) and found that a 26 gallon mix will spray 1.58 acres using the boom in this fashion. Next I multiplied the #of acres per tank (or capacity chosen), in this case 1.58, by the pesticide application rate to determine the amount of pesticide per tankfull (or total capacity chosen). For example, Rodeo calls for anywhere between 3pints/acre and 4.5 pints/acre. Thus, at 3 pints per acre I get $(1.58 \text{ acres/tank}) \times (3 \text{ pints/acre}) = 4.75 \text{ pints/tank}$. Similarly, at 4.5 pints/acre, I get about 7 pints. Likewise, Stinger calls for 2/3 pints/acre for canada thistle, which works out to about 1 pint/tank. **For the pesticide you are using, follow the manufacture's recommendations for application rates.**
10. To check the volume delivered per acre with the actual spray solution, repeat steps 3-6.

CALIBRATION OF THE BACKPACK SPRAYER¹⁰

1. Lay out an area 31.5 feet by 31.5 feet. This equals about 1,000 ft² or 0.023 acres.
2. With the backpack sprayer, spray this area with water twice, timing yourself each time. Note the *average* time it took you to spray this area. Maintain the walking speed similar to what you will keep in actual spraying operation.
3. Collect water from the nozzle for the same amount of time, or note how much it took to refill the backpack tank to the original volume.

Ex. It took me 3 minutes using 1 gallon the first time and 2.5 minutes using .59 gallons the second, for an average of 2 minutes and 45 seconds, using 0.8 gallons.

4. Calculate the rate of pesticide application.

Example 1. Using Rodeo at 3 pints/acre we get: 1 oz/0.8 gallons of water or 1.25 oz/gallon. So to fill the backpack sprayer tank, I need to add 5 oz of Rodeo to 4 gallons of water.

Example 2. At 4.5 pints/acre, I get 0.8 gal or 2 oz/gallon. Therefore, to fill the 4 gallon tank I add 8 oz of Rodeo to 4 gallons of water.

Calculations are made as follows: $(4.5 \text{ pints/acre} * 0.023 \text{ acres/0.8 gal}) = 0.129 \text{ pints/gal}$. Converting to ounces per gallon we get: $(0.129 \text{ pints/gal} * 16 \text{ oz/pint}) = 2 \text{ oz per gallon}$.

Follow a similar method to calculate the amount of the herbicide to add based on the manufacturer's recommendations.

Other Spraying Operation Guidelines

In areas where a lot of bare ground is expected, seed with a native grass mix about one week after applying herbicide. Follow manufacture's recommended seeding rates, of consult the NPS seeding rate booklet.¹¹

Keep timely and accurate records regarding what areas were sprayed, the target species, and the application rate. Record in general terms record what areas were sprayed (e.g. about 150 yards east and 50-100 yards north of Red Barn). In specific terms also note what species was targeted and the application *rate*. Tom will need this for a formal report. Also, for internal FLFO use, circle on the orienteering map or note on an ARC VIEW map where each treatment was, noting the species, date of treatment, herbicide(s) used and rate of application.

Check the weather before spraying. Without access to a televised forecast, I usually check the weather for FLFO by using the following URL: <http://www.weather.com> and typing in our zip code of 80816. Obviously, do not want to spray if it is going to rain or be windy. Since it rains about every summer afternoon around here, experience suggest the best days are following the movement of a major storm system out of the area, unless it is accompanied by high winds. Check the label to see how long the application needs to be applied before rain is advisable.

CHAPTER 5
MONITORING AND EVALUATION¹²

Effective monitoring and evaluation requires a balance between the time and money spent on a monitoring program and the usefulness of the information received. The complexity of a monitoring plan for each species depends on and what you information is required to determine if your management objectives are being met. Keeping a monitoring and evaluation program simple increases the likelihood of following it and therefore learning from it. Thus, the effort invested should be proportional to the risk involved should your control objectives fail. Therefore, the higher priority species usually require more monitoring efforts than lower priorities, since the risk of failure is greater.

MONITORING

The most basic form of monitoring is noting the stand size and general abundance of weed infestations. If the objective is total eradication of a stand, then monitoring could be as simple as determining if live individuals in the stand are present or not.

Generally, however, some rate of decline will be needed to justify continued resource allocation toward control efforts. In this situation photographs can be a quick and useful way to document changes over time when taken from permanent photo points. Photographs are generally best taken when the species is flowering and they are easily distinguishable from surrounding vegetation.

If treatments are similar on stands of the same species, then certain stands – a sample - could be selected as representative. These areas could then be mapped using GPS periodically and their decline rate extrapolated to all other stands – the entire population.

However, to determine a defensible species decline rate, attention should be given to sampling design procedures by following established statistical procedures. One consideration is to ensure enough samples (replicates) are present to provide a reasonable confidence in the decline rate. A similar methodology could be used to test whether certain control measures were more effective than others. Refer to any standard statistics text or consult a statistician for more information.

Another method is to estimate weed abundance using either weed density, or cover. Density can be estimated by counting the number of plants in a plot of a given size, or visually estimating the number. Cover is the proportion of the ground surface that is hidden by the target weed species. A good plot size is 2 feet by 4.5 feet which is an area of one square yard. Stand at the middle axis of the plot frame and count or visually estimate the number of individuals or cover of the target species. If estimates are used, I recommend assigning stands to classes of cover rather than trying to estimate actual numbers (Table 2). Record your initial impression of cover; it is usually more accurate. Density should also be assigned to classes. However, density measurements can vary greatly from one species to another and therefore must be tailored based on the species being sampled. Growth and life history characteristics will influence the maximum density possible for a given species. Consequently, initial density measurements for each species should be recorded. This data can be sorted into a table and/or plotted to determine if natural breaks suggest reasonable classes.

Studies have shown that cover estimates can be highly variable from one person to the next, and even by the same individual. Thus, actual density measurements are the recommended method, especially sampling will be done by more than one individual or if different individuals will be conducting the counts in different years.

Plots for both cover and density estimations can be made using permanent. If they are not permanent then they should always be located randomly each time. Make sure there are enough replicates (i.e. number of plots) to allow for valid statistical comparisons between years. Even if plots are permanent, it may still be necessary to initially locate the plots randomly, depending on the sampling design and analyses.

Finally, the monitoring plan should be field tested prior to implementation. It is better and usually easier to modify methods before implementation, than to change methods half way through a program. If a particular monitoring scheme is not providing the required information in an efficient manner, try new techniques. Most plant ecology texts discuss sampling protocols and are good sources of ideas.

The best monitoring protocol is likely going to use a variety of techniques. For example, high priority species could be monitored by taking photographs from permanent points annually, mapping the size every two years, and recording density from permanently located plots in the center and at the edges of stands. This would provide both visual and analytical comparisons between years and even among treatments if different control measures were used.

Table 2. Classes of Weed Density and Cover.

Category	Symbol	Cover of Weed in Plot
Absent	A	0
Light	L	1 % - 25%
Moderate	M	25% - 50%
Heavy	H	50% - 75%
Extreme	E	75% - 100%

EVALUATION

A major purpose of this document is to establish priorities for weed control. From this prioritization, measurable objectives or goals should be developed for each species targeted for control measures. Goals might include eradication of a noxious species in a given amount of time, or reduction in the number of stands, size of stands, or even prevention of new weeds from becoming established.

In essence, control actions need to be evaluated to see if the desired goals are being obtained. If not, then control actions need to be modified, monitoring plans re-evaluated and implementation of new strategies begun. From the objectives follow the design and implementation of control actions and monitoring actions. There should be an on-going evaluation of results, revision and implementation of management actions, and perhaps even the revision of monitoring protocols.

CHAPTER 6
FUTURE WORK

Weed management involves many steps. First weeds need to be identified, located, mapped, and approximate areas of infestation determined. Next, weed species should be ranked for control priority. Third, an integrated pest management plan (IPM) should be established for the priority weeds and control operations begun. Fourth, each weed identified should have an IPM plan developed even if the “control” is simply monitoring the infestation. Finally, a monitoring and evaluation plan should be developed and followed to determine the effectiveness of the control efforts. This handbook serves as an initial effort towards these steps.

That is all this handbook is – an initial effort. Much work remains to be done. First, control measures should be taken, and monitoring protocols established next field season for the eight noxious weeds reported at FLFO. Next, all remaining non-native species populations should be located and mapped, even if it is just approximating the location and area on a topographic map; although, GPS would provide more useful and accurate information. Third, abstracts similar to those found in chapter 2 should be developed for all exotic plants in the Monument, and the species added to the ranking prioritization. When this is done, and a new ranking generated, the actual 1998-1999 combined GPS'd areas should be used for the species previously ranked.

Measurable objectives or goals should be developed for each species targeted for control measures. Goals might include eradication of a noxious species in a given amount of time, or reduction in the number of stands, size of stands, or even prevention of new weeds from becoming established. From these goals, monitoring plans should be developed and followed which allow for the required evaluation of control effectiveness.

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