

Integrating Herbicides in Prairie and Grassland Management

A PRACTICAL AND TECHNICAL GUIDE



ELM



SWEET CLOVER



CANADA THISTLE



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About This Document



PURPOSE

This publication provides resources to land managers better understand how and when to integrate herbicides in prairie and grassland management programs. Information on herbicide use rates, herbicide selectivity on desirable forbs and grasses, seeding guidelines, invasive woody and herbaceous plant control, and other useful tips are provided in this document.

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Highlights the importance of protecting existing prairie from invasive plants and reconstructing or restoring mixed forb-grass prairie ecosystems.

Section 2. Invasive Plant Management Strategies

Guidelines and considerations to support an invasive plant management strategy on grasslands and prairies.

Section 3. Integrating Herbicides in Prairie Restorations that Require Seeding

Guidelines for reseeding and restoring prairie from former cropland and degraded sites; including seeding recommendations for weed-infested sites.

Section 4. Tolerance of Established Forbs and Grasses

Tolerance ranking for established forbs to Milestone® herbicide and a list of grasses tolerant to Milestone and Transline® herbicides.

Section 5. Herbaceous Weed Control on Prairies and Grasslands

Recommendations and rates for 28 species of forbs, vines, and grasses; includes detailed recommendations for managing Canada thistle and sweetclover in natural areas.

Section 6. Woody Plant Control in Northern Prairies

Recommendations, methods, and equipment for managing woody plants.

Section 7. Technical Facts and Answers to Frequently Asked Questions About Herbicides

Herbicide use rates, formulations, and attributes of various herbicide products; and questions regarding aminopyralid and triclopyr herbicides.

Impacts of Invasive Plants on Prairies and Grasslands

Native tallgrass prairie historically covered 140 million acres of North America. These ecologically important grasslands included a mix of species such as big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*) along with native forbs (*wildflowers*) like black-eyed susan (*Rudbeckia hirta*) and wild bergamot (*Monarda fistulosa*).

It is estimated that as much as 99 percent of native tallgrass prairie has been destroyed or severely impaired in the midwestern United States. This highlights the importance of protecting existing prairie from invasive plants, and reconstructing or restoring¹ mixed forb-grass prairie ecosystems.

A land manager's ability to reconstruct or rehabilitate mixed forb-grass prairie landscapes is often compromised by the presence of invasive plants i.e. Canada thistle (*Cirsium arvense* L.) and sweet clover (*Melilotus officinalis*). Although best management practices recommend applying herbicides to control noxious and invasive weeds prior to establishing mixed grass prairie systems, there is concern about the effect of herbicide residues on forb establishment.

WHY MANAGE INVASIVE PLANTS?

Fire suppression, removal of native nomadic grazers, and continued human disturbance, allow for the spread and establishment of invasive plants on prairies and

grasslands. Invasion by herbaceous weeds and woody plants has become a major threat to the conservation of biodiversity and ecosystem sustainability in both remnant and restored prairies (Figure 1.1).

Invasive Plants Can:

- Compete with and displace native plants and animals.
- Alter structure, organization and function of native plant communities, and threaten biodiversity.
- Hybridize with native species.
- Impact soil and water resources and promote other invaders.
- Alter fire regimes.

The good news is that many plant invasions can be reversed, halted or slowed, and many degraded sites can be restored to healthy systems dominated by native species. In some instances this requires taking action to control and manage invasive plants to meet conservation goals.



Invasive Plant Management Strategies

Successful long-term management programs for prairies and grasslands should be designed to include a combination of protection for native species, and implementation of biological, cultural, mechanical, and herbicide management methods for invasive plants.

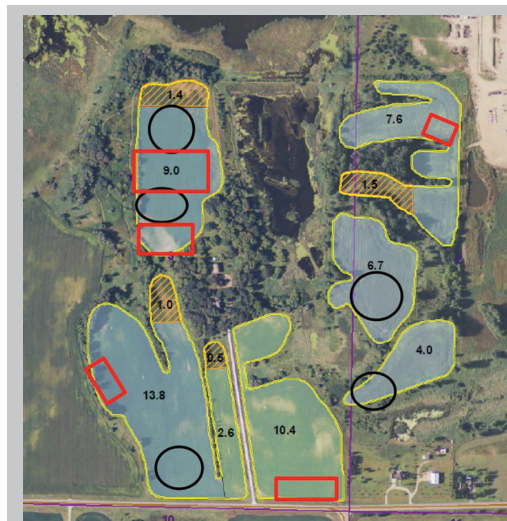
This is particularly true in restoration programs where seedling establishment is dependent upon suppression of competitive plants that may be present on the site. Enhancing the ecological health and integrity of prairies and grasslands can be achieved by identifying management actions that will promote a healthy, weed-resistant plant community that consists of diverse groups of species that occupy most of the abiotic niches.

The following guidelines and considerations support an invasive plant management strategy on grasslands and prairies:

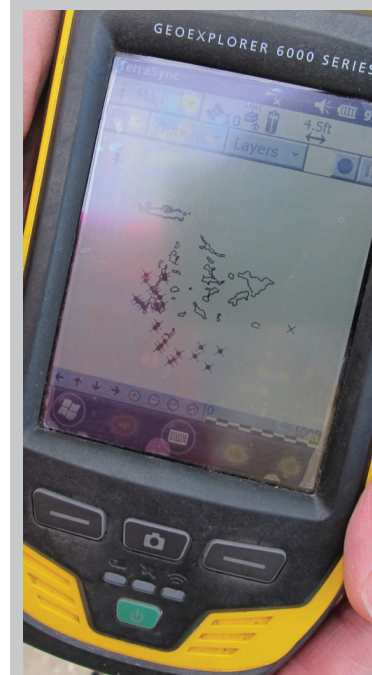
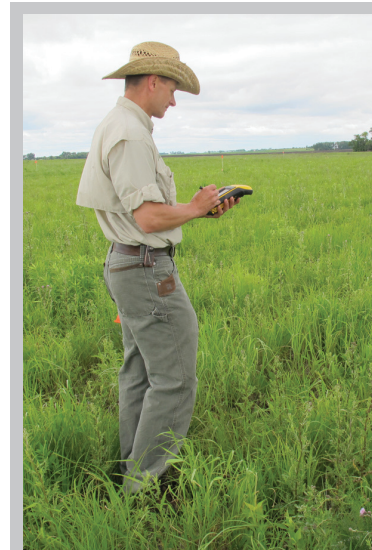
- **Identify the goal(s) you want to achieve** like enhance forage quantity and quality, restore prairie vegetation, improve wildlife habitat, protect existing grassland, etc.
- **Identify and accurately delineate lands infested with invasive plants.** Knowing the location and extent of an infestation can help to determine the control/management method needed, prioritize management strategies, and identify areas where eradication, containment or control can be achieved.
- **Prioritize sites** where treatments will most effectively contain and control the infestation while minimizing impact to native species.
- **Identify management constraints** such as environmental, financial, technological, social, and operational.
- **Gain a thorough understanding** of the biology and ecology of the invasive weed(s) you are managing,

including susceptible habitat, spread vectors, impact on desired goals, etc.

- **Review effectiveness of each management method** on the target plant including mechanical, cultural, biological, and herbicide methods. Then integrate management techniques that will optimize control.
- **Be flexible.** Use long-term monitoring and evaluation to identify strengths and weaknesses in your strategies and methods. Adapt management approaches to improve effectiveness and prevent reinvading populations from becoming established.
- **Plan for a long-term commitment** to your management program. Many invasive plants have seeds that remain viable in the soil for eight years or more, so long-term monitoring and follow-up management will be necessary for successful control.



Example of Canada thistle inventory showing location of Canada thistle infestations greater than 20% cover (red square) and sites with less than 10% cover of Canada thistle (black circles).



Collecting data on invasive plant density and distribution is important to develop management strategies and measure success of management actions over time.

Integrating Herbicides in Prairie Restorations that Require Seeding

Invasive plant management is a vital component of protecting and enhancing restored prairies, Conservation Reserve Program (CRP) lands, and remnant grasslands. Removing problem species, reintroducing fire, and possibly adding desirable seed or seedlings are management tools used to supplement existing species diversity. Increasing plant community diversity usually improves wildlife habitat value, water quality, and increasing plant community stability.

RECONSTRUCTION FROM CROPLAND

Includes former cropland or other sites where prairie seeding practices are starting with bare soil.

Seeding into former crop areas is usually straightforward, and most sites can utilize one of several approaches for successful prairie restoration. Often the former cropping practice has provided all the site preparation necessary.

RESTORATION OF DEGRADED SITES

Includes non-cropland, CRP, or grassland with high densities of invasive plants including Canada thistle, and insufficient desirable grasses or forbs to recover and repopulate the site.

Sites dominated by undesirable pre-existing vegetation should be evaluated to determine appropriate restoration activities. Often the best option is to start over with site preparation, which may include integrating herbicides, tillage, prescribed mowing and/or prescribed fire. Sites with pre-existing stands of competitive or over-dominant invasive plants e.g. Canada thistle, or vigorous stands of smooth brome may require multiple tillage events and/or treatment with herbicide to deplete carbohydrate reserves in rhizomes and minimize regrowth potential.

GENERAL GUIDELINES FOR PRAIRIE RESTORATION PROJECTS

Evaluate the site to determine appropriate activities for site preparation, which may include integrating herbicides, tillage, prescribed mowing and/or prescribed fire. Site preparation is the most important step in the prairie restoration process.

- Minimize risk of soil erosion during tillage operations or consider drilling directly into non-tilled land if some desirable species remain.
- Allow for good seed-to-soil contact at the time of seeding (e.g. *thatch removal*).
- Sites with pre-existing stands of competitive invasive plants such as Canada thistle, or vigorous stands of smooth brome may require herbicide treatments and multiple tillage events.
- Eliminate or decrease vigor and density of invasive, nonnative plants to minimize post-seeding maintenance issues.
- Fire can be an important tool to stimulate grass vigor and improve competition with weeds. Fire can also be used to remove litter, improving seed-to-soil contact and enhances herbicide coverage on target plants.
- On sites that are prone to Canada thistle invasion, consider planting forbs that are tolerant to broadleaf selective herbicides like Milestone® or Transline® herbicide.
- Clipping and mowing is not recommended for reconstructed prairie that is more than one year post-seeding.
- Monitor invasive plant populations and spot treat dense infestations with an appropriate selective herbicide. Selection of sites for spot treatment would depend on target plant species and density, and desirable forb presence.
- On restored prairie sites with desirable forbs, do not broadcast treat invasive plant populations using broadleaf herbicides until two years following seeding.



Grasses can be seeded after a summer or fall application of Milestone® or Transline® herbicides (top), and forbs can be seeded 90 days following application of Milestone or Transline (bottom). Note: grass and forb tolerance is based on a maximum application rate of 7 fluid ounces per acre (fl oz/ac) of Milestone and 16 fl oz/ac of Transline.

HERBICIDE USE IN RESTORATION

Regardless of the condition or composition of a restoration site, enriching the plant community by seeding desirable species can be accomplished by following a few basic steps/concepts:

FALL PRIOR TO SEEDING DEGRADED SITES

Apply appropriate herbicide at the correct application timing and rate to improve seeding success. For example, apply Transline® or Milestone® herbicide the growing season prior to seeding to control high-density infestations of Canada thistle (Figure 3.1). Field studies show that Milestone can be applied in the fall to control Canada thistle, followed by seeding forbs and grasses as a dormant fall planting or the following spring (Lym et al. 2011, Renz et al. 2012).

YEAR OF SEEDING CONVERTED CROPLAND

If weeds are present at the time of seeding, treat the area with glyphosate either before seeding or 5 to 8 days post-seeding.

Monitor weed growth as native desirable seedlings begin to grow, and mow during the growing season at a height slightly above the height of the observed prairie seedlings. This helps ensure desirable prairie seedlings will have access to adequate resources for growth, especially light, water, and nutrients.

YEAR AFTER SEEDING

Maintain the site to enhance growing conditions. Conduct vegetation maintenance practices, which may include mowing the growing season following supplemental seeding. This step is especially important in the case of supplemental forb seeding into competitive stands of native, warm season grasses. Dense infestations of broadleaf weeds can be spot treated with Transline the growing season following seeding.

TWO YEARS AFTER SEEDING

Treat invasive herbaceous weeds, trees and shrubs using spot herbicide treatments wherever practicable during the second year post-seeding. Mowing will not control invasive plants and may impact desirable forbs (Duncan 2011). Early detection and prompt treatment of problem weeds is important.

NOTE: Select forbs and grasses that are tolerant to Milestone for sites where it is likely that invasive plants, like Canada thistle, will become an issue (Table 3.1).

Figure 3.1. HERBICIDE APPLICATION TIMING IN RESTORATION PROJECTS

Fall Prior to Seeding DEGRADED SITES	Year of Seeding CONVERTED CROPLAND	Year After Seeding (1 year old plants)	Two Years After Seeding (2 year old plants)
<p>Apply MILESTONE® or TRANSLINE®</p> <p>in summer or fall to manage undesirable species before dormant fall or spring seeding.</p>	<p>Broadcast RODEO® or ACCORD® XRT II if weeds are present: apply before seeding or 5 to 8 days post-seeding.</p> <p>Mowing may be beneficial at height above desirable seedlings. (local recommendation)</p>	<p>TRANSLINE spot treatments</p> <p>Mowing will not control invasive plants and may adversely impact desirable plants.</p>	<p>MILESTONE spot or broadcast treatments</p> <p>Mowing will not control invasive plants and may adversely impact desirable plants.</p>
↑ ↑		↑ ↑	
Seed grass/forb species - late fall or spring		Site maintenance / Spot herbicide treatments	

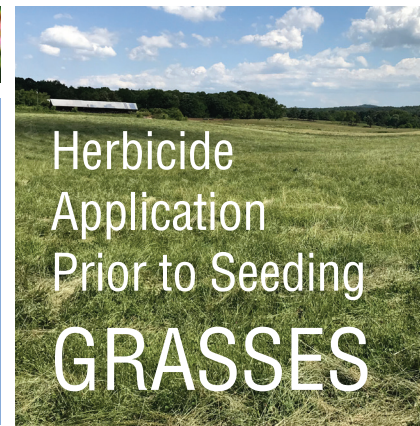


Table 3.1 Forbs Tolerant to Milestone® Herbicide Recommended for Seeding into Sites Infested with Canada Thistle or Other Invasive Weeds

Use this table to develop a seed mix tolerant to Milestone that meets the goal of structural diversity (height) and varied flowering times.

* Susceptible to fall herbicide treatment. See Section 4 for symptoms and injury levels associated with these rankings.

Common Name	Scientific Name	Flower Color	Height (feet)	Flower Time					
				Apr	May	Jun	Jul	Aug	Sep
Blanket flower	<i>Gaillardia aristata</i>	Red, Yellow	1 to 2			✓	✓		
Blue vervain	<i>Verbena hastata</i>	Blue	5				✓	✓	✓
Butterfly milkweed	<i>Asclepias tuberosa</i>	Orange	2 to 3			✓	✓	✓	
Button (or rough) blazingstar	<i>Liatris aspera</i>	Purple, Pink	3 to 5					✓	✓
Common milkweed	<i>Asclepias syriaca</i>	Lavender	2 to 4			✓	✓	✓	
Cup plant	<i>Silphium perfoliatum</i>	Yellow	3 to 10				✓	✓	✓
Golden alexanders	<i>Zizia aurea</i>	Yellow	3	✓	✓	✓			
Heart-leaved alexanders	<i>Zizia aptera</i>	Yellow	2	✓	✓				
Heath aster	<i>Aster ericoides</i>	White	2					✓	✓
Hoary vervain	<i>Verbena stricta</i>	Blue	2			✓	✓	✓	✓
Large flowered penstemon	<i>Penstemon gradiflorus</i>	Lavender	2 to 4		✓	✓			
Leadplant	<i>Amorpha canescens</i>	Purple	2 to 3			✓	✓		
Lupine	<i>Lupinus sericeus</i>	Blue	1 to 2		✓	✓			
Meadow blazingstar	<i>Liatris ligulistylis</i>	Purple, Pink	3 to 5					✓	✓
New England aster	<i>Aster novae-angliae</i>	Purple, Pink, Blue	3 to 6					✓	✓
Ox Eye sunflower	<i>Heliopsis helianthoides</i>	Yellow	3 to 6			✓	✓	✓	✓
Prairie blazingstar	<i>Liatris aspera</i>	Purple	3				✓	✓	✓
Prairie onion	<i>Allium stellatum</i>	Purple	1				✓	✓	
Purple meadow-rue	<i>Thalictrum dasycarpum</i>	Purple	6			✓	✓		
*Purple prairie clover	<i>Dalea purpurea</i>	Purple, Yellow	1 to 2				✓	✓	
Round-headed bush clover	<i>Lespedeza capitata</i>	White	3 to 5					✓	✓
Showy tickfoil	<i>Desmodium canadense</i>	Purple	5				✓	✓	
Smooth blue aster	<i>Aster laevis</i>	Blue	4					✓	✓
*Stiff goldenrod	<i>Solidago rigida</i>	Yellow	3 to 4					✓	✓
*Stiff sunflower	<i>Helianthus pauciflorus</i>	Yellow	5				✓	✓	✓
*White prairie aster	<i>Aster ericoides</i>	White	2 to 3					✓	✓
Swamp milkweed	<i>Asclepias incarnata</i>	Red, Pink	3 to 5			✓	✓		
White wild indigo	<i>Baptisia alba</i>	White	4			✓	✓		
Wild bergamot	<i>Monarda fistulosa</i>	Purple	4				✓	✓	✓



Sites that require revegetation after invasive plant control include 1) a plant community dominated by invasive weeds with no desirable vegetation present to establish after herbicide treatment; and 2) sites with remnant desirable plant populations that are insufficient to recover after herbicide treatments.

Field studies conducted in the Midwest and West concluded that applications of either Milestone® at 7 fluid ounces per acre (fl oz/ac) or Transline® at 24 fl oz/ac could be made in the spring through fall to control broadleaf weeds prior to grass planting. Grasses can be seeded as a dormant planting (in the late fall or early winter) in the year of application, or grasses can be seeded the following spring. With a dormant fall seeding, grasses should be planted when soil temperatures are low enough to ensure that the seeds do not germinate and emerge for at least 60 days after application of either Milestone or Transline.

Tolerance of Established Forbs and Grasses to Milestone® Herbicide

The effect of Milestone on desirable native forbs is a consideration for land managers when making decisions about controlling invasive plants. The following information summarizes research on **established** forbs that are tolerant to Milestone (Table 4.1). Established forbs include those growing for a minimum of two years at field sites, and less than one year in a greenhouse study. Experiments were conducted in three states: Minnesota, North Dakota, and South Dakota.

Table 4.1 Tolerance Rankings of Established Forb Species to Milestone® Herbicide

Milestone was applied at either 5 or 7 fluid ounces per acre in early summer (June) and/or fall (September or October). Rankings are shown for 1 and 2 years after treatment (YAT). Forbs are listed alphabetically by common name within plant family. Category descriptions are listed below.

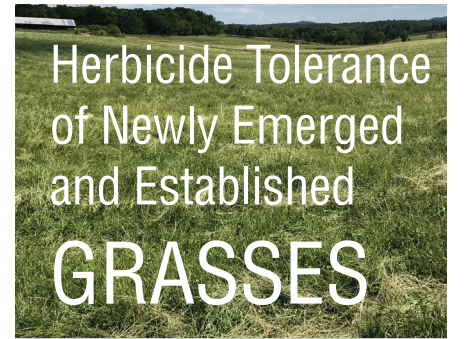
CATEGORIES FOR RANKING TOLERANCE OF FORBS TO MILESTONE®

- T Tolerant**
Minimal symptoms – may exhibit slight injury and cupping of leaves.
<15% stand reduction
- MT Moderately Tolerant**
Cupping/yellowing and possible inhibited flowering, with recovery the first growing season after application.
15 to 50% stand reduction
- MS Moderately Susceptible**
Significant injury the first year and possible stand reduction.
51 to 75% stand reduction
- S Susceptible**
Severe injury the season of application and stand reduction the year after treatment with possible death of established plants. Some plants may regenerate from seed bank.
>75% stand reduction

Family	Common Name	Genus species	1 YAT	2 YAT	Appl Time
Apiaceae	Golden Alexanders	<i>Zizia aurea</i>	T	T	Both
	Heart-leaved Alexanders	<i>Zizia aptera</i>	T	T	Both
Apocynaceae	Spreading dogbane	<i>Apocynum androsaemifolium</i>	T	T	Fall
Asclepiadaceae	Common milkweed	<i>Asclepias syriaca</i>	T	T	Fall
Asteraceae	Azure aster	<i>Symphotrichum oolentagiensis</i>	T	NA	Summer
	Black-eyed Susan	<i>Rudbeckia hirta</i>	S	MS	Both
	Blanket flower	<i>Gaillardia aristata</i>	MT	T	Both
	Canada goldenrod	<i>Solidago canadensis</i>	MT+	T	Summer
	Cup plant	<i>Silphium perfoliatum</i>	MS	MS	Fall
	Cup plant	<i>Silphium perfoliatum</i>	MT	NA	Both
	Giant goldenrod	<i>Solidago gigantea</i>	MT	NA	Both
	Giant sunflower	<i>Helianthus giganteus</i>	S	MS	Fall
	Maximilian sunflower	<i>Helianthus maximiliani</i>	S	S	Fall
	Panicled aster	<i>Aster lanceolatum</i>	MT	NA	Both
	Prairie blazingstar	<i>Liatris aspera</i>	MT	NA	Both
	Prairie goldenrod	<i>Solidago missouriensis</i>	MS	MT	Fall
	Purple coneflower	<i>Echinacea purpurea</i>	T	NA	Summer
	Smooth blue aster	<i>Aster laevis</i>	MT	NA	Both
	Stiff goldenrod	<i>Solidago rigida</i>	MT	MT	Summer
	Stiff sunflower	<i>Helianthus pauciflorus</i>	S	MS	Fall
	Stiff sunflower	<i>Helianthus pauciflorus</i>	MS	MT	Fall
	Sweet smooth oxeye	<i>Heliopsis helianthoides</i>	MT	NA	Both
	Tall sunflower	<i>Helianthus giganteus</i>	S	NA	Both
	White panicle aster	<i>Aster simplex</i>	S	MT	Fall
Asteraceae	White prairie aster (Heath aster)	<i>Aster ericoides</i>	MS	MT	Summer
	White prairie aster (Heath aster)	<i>Aster ericoides</i>	MT	T	Both
	White prairie aster (Heath aster)	<i>Aster ericoides</i>	MT	MT	Fall
Yellow prairie coneflower	<i>Ratibida pinnata</i>	S	NA	Both	
Campanulaceae	Harebell	<i>Campanula rotundifolia</i>	S	NA	Summer
	Palespike lobelia	<i>Lobelia spicata</i>	S	S	Fall

RESULTS SUMMARY

- Most native forb species were moderately tolerant to tolerant, or recovered following treatment with Milestone® herbicide.
- Land managers can use these data as a guideline to evaluate risk and benefits to native plant communities when using Milestone for invasive plant management.
- Milestone can be used to manage invasive plants in mixed plant communities and can serve as a catalyst to manage invasive plants and facilitate recovery of desirable forbs.



Newly Emerged Grasses

Milestone® or Transline® applications should be made after seeded grasses have established a secondary root system and plants are tillering (growing more than one shoot). A secondary root system is usually developed by 45 to 60 days after emergence, depending on growing conditions. Increased injury to grass seedlings may result when either Milestone or Transline is applied in tank mixes with other herbicides such as 2,4-D. Consult labels for all herbicides applied.

Established Grasses

Established grasses have excellent tolerance to Milestone at the maximum use rate of 7 fl oz/ac and to Transline at 24 fl oz/ac. Examples of desirable warm- and cool-season grasses with known tolerance to both Milestone and Transline are listed below.

Warm Season

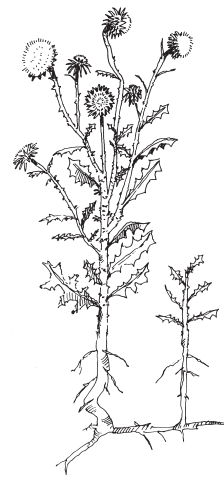
- Big bluestem (*Andropogon gerardii*)
- Blue grama (*Bouteloua gracilis*)
- Buffalograss (*Buchloe dactyloides*)
- Gallettagrass (*Pleuraphis jamesii*)
- Indiangrass (*Sorghastrum nutans*)
- Little bluestem (*Andropogon scoparius*)
- Sideoats grama (*Bouteloua curtipendula*)
- Switchgrass (*Panicum virgatum*)

Cool Season

- Green needlegrass (*Nassella viridula*)
- Perennial ryegrass (*Lolium perenne*)
- Siberian wheatgrass (*Agropyron spp.*)
- Slender wheatgrass (*Elymus trachycaulus*)
- Streambank wheatgrass (*Agropyron riparium*)
- Tall fescue (*Festuca arundinacea*)
- Western wheatgrass (*Pascopyrum smithii*)

Family	Common Name	Genus species	1 YAT	2 YAT	Appl Time
Commelinaceae	Prairie spiderwort	<i>Tradescantia occidentalis</i>	MS	NA	Both
Equisetaceae	Equisetum	<i>Equisetum arvense</i>	T	T	Both
Euphorbaceae	Flowering spurge	<i>Euphorbia corollata</i>	T	T	Both
Fabaceae	Lupine	<i>Lupinus sericeus</i>	T	T	Fall
	Lupine	<i>Lupinus sericeus</i>	MT	T	Summer
	Purple prairie clover	<i>Dalea purpurea</i>	S	MS	Fall
	Purple prairie clover	<i>Dalea purpurea</i>	T	T	Summer
	Round-headed bush clover	<i>Lespedeza capitata</i>	MS	NA	Both
	Showy tickfoil	<i>Desmodium canadense</i>	MS	NA	Both
	Silky prairie clover	<i>Petalostemum villosum</i>	MS	NA	Both
	Trailing wild bean	<i>Strophostyles helvola</i>	T	T	Both
	White prairie clover	<i>Dalea candida</i>	S	S	Fall
	White wild indigo	<i>Baptisia alba</i>	MT	NA	Both
Gentianaceae	Closed bottle gentian	<i>Gentiana andrewsii</i>	T	NA	Summer
Lamiaceae	American water horehound	<i>Lycopus americanus</i>	T	T	Fall
	Hedgenettle	<i>Stachys palustris</i>	T	T	Both
	Wild bergamot	<i>Monarda fistulosa</i>	T	T	Both
	Wild mint	<i>Mentha arvensis</i>	T	T	Fall
Liliaceae	Prairie onion	<i>Allium stellatum</i>	T	T	Both
Onagraceae	Common primrose	<i>Oenothera biennis</i>	S	NA	Both
Oxalidaceae	Common yellow woodsorel	<i>Oxalis stricta</i>	T	T	Fall
Polygonaceae	Pale dock	<i>Rumex altissimus</i>	S	NA	Both
	Water smartweed	<i>Polygonum amphibium</i>	MS	T	Fall
Ranunculaceae	Purple meadow-rue	<i>Thalictrum dasycarpum</i>	MT	MT	Fall
Rosaceae	Prairie cinquefoil	<i>Potentilla arguta</i>	S	NA	Both
Solanaceae	Clammy groundcherry	<i>Physalis heterophylla</i>	S	NA	Both
Urticaceae	Stinging nettle	<i>Urtica dioica</i>	MT	NA	Both
Verbenaceae	Blue vervain	<i>Verbena hastata</i>	T	T	Both
	Hoary vervain	<i>Verbena stricta</i>	T	T	Both

Herbaceous Weed Control on Prairies and Grasslands



Field trials indicate that the following weeds will be controlled at herbicide rates indicated below. For best results, most weeds should be treated when they are actively growing and under conditions favorable for growth.

Use a higher rate in the rate range when growing conditions are less than favorable or when weed foliage is tall and dense. Milestone® herbicide also provides preemergence control of germinating seeds or seedlings of susceptible weeds following application. Some weed species, i.e. Canada thistle and biennial thistles, can be effectively controlled with fall applications.

TABLE 5.1. RECOMMENDATIONS AND RATES FOR CONTROLLING KEY SPECIES

COMMON NAME SCIENTIFIC NAME	PLANT FAMILY LIFE CYCLE	HERBICIDE/RATE	APPLICATION TIMING/SPECIFICATIONS
BROADLEAF WEEDS			
buttercup, tall <i>Ranunculus acris</i>	Ranunculaceae Perennial	Milestone® 4 to 7 fl oz/ac	Apply after complete plant emergence to flower or in the fall.
chamomile, scentless <i>Matricaria inodora</i>	Asteraceae Annual	Milestone 4 to 7 fl oz/ac	Apply after complete plant emergence to pre-bud. Optimum is 12 inches high or less.
common tansy <i>Tanacetum vulgare</i>	Asteraceae Perennial	Opensight® 2.5 to 3.3 oz/ac	Apply to vegetative stage prior to bloom. Use higher rate when weeds are larger.
crownvetch <i>Securigera varia</i>	Fabaceae Perennial	Milestone 5 to 7 fl oz/ac	Apply to vegetative stage prior to bloom. Use higher rate when weeds are larger.
daisy, oxeeye <i>Leucanthemum vulgare</i>	Asteraceae Perennial	Milestone 4 to 7 fl oz/ac or Transline® 2/3 to 1 1/3 pt/ac or Opensight 2.5 to 3.3 oz/ac	Apply to vegetative stage prior to bloom. Use higher rate when weeds are larger.
garlic mustard <i>Alliaria petiolata</i>	Brassicaceae Biennial	Garlon® 4 Ultra 1.25 to 2.5% v/v	Apply prior to bolting.
hawkweeds (yellow/orange) <i>Hieracium caespitosum</i> and <i>aurantiacum</i>	Asteraceae Perennial	Milestone 5 to 7 fl oz/ac or Transline 1 pt/ac	Apply from spring rosette to late bolting stage. For optimum results do not apply in the fall.
houndstongue <i>Cynoglossum officinale</i>	Boraginaceae Biennial	Opensight 2.5 to 3.3 oz	Apply to rosettes. As plant bolts, increase the rate to 3.0 to 3.3 ounces up to early bud stage. Add 1 quart of 2,4-D after the bud stage.
Japanese knotweed or other invasive knotweeds <i>Fallopia japonica</i>	Polygonaceae	Milestone 7 to 14 fl oz/ac in high volume foliar applications	Apply Milestone at 7 fl oz per acre broadcast using high volume per acre (100 gallons per acre) or apply as a spot treatment using 14 fl oz per acre. Optimum results for suppression of plant growth are obtained when applications are made to plants that are about 3 to 4 feet in height in early summer. Multiple applications/retreatments will be necessary for control of resprouting stems.

COMMON NAME SCIENTIFIC NAME	PLANT FAMILY LIFE CYCLE	HERBICIDE/RATE	APPLICATION TIMING/SPECIFICATIONS
knapweed, spotted and diffuse <i>Centaurea</i> spp.	Asteraceae Biennial / Perennial	Milestone® 5 to 7 fl oz/ac or Transline® 2/3 to 1 pt/ac or Opensight® 2.5 to 3.3 oz/ac	Apply during active growth with the optimum time from rosette to the bolting stage or fall regrowth.
lespedeza, sericea <i>Lespedeza cuneata</i>	Fabaceae Perennial	PastureGard® HL .75 to 1 pt/ac or Garlon® 4 Ultra 1 to 1.5 pt/ac or Garlon 4 Ultra 9 to 12 fl oz/ac + 4 to 6 fl oz/ac Vista® XRT	Begin treatment when plants are a minimum of 8 inches tall (May to June) and continue through summer. Use the higher labeled rate when plants are larger than 18 inches or in early fall.
poison hemlock <i>Conium maculatum</i>	Apiaceae Perennial	Opensight 2.5 to 3.3 oz/ac	Apply when actively growing in early growth stage before bloom.
purple loosestrife <i>Lythrum salicaria</i>	Lythraceae Perennial	Milestone 7 fl oz/ac + 1 to 2 pt/ac of 2,4-D or 0.75 to 1.5 qt/ac of Vastlan®	For optimum control apply at mid bloom stage through late bloom using Milestone at 7 fl oz/ac plus 1 pt to 1 qt of 2,4-D amine or 0.75 to 1.5 qt/ac of Vastlan. Spot treatments may also be made by applying Milestone at 14 fl oz with or without the addition of 2,4-D or Vastlan.
spurge, leafy <i>Euphorbia esula</i>	Euphorbiaceae Perennial	Tordon® 22 K 1 to 2 qt/ac or 1 to 2 pt/ac + 1 lb ai/ac 2,4-D Milestone 7 fl oz + 1 q/ac 2,4-D + 4 oz/ac Overdrive	Apply at the true flower growth stage (mid to late June) or during fall regrowth. Reapply herbicide when level of control drops below 80%.
St. Johnswort, common <i>Hypericum perforatum</i>	Clusiaceae Perennial	Milestone 5 to 7 fl oz/ac or Opensight 2.5 to 3.3 oz/ac	Apply when actively growing in early growth stage before bloom.
starthistle, yellow and malta <i>Centaurea solstitialis</i> ; <i>melitensis</i>	Asteraceae Annual	Milestone 3 to 5 fl oz/ac or Opensight 2 to 2.5 oz/ac or Transline ½ to 1 pt/ac	Apply at the rosette through bolting stages, when soil moisture is present and the plants are actively growing. Use higher rates when weeds are larger.
teasel <i>Dipsacus</i> spp.	Dipsacaceae Biennial	Milestone 4 to 7 fl oz/ac or Opensight 2 to 3.3 oz/ac	Apply in the spring and early summer to rosette or bolting plants. Use higher rates after bolting through early flower.
thistle, Canada <i>Cirsium arvense</i>	Asteraceae Perennial	Milestone 5 to 7 fl oz/ac or Transline 2/3 to 1 pt/ac or Opensight 2.5 to 3.3 oz/ac	Apply when plants have fully emerged in the spring up to early bud growth stage and fall before a killing frost.
thistle, Scotch <i>Onopordum acanthium</i>	Asteraceae Biennial	Milestone 5 to 7 fl oz/ac or Transline 2/3 to 1 pt/ac or Opensight 2.5 to 3.3 oz/ac	Apply in spring and early summer to rosette or bolting plants or in fall to seedlings and rosettes before ground is frozen. Use higher rates after bolting through early flower.
thistles, biennial <i>Cirsium</i> and <i>Carduus</i> spp.	Asteraceae Biennial	Milestone 3 to 5 fl oz/ac or Transline 1/2 to 2/3 pt/ac or Opensight 1.5 to 2.0 oz/ac	Apply in spring and early summer to rosette or bolting plants or in fall to seedlings and rosettes before ground is frozen. Use higher rates after bolting through early flower.
toadflax, Dalmatian <i>Linaria dalmatica</i>	Scrophularia- ceae Perennial	Tordon 22 K 1 to 2 qt/ac	Apply at bud to flower growth stage or in fall when basal regrowth develops.
vetch (cow and hairy) <i>Vicia</i> spp.	Fabaceae Perennial	Milestone 3 to 7 fl oz/ac or Transline ½ to 2/3 pt/ac	Apply to vegetative stage prior to bloom. Use higher rate when weeds are larger.
wild parsnip <i>Pastinaca sativa</i>	Apiaceae Biennial	Opensight 2.0 to 3.0 oz/ac	Apply to vegetative stage prior to bloom. Use higher rate when weeds are larger.
wormwood, absinth <i>Artemisia absinthium</i>	Asteraceae Perennial	Milestone 6 to 7 fl oz/ac	Apply before wormwood is 12 inches tall. Remove old duff and litter by fire or mowing for best results.

COMMON NAME SCIENTIFIC NAME	PLANT FAMILY LIFE CYCLE	HERBICIDE/RATE	APPLICATION TIMING/SPECIFICATIONS
VINES			
wisteria, Chinese and Japanese <i>Wisteria sinensis</i>	Fabaceae	FOLIAR: Milestone® 7 fl oz/ac BASAL: 25% Garlon® 4 Ultra in basal oil or Pathfinder® II	Apply to the foliage during the growing season when plants are not under drought stress. This treatment can be applied any time of the year, including winter months, except when the bark is wet or frozen, better results are late winter and early spring.
kudzu <i>Pueraria montana var. lobata</i>	Fabaceae	Milestone 7 fl oz/ac or Transline® 1 to 1 1/3 pt/ac	Applications are most effective between late June and early October as long as kudzu are actively growing and not under drought stress. The ideal time to apply is during vigorous growth and just prior to or during flowering.
mile-a-minute <i>Persicaria perfoliata</i>	Polygonaceae	Capstone® 8 pt/ac or Garlon 4 Ultra or Vastlan® Foliar 2.27 to 3.75% v/v	Apply to the foliage during the growing season. Use Vastlan in hot conditions.
GRASSES			
microstegia (Japanese stiltgrass) <i>Microstegium vimineum</i>	Poaceae	Milestone 5 to 7 fl oz	Apply pre or post emergence.

MAKE THE MOST OF YOUR HERBICIDE TREATMENTS

ACCURATE APPLICATION TIMING, CAREFUL MEASUREMENT OF HERBICIDE AND A UNIFORM APPLICATION PATTERN ARE ESSENTIAL TO ECONOMICAL AND EFFECTIVE HERBICIDE TREATMENTS.

The amount of herbicide to add to your sprayer depends on your spray volume and application rate. Consistent, uniform application can help ensure good coverage of troublesome weeds and avoid excessive rates that could injure desirable species.



MANAGING SWEETCLOVER IN NATURAL AREAS

Yellow (*Melilotus officinalis*) and white (*M. alba*) sweetclover are herbaceous, non-native legumes that are widely distributed in the United States. A native to Europe, sweetclover was introduced to North America by the mid 1600s. Spread of the plant was likely facilitated by beekeepers and agriculturalists.

Sweetclover is considered both a beneficial plant and a problematic weed. The plant has been cultivated for wildlife and livestock forage, for soil stabilization, and as a nitrogen-fixer and bee plant. However, both white and yellow sweetclover are classified as invasive in some Midwestern states and Alaska. Sweetclover is known to degrade grasslands in prairie and natural areas by overtopping and shading native plants, thereby reducing diversity. The success of prairie restorations is often hindered by sweetclover invasion (Figure 5.1). These clovers readily occupy open habitats and have successfully exploited many native prairies and open, mesic plant communities in the midwestern United States.

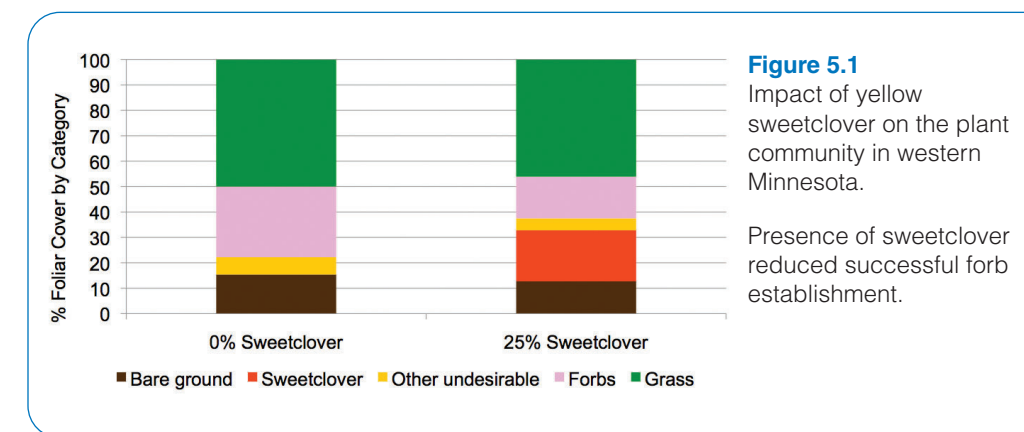


Figure 5.1
Impact of yellow sweetclover on the plant community in western Minnesota.

Presence of sweetclover reduced successful forb establishment.

MANAGEMENT

Integrated management methods are used for controlling white and yellow sweetclover. An important consideration in managing these species is long-term viability of seeds in soil. Practices that stop flowering are important for seed bank depletion.

Plant community response to various herbicide treatments in a prairie restoration was evaluated in western Minnesota and Wisconsin field studies. Results one year following application indicated that sweetclover cover declined to about 0.1 percent post-herbicide application (99 percent control) with Milestone® at 5 fluid ounces per acre (fl oz/ac). On adjacent non-treated plots sweetclover cover increased to 36 percent during the same time period (Figure 5.2). [Continued on page 15]

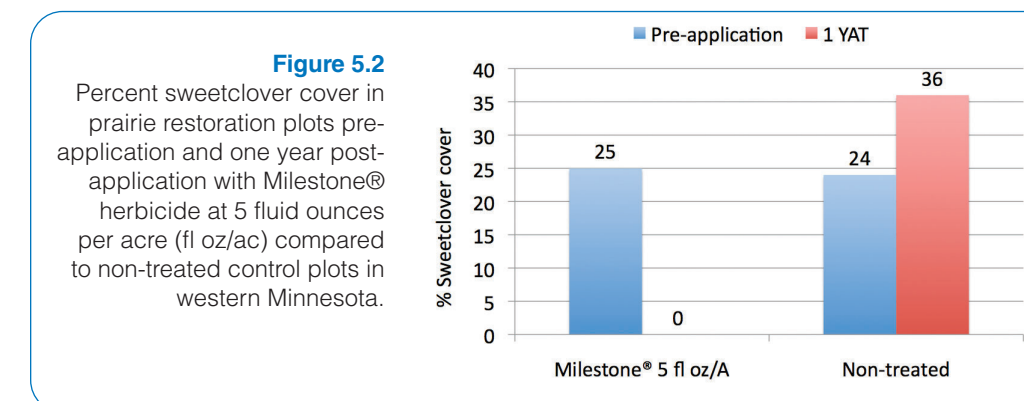
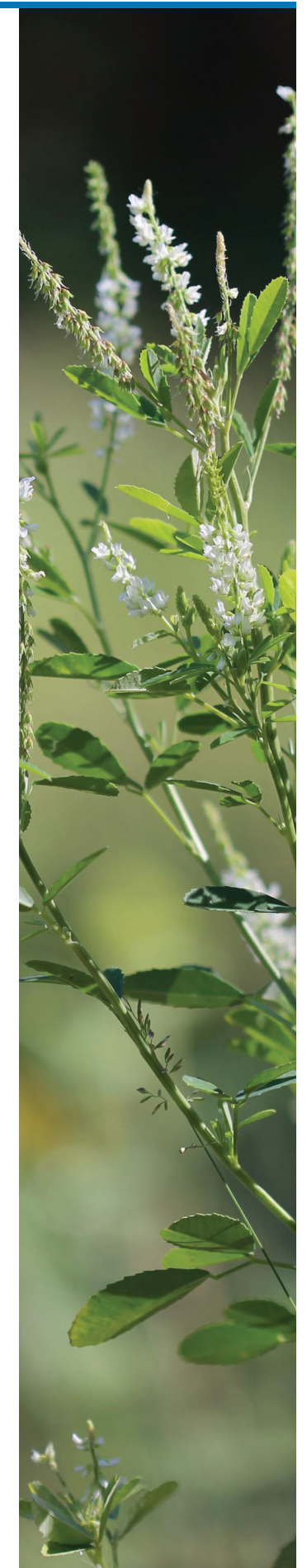


Figure 5.2
Percent sweetclover cover in prairie restoration plots pre-application and one year post-application with Milestone® herbicide at 5 fluid ounces per acre (fl oz/ac) compared to non-treated control plots in western Minnesota.





MANAGING CANADA THISTLE IN NATURAL AREAS

Canada thistle is a perennial noxious weed that is widespread in many prairie and grassland areas in the midwestern United States. Field trials show that Milestone® herbicide at 5 fluid ounces per acre (fl oz/ac) or Transline® herbicide at 10.6 fl oz/ac applied prior to bud stage in June or in fall following a light frost will provide good to excellent Canada thistle control (Table 5.2, Figure 5.3). A temperature of 28°F in fall will cause many forbs to become dormant, but Canada thistle remains susceptible to herbicide treatments for a longer period of time, even at a lower temperature.

Table 5.2. Canada thistle control 12 to 15 months after treatment (MAT) in response to Milestone® and Transline® applications in June compared to September.

Treatment	Application Timing	% Canada Thistle Control* 12 or 15 MAT
Milestone at 5 fl oz/ac	June	83 ab
	September	93 a
Transline at 10.6 fl oz/ac	June	65 b
	September	90 a
Non-treated		0

*Numbers followed by the same letter are not significantly different at the 0.05 level

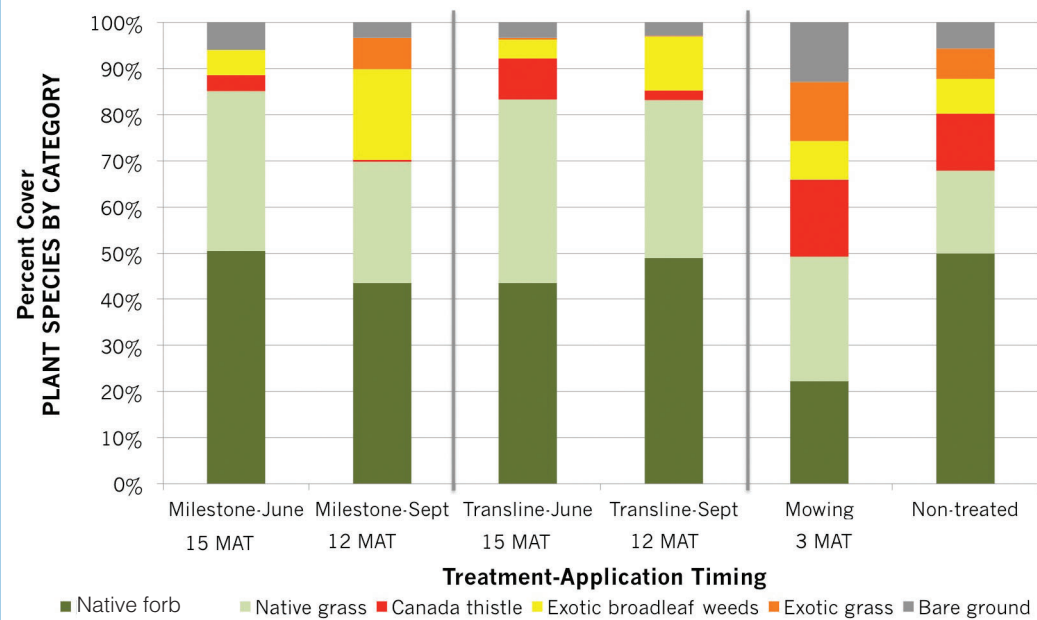
Although fall application timing minimizes injury to some desirable forbs, it is important for land managers to understand the species of forbs present on the site since some are sensitive to fall application. In general, the benefits of Canada thistle control, removal of other undesirable broadleaf species, and the increase in native grass cover should lead to an overall improvement in the long-term stability and composition of the restored prairie plant community (Almquist and Lym 2010).

[Continued on page 15]

Figure 5.3.

Percent cover of plant species by category in response to Milestone® herbicide at 5 fl oz/ac and Transline® at 10.6 fl oz/ac applied in June and September 2009 compared to mowing and non-treated plots. Data collected September 21, 2010.

Note: Exotic broadleaf weeds include sweetclover, perennial sowthistle, and dandelions.



CANADA THISTLE [Continued from page 14]

PRACTICAL TIPS FOR MANAGING CANADA THISTLE

by Dennis Pederson, Habitat Forever Specialist

MOWING OR FIRE ALONE WILL NOT CONTROL CANADA THISTLE

For optimum Canada thistle control, use fire and/or mowing in conjunction with herbicides. Spring fire and spring mowing reduce vegetative cover, which allows for better herbicide coverage on thistle. Fire and mowing also add an additional stress to Canada thistle. It is important to delay herbicide application until all Canada thistle has emerged and plants are at rosette to late bolting growth stage following fire or mowing.

CONTROL THE ROOT SYSTEM

About 95 percent of thistle biomass is underground, so the root system has to be killed to effectively control Canada thistle.

USE THE MOST EFFECTIVE HERBICIDES AT LABELED RATES

Milestone® herbicide at 5 to 7 fluid ounces per acre (fl oz/ac) or Transline® herbicide at 10 to 12 fl oz/ac translocate into the root system giving the best control. Of the two products, Milestone is more effective on Canada thistle. However, Transline is an option for use in areas where there is desirable woody vegetation because it is more selective. Milestone and Transline can be applied in either spring or fall; however, Milestone is more effective than Transline when applied in the fall.

SPRING/EARLY SUMMER HERBICIDE APPLICATIONS SHOULD BE MADE WHEN THISTLE IS FULLY EMERGED, AND WHEN THE LARGEST PLANTS ARE AT EARLY BUD GROWTH STAGE

Mowing or fire prior to application will allow for more consistent Canada thistle growth, but be sure plants are completely emerged and at rosette to bolt growth stage prior to herbicide application.

FALL APPLIED HERBICIDES

Thistle can tolerate temperatures as low as 25°F so applications can be made from September until early- to mid-October as long as green growth remains on thistle.

USE BROADCAST HERBICIDE APPLICATIONS

Thistle patches that are completely defined and well documented can be treated with spot spraying. To ensure the greatest chance for thorough and complete application, the whole field should be treated if good inventory data is not completed.

CONTROL INFESTATIONS ON EDGES OF PRAIRIE AND NATURAL AREAS

If field edges, ditch banks, wetland edges and fence lines are not treated along with the main grassland body, thistle colonies will maintain a foothold in those locations and reestablish quickly.



SWEETCLOVER [Continued from page 13]

Results from Wisconsin indicate that Milestone® at 5 to 7 fl oz/ac or Transline® at 1 pint/ac applied in the fall provides similar control of sweetclover the spring following treatment (Renz unpublished data).

HERBICIDE APPLICATION TIMING

Sweetclover is capable of germinating throughout the growing season into fall. Herbicide applications applied in fall will control first year plants that haven't flowered. However, soil residual properties of the herbicide are important to prevent seedling germination the following spring and summer. Milestone, Tordon® 22K herbicide or Transline applied in spring or early summer may control both bolting plants (second year growth) and seedlings that can germinate throughout the summer into fall. In prairie plantings Milestone and Transline would provide more selective control of sweetclover than Tordon 22K. Design herbicide selection and application timing to meet management objectives for other desirable broadleaf species on the site and minimize non-target damage.

Sweetclover abundance can be reduced through integrated management strategies that are designed to encourage native vegetation and limit sweetclover growth and reproduction. Integrating late spring to early fall burns, seeding desirable species, mowing and herbicides will help reduce the competitive ability of sweetclover.

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Gucker CL. 2009. *Melilotus alba*, *M. officinalis*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: <http://www.fs.fed.us/database/feis/> [2014, May 5].

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Woody Plant Control in Northern Prairies



Encroachment of woody vegetation threatens the biology and ecology of prairie grasslands. Historically, wildfire and large herds of bison maintained open prairies. The loss of these natural forces, human-caused disturbance, and the introduction of non-native plants combine to impact native prairie vegetation and its associated wildlife. Removing invasive woody species improves the function of prairie systems and opens the landscape to provide more suitable habitat for birds and other wildlife that need large blocks of grassland for survival.

Managing invasive plants including Siberian elm (*Ulmus pumila*), buckthorn (*Rhamnus cathartica*), honeysuckle (*Lonicera* spp.), locust (*Robinia* spp.), and other woody species is often difficult. Herbicide treatments applied alone or in combination with fire and mechanical methods, like cutting and shredding, can provide cost effective management of woody vegetation. Use of herbicides minimizes site disturbance compared to mechanical methods, and can be applied on a variety of sites often throughout the year.

Woody plants and understory vegetation vary in their susceptibility to different herbicides and application methods. Land managers need to consider factors including the biology, density, size and distribution of the target plants across the landscape. Combining two herbicides in a tank mix may improve woody plant control especially when treating a mixed stand of different species. It is also important to consider goals for desirable understory vegetation on the site. For example, if the goal is to maintain desirable grasses, then apply selective herbicides like Vastlan® herbicide, Garlon® 4 Ultra, Pathfinder® II, Milestone®, and Opensight® to control woody species and allow grasses to thrive. Non-selective herbicides such as those containing glyphosate or imazapyr can cause injury to desirable understory vegetation. Read herbicide labels carefully and refer to “Recommendations, Methods and Equipment” below for species-specific recommendations.

Recommendations, Methods and Equipment

Controlling woody plants while they are small is the best management strategy. Woody growth less than six feet in height can be controlled efficiently and effectively with a foliar

herbicide application. Trees and other woody plants scattered across the site can be treated by spraying either the foliage or the lower portions of the bark (referred to as “low volume basal applications” or LVB). Low Volume Basal applications with Garlon 4 Ultra or Pathfinder II will provide good control of trees too tall to treat with a foliar application.

Trees over six inches in diameter are difficult to control with a LVB application. The best management strategy for larger trees is to cut the tree down and treat the stump with a herbicide mixture. Follow-up monitoring and control will be necessary to treat re-growth that may occur from the cut stump or roots. Recommendations for larger trees that sucker from roots (e.g. cottonwood [*Populus deltoides*]) include cutting down the tree, treating the stump, and then monitoring the area for any new sprouts and seedlings. After one growing season, follow-up treatments can be made with foliar herbicide applications.

Foliar Applications

HIGH VOLUME FOLIAR

The most efficacious and cost effective method to control woody plants is the use of a dilute herbicide/water mixture applied with a hand gun to fully emerged leaves and stems, referred to as a HIGH VOLUME FOLIAR application. It is important to thoroughly cover all leaves and stems, including the tops of the woody plants. Control will be greatest with complete coverage of the target plant with the herbicide mixture. Application with ground-based equipment is restricted by height of the target plant. Aerial application may be an option for taller trees (discuss with your Corteva Representative https://www.corteva.us/content/dam/dpagco/corteva/na/us/en/products/us-land-management/DF_LM_Rep_Map_Vertical_FactSheet.pdf). Aerial treatments are suited to

sites where there is less concern for damage to desirable plants (herbaceous and woody) growing in close proximity to the target plants. Aerial applications are generally less targeted to specific plants than backpack, LVB, or cut-surface treatments. See Table 6.1 for herbicide recommendations when using high volume foliar application.

Basal Applications

LOW VOLUME BASAL (LVB) treatments are well suited for controlling individual woody plants near desirable vegetation or sensitive areas, in low density brush situations, and for trees less than six inches in diameter that are too tall to foliar spray. Apply the herbicide solution (Table 6.2) entirely around the circumference of the stem in a band 12 to 15 inches wide, until the stem is thoroughly wet, but not to the point of runoff or puddling (Figure 6.1).

BASAL CUT STUMP treatments involve cutting six inches above the ground level followed by an herbicide application (Figure 6.2, left). Apply the herbicide solution (see Table 6.2 for a tank-mix guide) to sides of the stump, including the root collar area, and outer portion of the cut surface (cambium) until thoroughly wet but not to the point of runoff. Avoid cutting followed by herbicide application during heavy sap flow since this can interfere with penetration of oil-based basal mixes and decrease control. Heavy sap flow can also carry the herbicide mixture off the stump resulting in poor control. While it is customary to treat soon after cutting, applications may be made any time after cutting (for example, cut in winter and treat the following spring).

HERBICIDE RECOMMENDATION FOR BASAL APPLICATIONS

Garlon® 4 Ultra herbicide plus basal bark oil is recommended for LVB and basal cut stump treatments. Basal bark oils are available from your herbicide supplier. To prepare the herbicide/oil mixture, make a solution of 25% Garlon 4 Ultra with 75% basal oil (Table 6.2). These mixtures can be applied all year; however, do not treat when stems are wet from rain, dew or condensation. Pathfinder® II is a ready-to-use formulation if you do not wish to mix your own herbicide solution; however, it becomes too thick to spray out at temperatures below 30°F.

Cut Stump Applications

Cut stump treatments involve cutting the tree close to the ground and applying herbicide only to the exposed cambium (Figure 6.2, right). Cut stump treatments may be made any time of the year as long as the herbicide does

not freeze when applied, and the tree is not frozen. Avoid cutting followed by herbicide application during heavy sap flow since this can interfere with translocation. Heavy sap flow can also carry the herbicide mixture off the stump resulting in poor control. Cut stump applications should be made by thoroughly spraying the outer two inches of the cut stump of the tree. Apply herbicide in a continuous ring between the bark and the wood of the stump. If the bark is torn away from the stump, be sure to treat down the side to form a continuous ring around the bark since the coverage and uptake is essential for root kill. Cut tree surfaces should be treated *immediately* (within 30 minutes) with undiluted Vastlan® herbicide.



Figure 6.1

Low Volume basal bark applications can be used on trees with stems up to but not greater than six inches in diameter. Spray around the circumference of the trunk at a height of about 12 to 15 inches until wet, all the way around the main stem to the ground line, but not to the point of runoff or puddling.



Figure 6.2

Comparison of a basal cut stump application (left) and cut stump application (right).



Control of scattered individual trees or other woody vegetation is best suited to low volume basal or high volume foliar treatment.



Clusters of woody brush, including species that "sucker" from roots like cottonwood, are best controlled with high volume foliar treatments.

Buckthorn and Black Locust Control



Buckthorn

For non-grazed and non-hayed sites, to control buckthorn with a high volume foliar application, mix a 2.5% solution of Garlon® 4 Ultra herbicide (2.5 gallons Garlon

4 Ultra in 100 gallons of water) + 1 quart surfactant (0.25% v/v) and spray to thoroughly wet all leaves and stems. When treating buckthorn with a low volume basal application, mix 25% Garlon 4 Ultra with basal oil (Table 6.2) and apply to the lower 12 to 15 inches of the stem, all the way around the bark.



Black Locust

Black locust is more difficult to control than most woody plants. It spreads vigorously by sending up new sprouts from its stump and entire root system, especially after cutting. FOLIAR

APPLICATIONS with Milestone® herbicide at 7 fluid ounces per acre (fl oz/ac) offers outstanding control on sprouts, provided coverage is complete. LOW VOLUME BASAL TREATMENTS can be used effectively if applied several months prior to cutting. Apply a 25% Garlon 4 Ultra + 2% Milestone LVB mixture (Table 6.2) to thoroughly coat bark completely around the entire stem, 12 to 15 inches above the ground level; allow at least two months of growing season conditions to elapse before cutting down black locust. Cut surface and basal cut stump treatments are not effective.

Photos, bugwood.org: Buckthorn by John Randall, The Nature Conservancy; Black locust by Richard Old, XID Services, Inc.

Tips for Successful Low Volume Basal and Basal Cut Stump Applications

- Use a sprayer that has a shut off at the spray tip (Figure 6.3) to avoid wasting material.
- Sprayer seals, hoses and pumps should be resistant to oil-based carriers.
- Use an adjustable cone spray tip, such as Spraying Systems ConeJet 5500-X3 or Y3 up to X8 is ideal.
- Apply herbicide spray to plant stems similar to applying spray paint.
- Treat all the way around the plant stem in a band from the soil surface (root collar area) to 12 to 15 inches in height (Figure 6.1).
- Do not treat plant stems that are saturated with water/precipitation.



Figure 6.3 Spray wand for LVB applications showing mechanical shut-off at the tip (Photo MN Wanner www.4-control.com)



Figure 6.4 Basal Brush Sprayer (Model 942) that can be used for LVB or cut stump applications. Attributes include chemical resistant seals, adjustable brass nozzle, and durability (Photo MN Wanner, www.4-control.com).

Table 6.1. HIGH VOLUME FOLIAR Treatments for Woody Plant Control

Mix herbicide with 100 gallons water. The addition of surfactant is recommended. Spray to thoroughly wet all leaves and stems. Treatments can be made until leaves begin to change color in autumn. Review label guidelines for mixing and application. Follow label instructions. (Shaded bar indicates an effective herbicide treatment for that species).

Common name (Scientific name)	7 fl oz Milestone® + 1 gal Garlon® 4 Ultra	7 to 10 fl oz Milestone + 2 qt DMA®4 IVM (2,4-D)	3.3 to 5 oz Opensight® + surfactant 1	1 gal Garlon 4 Ultra	1 gal Garlon 4 Ultra + 2 qt DMA4 (2,4-D)
Aspen (<i>Populus tremuloides</i>)	✓	✓			
Autumn olive (<i>Elaeagnus umbellata</i>)	✓				
Blackberry (<i>Rubus</i> spp.)	✓		✓		
Black locust (<i>Robinia pseudoacacia</i>)	✓		✓		
Boxelder (<i>Acer negundo</i>)	✓				
Cherry (<i>Prunus serotina</i>)			✓		
Cottonwood (<i>Populus deltoides</i>)		✓			
Green ash (<i>Fraxinus pennsylvanica</i>)				✓	✓
Multiflora rose (<i>Rosa multiflora</i>)	✓		✓		
Prickly ash (<i>Xanthoxylem americanum</i>)				✓	✓
Red cedar ² (<i>Juniper virginiana</i>)			✓		
Russian olive (<i>Elaeagnus angustifolia</i> L)	✓				
Siberian elm (<i>Ulmus pumila</i>)	✓				
Sumac (<i>Toxicodendron vernix</i>)	✓	✓	✓	✓	
Willow (<i>Salix</i> spp.)	✓	✓	✓		✓

¹ Do not apply more than 3.3 oz per acre per growing season in a broadcast application or 6.6 oz per acre on 50% of the site.

² For small trees only, 3 feet (in height) or less.

Herbicide applications to woody plants growing in or adjacent to standing water must follow state and federal permit requirements for aquatic environments. On these sites, the control recommendation for all woody species listed in Table 6.1 is 1.5 quarts Vastlan® herbicide + 2 quart DMA® 4 herbicide + 1 quart of aquatic approved surfactant (0.25% v/v) with 100 gallons of water for high volume foliar application to leaves. Aquatically labeled surfactants are available from your herbicide supplier. This treatment may not provide best control for all species, but it is the right option to use in areas where the spray solution will contact standing water.

Table 6.2. LOW-VOLUME BASAL and BASAL CUT STUMP tank-mix guide for Garlon® 4 Ultra herbicide alone and in combination with Milestone® herbicide, plus oil-based carrier

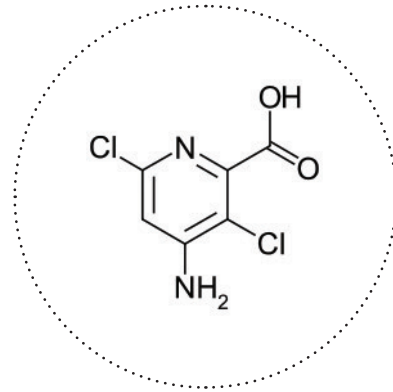
Sprayer Mix Size	For a 25% mix with Garlon 4 Ultra (Use 25% Garlon 4 Ultra + 75% Oil-Based Carrier ¹)
1 gallon	1 quart Garlon® 4 Ultra + 3 quarts oil-based carrier
1 gallon	Mix 1 quart Garlon 4 Ultra + 2.5 fluid ounces Milestone then add to 3 quarts of oil based carrier ²
3 gallons	3 quarts Garlon 4 Ultra + 9 quarts (2 gallons + 1 qt) oil-based carrier
3 gallons	Mix 3 quarts Garlon 4 Ultra + 7.5 fluid ounces of Milestone®; then add to 9 quarts of oil based carrier ²
20 gallons	5 gallons Garlon 4 Ultra + 15 gallons oil-based carrier
50 gallons	12.5 gallons Garlon® 4 Ultra + 37.5 gallons oil-based carrier

¹ Prepare oil-based spray mixtures using commercially available basal oil. Substitute other oils or diluents only as recommended by the oil or diluent's manufacturer.

² Milestone is an amine formulation that does not mix with all basal oils. For best mixing results, add Milestone to Garlon 4 Ultra, and then add the herbicide mixture to basal oil. Walking and moving while applying herbicide solution is enough to keep Milestone in suspension. However, if the herbicide/oil mixture sits in the spray tank for more than an hour it will need vigorous agitation prior to application (e.g., shaking the backpack sprayer).

Technical Facts & Answers to Frequently Asked Questions About Herbicides

Herbicides are an important component of integrated vegetation management programs on natural areas, trails and roadsides. This section includes technical information on herbicides in the pyridine chemical family that have a synthetic auxin/growth regulator mode of action (http://bit.ly/herb_performance). Herbicide use rate, formulation, and attributes are described and questions regarding aminopyralid and triclopyr herbicides are discussed.



TECHNICAL FACTS ABOUT HERBICIDES

Herbicides are formulated to include the active ingredient (chemical that inhibits growth or kills the plant) and inert ingredients. Active ingredients include aminopyralid (Milestone®), aminopyralid plus metsulfuron (Opensight®), triclopyr (Vastlan® Garlon® 4 Ultra, Pathfinder® II), clopyralid (Transline®), and fluroxypyr plus triclopyr (PastureGard® HL). These herbicides are absorbed by leaves, stems and roots and are translocated (moved) throughout the plant accumulating in meristematic tissue. Herbicides listed in this section have soil residual activity with the exception of triclopyr and fluroxypyr.

HERBICIDES CONTAINING AMINOPYRALID

Milestone® HERBICIDE

USE RATE RANGE

3 to 7 fluid ounces of product per acre. Spot treatments may be made up to 14 fl oz/ac per annual growing season; however, not more than 50% of an acre may be treated when using this rate.

ATTRIBUTES

Milestone provides excellent post-emergent and residual control of over 70 broadleaf weeds and woody plants.

Opensight® HERBICIDE

USE RATE RANGE

1.5 to 3.3 ounces of product per acre. Spot treatments may be made up to 6.6 oz/ac per annual growing season however, not more than 50% of an acre may be treated when using this rate. The dry formulation requires the addition of a surfactant (NIS, MSO, COC) for effective control.

ATTRIBUTES

Opensight herbicide provides excellent post-emergent and residual control of over 160 broadleaf weeds and woody plants including many difficult to control invasive or noxious weeds.

HERBICIDE CONTAINING CLOPYRALID

Transline® HERBICIDE

USE RATE RANGE

1/4 pint to 1.33 pints of product per acre.

ATTRIBUTES

Transline offers excellent control of target invasive and noxious weeds and certain woody plants, while providing the greatest selectivity to many tree (except legume species), brush, and grass species.

HERBICIDES CONTAINING TRICLOPYR

Vastlan® HERBICIDE

USE RATE RANGE

1 quart to 2.25 gallons of product per acre.

Apply no more than 1/2 gallon of Vastlan per acre per growing season on range and pasture sites or other grazing sites. On forestry sites, Vastlan may be used at rates up to 1.5 gallons per acre per year. For all terrestrial use sites other than range, pasture, forestry sites, and grazed areas, the maximum application rate is 2.25 gallons of Vastlan per acre per year.

ATTRIBUTES

Vastlan is a broad-spectrum herbicide with excellent activity on brush and some emerged broadleaf weeds, with no residual soil activity.

Garlon® 4 Ultra HERBICIDE

ACTIVE INGREDIENT

One gallon of Garlon 4 Ultra contains 4 lb ae of triclopyr formulated in a plant-based oil carrier as a low volatile ester.

USE RATE RANGE

1 to 4 quarts of product per acre broadcast to foliage or mixed as a percent solution in water or basal oil for woody plant treatments (see label by species).

ATTRIBUTES

Garlon 4 Ultra controls many woody plants, with no residual soil activity.

Pathfinder® II HERBICIDE

ATTRIBUTES

Pathfinder II herbicide is a ready-to-use (no mixing required) herbicide for low-volume basal and cut-stump application of woody plants in forests, rangeland, permanent pasture and non-crop areas. Not intended for foliage applications.

PastureGard® HL HERBICIDE

USE RATE RANGE

3/4 pint to 4 pints of product per acre.

ATTRIBUTES

PastureGard HL provides excellent selective control of many woody plants and broadleaf weeds such as sericea lespedeza and kochia. The herbicide is not harmful to established grasses and many forbs, and can be applied under the canopy of desirable trees.

HERBICIDES CONTAINING GLYPHOSATE

Accord® XRT II HERBICIDE

USE RATE RANGE

The maximum use rate is 2 gallons of product per acre per year.

ATTRIBUTES

Provides excellent non-selective post-emergence control of annual, biennial, and perennial weeds, vines, and woody plants in forests and non-crop sites. Contains a unique surfactant to enhance woody plant control. The high load formulation is easy to handle with low-foaming characteristics. No grazing/haying restrictions for dairy animals or other livestock. May be used around non-irrigation ditch banks, seasonally dry wetlands, flood plains, marshes, swamps. Do not apply to open water areas.

Rodeo® HERBICIDE

USE RATE RANGE

Maximum terrestrial use rate is 2 gallons of product per acre per year.

ATTRIBUTES

Approved for aquatic and wetland sites with an appropriate aquatic surfactant. Provides non-selective control of emerged aquatic vegetation; annual, biennial, and perennial weeds; vines; and woody plants. Excellent tank mix partner. Binds readily to soil so may be used under the tree canopy without concern of tree damage. Can be used for foliar, cut stump, tree injection/hack and squirt, and grass growth suppression.



MILESTONE® HERBICIDE AND THE ENVIRONMENT

The Environmental Fate of Milestone®

SOIL: Aerobic microbial degradation is the primary route of breakdown in soil. Average field soil half-life is 34.5 days for eight North American sites. There are no degradation metabolites of concern.

WATER: Photolysis (*UV portion of the light spectrum*) is the primary route of degradation in water. Photolysis half-life under standard conditions is 0.6 days. Groundwater contamination potential is low because of low use rates combined with moderate soil half-life.

AIR: Minimal volatility

Where Milestone® Should Be Used

Milestone is labeled for use on rangeland, permanent grass pastures, Conservation Reserve Program (CRP) acres, non-cropland areas (*roadsides*), non-irrigation ditch banks, seasonally dry wetlands, natural areas (*wildlife management areas, wildlife openings, wildlife habitats, recreation areas, campgrounds, trailheads and trails*), and grazed areas in and around these sites.

The Runoff Potential of Milestone®

Milestone has a low risk of runoff in surface water compared to the current market standards. The runoff impact of Milestone is mitigated by low use rate and rapid photolysis in water.

Ecotoxicology Profile of Milestone®

Milestone exhibits low acute and chronic toxicity to mammals, birds, fish, aquatic and terrestrial invertebrates, algae and aquatic vascular plants in laboratory studies.

Risk of adverse effects is substantially below all of the EPA levels of concern (LOC) for non-target organisms.

Milestone produces no significant soil or water metabolites other than CO₂ and NH₃ and has a low bioaccumulation potential.

In EPA's assessment under the Reduced Risk Pesticide Initiative, Milestone was found to have reduced acute and chronic toxicity to mammals, birds, algae and aquatic vascular plants compared to market standards.

The Rainfast Period for Milestone®

Foliar absorption of Milestone applied post emergence is relatively rapid. Milestone herbicide appears to be rainfast within two hours after application when applied at recommended label rates.

Milestone® Can Be Used to the Waters Edge

Milestone can be used to the waters edge but do not apply directly to water or to areas where surface water is present or to intertidal areas below the mean high water mark. Take precautions to avoid spray drift onto water. Do not spray on inner banks of ditches or canals used to transport irrigation water.

It is permissible to treat non-irrigation ditch banks, seasonally dry wetlands (*flood plains, deltas, marshes, swamps, or bogs*) and transitional areas between upland and lowland sites.

Milestone® Can Be Used in Riparian Areas

Under the following guidelines:

- The label does not allow applications directly to water (*ponds, lakes, rivers, streams and irrigation canals*).
- Avoid applications that may result in movement of Milestone into water used to irrigate crops.
- The non-target plant community should be considered (*see forb and shrub tolerance section, page 8*).

How Long Does Milestone® Persist in the Soil?

While Milestone herbicide will provide season-long residual control of emerging broadleaf weeds, this herbicide has a moderate field soil half-life.

Half-lives in U.S. and Canadian field studies have averaged approximately 34.5 days. Ninety percent of Milestone applied at a rate of 7 fl oz/acre dissipated within 90 days.

In a large majority of studies, the herbicide has remained in the top six to 12 inches of the soil profile.

The Effect of pH on Degradation of Milestone®

Due to the low pKa (*ionization constant*) of the active ingredient, pH will have no impact on Milestone degradation in any matrix.



Milestone® Can Be Applied with Spot Treatments

Yes, spot treatments may be made at an equivalent broadcast rate of up to 0.22 lb active ingredient (*14 fl oz of Milestone*) per acre per annual growing season; however, not more than 50% of an acre may be treated.

Do not apply more than a total of 0.1 lb active ingredient per acre (*7 fl oz per acre of Milestone*) per annual growing season.

(*See resource for spot treatment calibration guidelines on page 12.*)

Milestone® and Surfactants

The addition of a high quality non-ionic surfactant (of at least 80% active ingredient) at 0.25 to 0.5% volume per volume (1 to 2 quarts per 100 gallons of spray) is recommended to enhance herbicide activity under adverse environmental conditions (high temperature, low relative humidity, drought conditions, dusty plant surfaces), when weeds are heavily pubescent, or with more mature plants.

Longevity of Milestone® in the Spray Tank Solution

Milestone is not degraded by the hydrolysis process like sulfonyleurea herbicides. Milestone will break down in water when exposed to ultra-violet (UV) light from the sun. Provided the spray tank is a UV resistant tank (most are), or if the sprayer or mix tank is parked inside, the solution would be stable for very long periods of time. Although once herbicides are mixed, it is advisable to use them as soon as possible.

Sprayer Clean-Out Instructions to Avoid Damage to Sensitive Plants

Yes. It is important to not use spray equipment used to apply Milestone for other applications to land planted to crops or desirable sensitive plants unless it has been determined that all residues of this herbicide have been removed by thorough cleaning of equipment. No exceptions! See label for detailed cleaning instructions.

Established Grasses are Not Harmed by Milestone®

Research was conducted on over 33 different grass species and both warm and cool season grasses show excellent tolerance to Milestone. In fact, grass production increases significantly after weeds are removed.

No Grazing or Haying Restrictions for Milestone®

There are no restrictions on grazing (*any livestock including lactating dairy and horses*) or hay harvest following application of Milestone at labeled rates¹.

Milestone passes through an animal's digestive system unchanged and is excreted in urine and manure. This occurs relatively rapidly, within about three days.

Cutting hay too soon after spraying weeds will reduce weed control. Wait 14 days after herbicide application to cut grass hay to allow herbicide to work.

Milestone does not break down in plants. Therefore, hay from areas treated with Milestone may contain residues. Inform the recipient of hay or manure from animals grazing pastures or feeding on hay from areas treated with Milestone of the label use precautions and restrictions.

Hay from grass treated with Milestone within the preceding 18-months can only be used on the farm or ranch where the product is applied unless allowed by supplemental labeling.

Do not transfer livestock from treated grazing areas to sensitive broadleaf crop areas without first allowing three days of grazing in an untreated pasture. Otherwise, urine and manure may contain enough Milestone to cause injury to sensitive broadleaf plants. Refer to Milestone label for additional instructions.



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Milestone has no grazing or haying restrictions for any class of livestock, including lactating dairy cows, horses (including lactating mares) and meat animals prior to slaughter. However, label precautions do apply to forage treated with Milestone and to manure from animals that have consumed treated forage within the last three days. Consult the label for full details. ®,™,SM Trademarks or Service Marks of Dow AgroSciences, DuPont or Pioneer and their affiliated companies or respective owners. When treating areas in and around roadside or utility rights-of-way that are or will be grazed, hayed or planted to forage, important label precautions apply regarding harvesting hay from treated sites, using manure from animals grazing on treated areas or rotating the treated area to sensitive crops. Label precautions apply to forage treated with Milestone and to manure from animals that have consumed treated forage within the last three days. Consult the label for full details. Milestone is not registered for sale or use in all states. Contact your state pesticide regulatory agency to determine if a product is registered for sale or use in your state. State restrictions on the sale and use of Garlon 4 Ultra, Accord XRT II, Milestone and Transline apply. Tordon 22K is a Restricted Use Pesticide. See product labels for details. Opensight and Vastlan are not registered for sale or use in all states. Contact your state pesticide regulatory agency to determine if a product is registered for sale or use in your state. Consult the label before purchase or use for full details. The information presented here is to provide technical information only and is not an offer for sale of product.

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