Integrated Weed Control for Land Stewardship at Legacy Management's Rocky Flats Site in Colorado - 13086

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ABSTRACT

Land stewardship is one of nine sustainability programs in the U.S. Department of Energy's Environmental Management System. Land stewardship includes maintaining and improving ecosystem health. At the Rocky Flats Site near Westminster, Colorado, land stewardship is an integral component of the Office of Legacy Management's post-closure monitoring and management at the site. Nearly 263 hectares (650 acres) were disturbed and revegetated during site cleanup and closure operations. Proactive management of revegetation areas is critical to the successful reestablishment of native grasslands, wetlands, and riparian communities. The undisturbed native plant communities that occur at the site also require active management to maintain the high-quality wetlands and other habitats that are home to numerous species of birds and other wildlife such as elk and deer, rare plant communities, and the federally listed threatened Preble's meadow jumping mouse. Over the past several decades, an increase of noxious weeds has impacted much of Colorado's Front Range. As a result, weed control is a key component of the land stewardship program at Rocky Flats. Thirty-three species of state-listed noxious weeds are known to occur in the Central and Peripheral Operable Units at Rocky Flats, along with another five species that are considered invasive at the site. Early detection and rapid response to control new invasive species is crucial to the program. An integrated weed control/vegetation management approach is key to maintaining healthy, sustainable plant communities that are able to resist noxious weed invasions. Weed mapping, field surveys, and field-staff training sessions (to learn how to identify new potential problem species) are conducted to help detect and prevent new weed problems. The integrated approach at Rocky Flats includes administrative and cultural techniques (prevention), mechanical controls, biological controls, and chemical controls. Several species of biocontrol insects have been released to assist with control of different target weed species. Monitoring is conducted to evaluate the effectiveness of control efforts and to provide information for future control efforts. The effective implementation of this integrated approach has reduced the infestation levels of many species and has kept several newly discovered invasive species from spreading and becoming larger problems at the site.

INTRODUCTION

The U.S. Department of Energy's (DOE's) Rocky Flats Site (RFS) is located between Boulder and Golden, Colorado, along the Front Range of the Rocky Mountains approximately 26 km (16 miles) northwest of downtown Denver. The site was established in 1951 to manufacture nuclear weapons components for the nation's nuclear weapons program. During the height of operations, over 6,000 employees worked at the site. Weapons production halted in 1992, and the

site's mission changed to include environmental investigations, cleanup, and site closure. In October 2005, DOE and its contractor completed an accelerated 10-year, $7 billion cleanup of chemical and radiological contamination left from nearly 50 years of production. The cleanup required the decommissioning, decontamination, demolition, and removal of more than 800 structures; removal of more than 500,000 m^3 (650,000 yd^3) of low-level radioactive waste; and remediation of more than 360 potentially contaminated environmental sites. As a result of cleanup operations, approximately 263 hectares (650 acres) of disturbed land required revegetation.

Prior to site closure, DOE managed approximately 2,505 hectares (6,191 acres) at RFS. Of this, approximately 162 hectares (400 acres) was developed as the industrial complex. The remainder was a Buffer Zone (BZ) between the industrial area and off-site areas. Little work or disturbance took place in the BZ and most of it remained as undisturbed native natural areas. Today, the Office of Legacy Management (LM) within DOE manages approximately 529 hectares (1,308 acres) in the Central Operable Unit and approximately 384 hectares (948 acres) in the Peripheral Operable Unit. Approximately 1,592 hectares (3,935 acres) were transferred to the Rocky Flats National Wildlife Refuge (Refuge) in 2007 and the remaining Peripheral Operable Unit acres will eventually be transferred once private mineral rights issues are resolved. Refuge areas are managed by the U.S. Fish and Wildlife Service (USFWS).

ECOLOGICAL SETTING

At an elevation of approximately 1,830 m (6,000 ft), the site contains a unique ecotonal mixture of mountain and prairie plant species resulting from the topography of the area and its proximity to the mountain front. High-quality native plant communities at the site include the xeric tallgrass prairie, mesic mixed-grass prairie, shrublands, wetlands, and Great Plains riparian woodland communities. The spatial distribution of the plant communities is largely determined by the hydrology and soil types at the site. The xeric tallgrass prairie is present on the pediment tops (upper flat surfaces extending from the mountain front) and ridge tops, primarily on the western side of the site, although smaller pockets occur on the eastern side. The pediment tops are underlain by the Flatirons very cobbly, sandy-loam soil type, which has developed from the Rocky Flats Alluvium. The xeric tallgrass prairie community dominates this soil type and is characterized by native graminoid species such as big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), needle and thread (*Stipa comata*), mountain muhly (*Muhlenbergia montana*), and forbs such as Porter's aster (*Aster porteri*) and blazing star (*Liatrus punctata*).

The mesic mixed grassland community dominates the hillsides at the site. Denver-Kutch-Midway clay loams form the complex of soil types on the hillsides where species such as western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), side oats grama (*Bouteloua curtipendula*), green needle grass (*Stipa viridula*), and Kentucky bluegrass (*Poa pratensis*) are common. At locations where more moisture is available, particularly on the hillsides and in the drainage bottoms, shrubland communities, wetlands, and Great Plains riparian woodland communities predominate. The underlying geology influences the locations of the more hydric communities at the site. Where the Rocky Flats Alluvium meets the underlying bedrock, groundwater seeps form on the hillsides, and large hillside seep wetlands occur at these

locations. These wetlands are dominated by various species of sedges (*Carex* sp.), rushes (*Juncus* sp.), cattails (*Typha* sp.), and various forb species. On the hillsides above the seep lines and wetlands, shrublands grow in long narrow bands. The shrublands are dominated by chokecherry (*Prunus virginiana*), hawthorn (*Crataegus erythropoda*), and American plum (*Prunus americana*). In the valley bottoms along the intermittent streams, plains cottonwood (*Populus deltoides*), peachleaf willow (*Salix amygdaloides*), coyote willow (*Salix exigua*), and wild indigo (*Amorpha fruticosa*) predominate.

These plant communities provide habitat for a wide variety of wildlife species. The grassland communities support a variety of grassland birds that breed and forage in this habitat. Small mammals are abundant and diverse and provide a suitable prey base for a variety of avian and mammalian predators. The shrubland and riparian woodland communities provide important habitat for mule deer (*Odocoileus hemionus*) and elk (*Cervus canadensis*) that frequent or live at the site. They rely on these areas for fawning/calving cover, winter thermal cover and browse, and summer shade and isolation cover. The shrublands and woodlands also provide habitat for a great diversity of songbirds and raptors that live along the drainage bottoms at the site. The riparian areas at RFS also contain protected critical habitat for the Preble's meadow jumping mouse (*Zapus hudsonius preblei*), a federally listed, threatened species under the Endangered Species Act. Wetland areas and small areas of open water at the site provide habitat for various waterfowl and amphibian species.

LAND STEWARDSHIP PROGRAM

Within DOE, the Land Stewardship Program (LSP) is one of nine sustainability programs in the Environmental Management System (EMS). The purpose of the LSP is to advocate improved ecosystem health on LM properties in accordance with DOE Order 436.1 and other federal regulations, such as the Endangered Species Act, the Noxious Weed Act, the Farmland Protection Policy Act, and floodplains and wetlands compliance (10 CFR 1022). The LSP establishes a process to enhance ecosystem health at LM sites. At RFS, weed control and vegetation management activities are a key component of the land stewardship program.

HISTORICAL BACKGROUND

The need for proactive land stewardship at RFS came to the forefront in the mid-1990s as noxious weeds became more prevalent and problematic at the site. Prior to the 1990s, only minimal weed control efforts were necessary and conducted at RFS. In the mid-1990s site ecologists began mapping specific noxious weed infestations across the site. Species such as diffuse knapweed (*Centaurea diffusa*), musk thistle (*Carduus nutans*), dalmatian toadflax (*Linaria dalmatica*), and common mullein (*Verbascum thapsus*) had become so abundant that they were threatening wildlife habitat and the high-quality native plant communities. Figure 1 shows a nearly solid stand of diffuse knapweed on an otherwise native grassland on a hillside at the site in the mid-1990s. Diffuse knapweed, one of the most invasive of the weeds, swept across the prairies at the site like a wildfire in the wind. Initial control efforts were conducted with ground and aerial applications of herbicides (Figure 2). Later, biological control (biocontrol) insects were released assist with control efforts. As site closure approached and approximately half of the 529 hectares (1,308 acres) in the Central Operable Unit were disturbed and required

revegetation, the need for proactive management of revegetation areas increased. The RFS Revegetation Plan[1] and RFS Vegetation Management Plan[2] were written to provide direction for the land stewardship activities at the site. These "living" documents have continued to evolve through the years since site closure as experience and advances in resource management techniques have improved.

Fig. 1. Diffuse knapweed (the brownish plant) had exploded across the grasslands at RFS in the mid-1990s and was threatening wildlife habitat and the quality of the native grasslands.

INTEGRATED WEED CONTROL/VEGETATION MANAGEMENT

At RFS, an integrated ecosystem approach to natural resource management is used that utilizes as many management techniques as possible. It is understood that no single weed control strategy will completely remedy the noxious weed problems at RFS, so this approach seeks to integrate various techniques to control present and future infestations of noxious weeds, reduce wildfire hazards, and enhance the native plant communities and wildlife habitat while minimizing environmental damage and optimizing the use of available resources.

Most noxious weeds invade ecosystems because of disturbance, degradation, or changes in the natural system that alter resource availability, thus making the plant community more prone to invasions[3]. Long-term control of noxious weeds ultimately depends on restoring the natural processes (e.g., fire, grazing) that originally kept the ecosystem healthy. However, weed control is a critical component of an integrated management approach because it focuses efforts directly on the undesired species.

The weed management strategy used at RFS includes the identification of the problem through inventory and mapping efforts, the development of management goals, the setting of priorities, the development and evaluation of weed management techniques for selected species, and monitoring.

Fig. 2. Aerial herbicide applications with a helicopter were initially made to control diffuse knapweed and other noxious weed species on the grasslands at the site.

Inventory and mapping efforts for noxious weeds and other undesirable species have been ongoing at Rocky Flats since the mid-1990s. Through fortuitous observations and targeted mapping efforts for selected species, site ecologists have a good working knowledge of which species are present onsite, most problematic, and in need of prioritization and control. Early detection and rapid response to control new invasive species is crucial to an effective program. Annual training is provided to field staff to make them aware of what species to be on the watch for at the site. Additional eyes are important for catching a new infestation early on so that control efforts can be implemented quickly.

A total of 33 species of Colorado state-listed noxious weeds are known to occur or have historically occurred at RFS. An additional five species that are not Colorado state-listed species, but are species either listed on the Jefferson County noxious weed list or that are considered problematic at RFS are also of concern at the site. Not all of these species are known to currently exist at RFS because some species were found once and pulled, and have never been found again. However, it is important to continue to be watchful and to be aware of what might be found again.

The effectiveness, feasibility of implementation, and costs of weed control techniques vary by target species. The biology of each species is different, and therefore different considerations must be taken into account when developing an effective integrated weed control program. The size of an infestation may also influence what methods may be used. In general, priorities for control are based on the State of Colorado's weed list categories and management goals. Species that are not on the noxious weed list but that are considered problematic at RFS are prioritized for control based on field observations and professional judgment.

Pre- and post-control monitoring is conducted using a variety of techniques. Mapping of weed infestations is conducted for various selected species for use in developing annual control activities. Qualitative or quantitative vegetation monitoring may be conducted to provide data for specific informational needs. In other cases, a post-control walkdown of the treated area is conducted to visually observe the effectiveness of controls. Notes may be taken in a field notebook or photographs may be used to document conditions for future reference.

Table I lists the weed and vegetation control methods currently in use at RFS. The control measures are listed in the order they are considered from an integrated weed management viewpoint, starting with the least toxic, nonchemical measures.

Administrative and cultural weed management actions are incorporated into the program with the intention of preventing the introduction and spread of weeds at RFS. These measures are of particular importance for revegetation activities and hence focus on preventing the introduction of weed species during these activities. Prevention measures include the requirement to use only weed-free sources of erosion control materials (straw or hay bales, wattles, erosion control matting/hydromulch), the use of desirable native plant species in seed mixes, restrictions on the use of specific non-native graminoid species in seed mixes, requirements for weed control and reseeding for a minimum of 2 years after a revegetation effort, and eradication of any new noxious weed species to prevent increase and further spread on site. Interseeding is used to increase the vegetation cover in an area and is used to further increase the abundance of desirable species that can help outcompete weeds.

Table I. Weed Control Methods for Rocky Flats

Treatment Option	Control Method
Administrative controls	Administrative policies and procedures
Cultural controls	Revegetation requirements; maintain healthy native plant communities; interseeding
Physical or mechanical controls	Mowing
	Prescribed burns
	Hand-pulling, trimmers, chainsaw
Biological controls	Biological control insects
	Grazing
Chemical controls	Herbicide applications

Physical or mechanical controls used at the site include mowers, trimmers, hand-pulling, and chainsaws. Properly timed mowing can stress weeds and impact seed-set of undesirable plants,

which aids in the control of noxious weeds. It can also be used to stimulate additional growth and vigor of desirable graminoid species by mimicking some of the effects of grazing. Mowing road edges reduces the amount of fuel available at the margins of the firebreak and gravel roads, and it increases visibility of wildlife crossing the roads to help reduce collisions between wildlife and vehicles. Hand-pulling and the use of trimmers (gas-powered or manual trimmers) to control small infestations is conducted where practical and effective. This method has proven effective to prevent the spread of Scotch thistle (*Onopordum acanthium*), a biennial noxious weed, found in only a few small localized infestations at the site. Chainsaws are used to control some woody species such as Russian olive. A chainsaw is often used in conjunction with a spot herbicide application on a cut trunk, as part of a cut-and-spray treatment that has been shown to be effective.

The use of prescribed burns on RFS grasslands has been recommended as a management tool to help control weeds, reduce plant litter, recycle nutrients, and improve the health and vigor of the native plant communities. The natural process of fire is essential for prairie health. Weed control strategies that focus solely on the weed species and not on enhancing conditions for desired native species typically provide only limited success. If desired native species are not able to fill in the openings created in the native plant communities after target weed species are eliminated, then other undesirable weeds often take the place of the target species. Site policies, however, currently restrict the use of prescribed fire for resource management at the site.

Biological controls include the use of biological control agents such as grazing animals or insects to help control undesirable vegetation. Similar to the use of prescribed burning, grazing is highly recommended as a management tool to help control weeds, reduce plant litter, recycle nutrients, and improve the health and vigor of the native plant communities. Unfortunately, similar to prescribed burning, grazing is a management tool that has not been and is currently restricted at RFS. The lack of these two specific natural processes, which likely would contribute to the long-term health of the prairie ecosystem, make it challenging to enhance conditions for desirable prairie species. At some point in the future these two processes may be allowed for use at RFS.

The use of biocontrol insects to help control undesirable species at RFS has been conducted since the 1970s. Biocontrol insects are used at RFS to assist in the control of musk thistle, bull thistle (*Cirsium vulgare*), St. Johnswort (*Hypericum perforatum*), dalmatian toadflax, Canada thistle (*Cirsium arvense*), field bindweed (*Convolvulus arvensis*), and diffuse knapweed. The insects have been provided to the site by the Colorado Department of Agriculture and USFWS through an agreement with Texas A&M University to target specific weed infestations. Table II lists the biological controls that have been released at RFS, their target species, and the effect they have on the plants. Several of the biocontrol insects have proven effective in helping reduce the abundance of specific species such as diffuse knapweed, St. Johnswort, and dalmatian toadflax. Figure 3 shows biocontrol insects that have been released at the site to help control diffuse knapweed and dalmatian toadflax.

Chemical controls (i.e., herbicides) have been used effectively at Rocky Flats to control numerous noxious weed species. When other techniques are ineffective or not cost-effective, then herbicide applications are considered. Herbicide application locations are developed on the basis of noxious-weed-mapping results, field observations, and management objectives.

Herbicides have been applied at RFS using both ground (truck and ATV mounted equipment, and backpack sprayers) and aerial application (helicopter) methods. A list of "approved" herbicides for use at RFS is contained in the RFS Vegetation Management Plan and is updated as needed.

Table II. Biological Control Agents Released at Rocky Flats

Target Species	Beneficial Organism	Effect
Diffuse knapweed (*Centaurea diffusa*)	*Urophora quadrifasciata*	Attacks knapweed flowers, producing galls that reduce seed production.
	Urophora affinis	Attacks knapweed flowers, producing galls that reduce seed production.
	Sphenoptera jugoslavica	Beetle larvae bore into root crown and upper roots of knapweed, retarding plant development and stunting growth.
	Larinus minutus	A seedhead weevil.
	Cyphocleonus achates	A root-boring weevil.
Musk thistle (*Carduus nutans*)	*Rhinocyllus conicus*	A weevil that eats the seeds in the musk flower heads.
	Trichosirocalus horridus	Weevil that attacks the crown of musk thistle, thus killing the apical meristem and reducing the potential of the plant to flower.
Bull thistle (*Cirsium vulgare*)	*Urophora stylata*	A gall fly that attacks flower heads and reduces seed set.
Canada thistle (*Cirsium arvense*)	*Urophora carduii*	A gall fly that attacks flower heads and reduces seed set.
	Cassida rubiginosa	A defoliating beetle.
St. Johnswort (*Hypericum perforatum*)	*Chrysolina quadrigemina*	A foliage-feeding beetle.
Dalmatian toadflax (*Linaria dalmatica*)	*Calophasia lunula*	Larvae of this moth feed on the leaves and flowers of the plant.
	Mecinus janthinus	A stem-mining weevil.
Field bindweed (*Convolvulus arvensis*)	*Aceria malherbae*	A gall mite.

In accordance with a 2009 U.S. Court of Appeals ruling (*National Cotton Council, et al. v. EPA*), effective October 31, 2011, discharges to waters of the United States from the application of pesticides require National Pollutant Discharge Elimination System (NPDES) permits. In response to the court's ruling, the U.S. Environmental Protection Agency promulgated its *Final National Pollutant Discharge Elimination System (NPDES) Pesticide General Permit for Point Source Discharges From the Application of Pesticides*, 76 FR 68750-68756, November 7, 2011. This rule requires an evaluation of management techniques when herbicides may be used in or near "waters of the U.S." This evaluation is conducted for weed control activities that will take place in or near "waters of the U.S." at RFS.

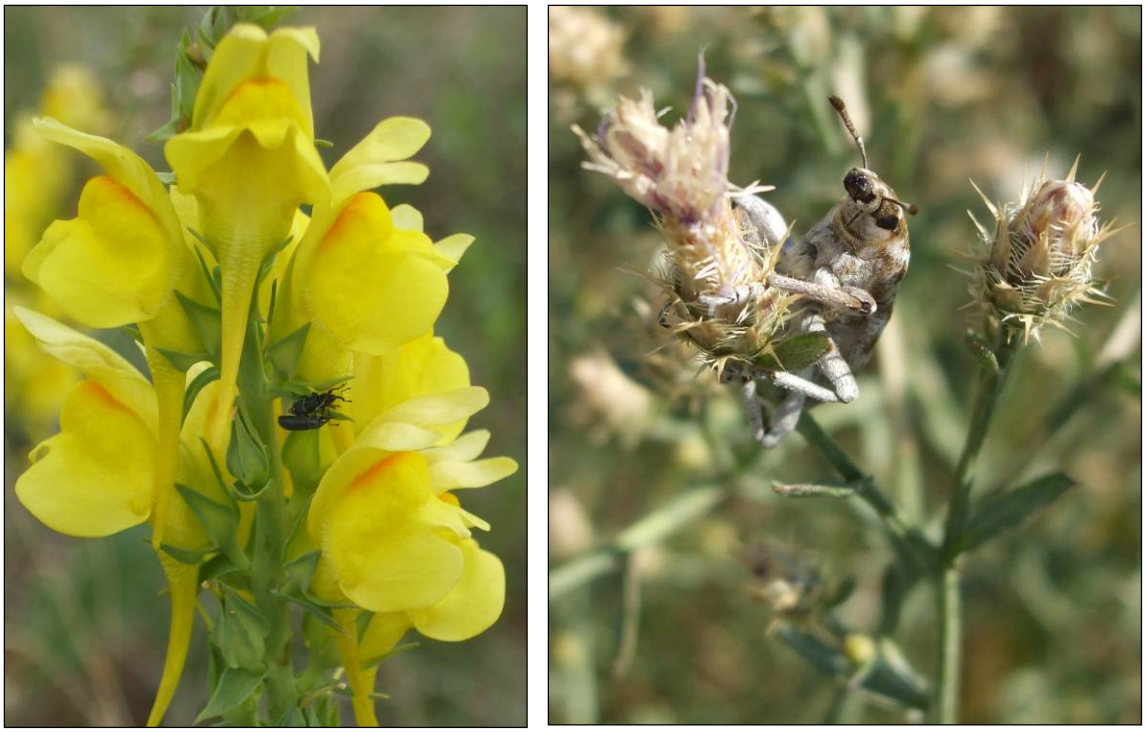

Figure 3. *Mecinus janthinus* (left), is a stem boring beetle that lays its eggs in the stems of dalmatian toadflax. The larvae then eat out the stem, killing the stem and reducing flowers and seed set. Eventually the plants are killed. *Cyphocleonus achates* (right), is a root boring weevil that has a similar effect on diffuse knapweed.

One other factor that places some limitations on weed control/vegetation management activities at RFS is the Preble's meadow jumping mouse (Preble's mouse; *Zapus hudsonius preblei*). The Preble's mouse is a federally listed threatened species under the Endangered Species Act. Critical habitat for the mouse was designated at the site in 2010. Through several consultations with the USFWS, DOE has received concurrence for its current weed control activities that take place in critical habitat at RFS. All weed control activities at the site that take place in critical habitat are required to follow the guidance provided in these documents. The USFWS must be consulted before any changes or modifications can be made to the weed control activities as outlined in these documents.

CONCLUSIONS

In combination, the various tools available for weed control/vegetation management at RFS have proven quite effective. Prevention is the critical element since there is no need to control a species if it doesn't occur on site. Knowledge of what species might come onto the site from surrounding areas is also an important component of prevention. Working with surrounding landowners, being observant of nearby properties, and attending local weed conferences keeps site ecologists knowledgeable of new potential problem species in the area. Requiring the use of weed-free erosion controls and seed mixes reduces the chances of accidental introductions from other areas.

Early detection and rapid response is necessary for undesired species that do show up at RFS. Annual training for field staff provides them the ability to identify potential new problem species or species already present with limited distribution at the site. This allows control of a limited infestation and can keep it from becoming larger. Scotch thistle is a relatively new noxious weed species that showed up at the site several years ago. Annual hand control (i.e., popping rosettes out of the ground with a spade or cutting off and bagging flower heads) has kept the species from spreading and has eradicated it from some of the locations where the plants were initially found.

The combined use of herbicides and biocontrol insects has provided good control of diffuse knapweed at the site. In the mid-1990s diffuse knapweed was common across many of the grassland areas at RFS. Helicopter spraying was used to treat hundreds of acres in the late 1990s and the early 2000s for initial control of the species. Five different biocontrol insects (Table II) for diffuse knapweed were then released at various locations across the site. Since that time the biocontrol insects have spread across RFS and can be found nearly everywhere on site. The infestation levels of diffuse knapweed have never returned to the mid-1990 levels and at many locations is very sparse. Herbicide applications are still made at selected locations for diffuse knapweed, but most of these locations are in revegetation areas where vegetation is still establishing. Applying the herbicide improves the ability of the grasses to establish and out compete the non-natives.

REFERENCES

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3. Davis, M.A., J.P. Grime, and K. Thompson, 2000. "Fluctuating resources in plant communities: a general theory of invisibility," *Journal of Ecology*, 88: 528–534.