Native Forb Tolerance to Aminopyralid Applications for Invasive Weed Control

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Milestone® (Aminopyralid) Attributes

- Important for invasive weed management programs in natural areas:
  - ✓ **Low use rate** of 3 to 7 fluid oz/acre (0.06 to 0.1 lb ae/acre)
  - ✓ Reviewed and registered under the **Reduced Risk Pesticide Initiative** of the U.S. EPA
  - ✓ **Very low toxicity** (“practically non-toxic”) to birds, fish, mammals and aquatic invertebrates
  - ✓ Surface water breakdown in **16 hours**
  - ✓ Can be applied to **seasonably dry wetlands**
  - ✓ Spray up to the **waters edge**
  - ✓ **Grass** selectivity
  - ✓ A single active ingredient to improve **selectivity**

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Milestone® (Aminopyralid) is Effective on Many Invasive Weeds

Canada thistle

Spotted knapweed

Absinth wormwood

Crown vetch

Sweet clover

Biennial thistles

And many more – see label

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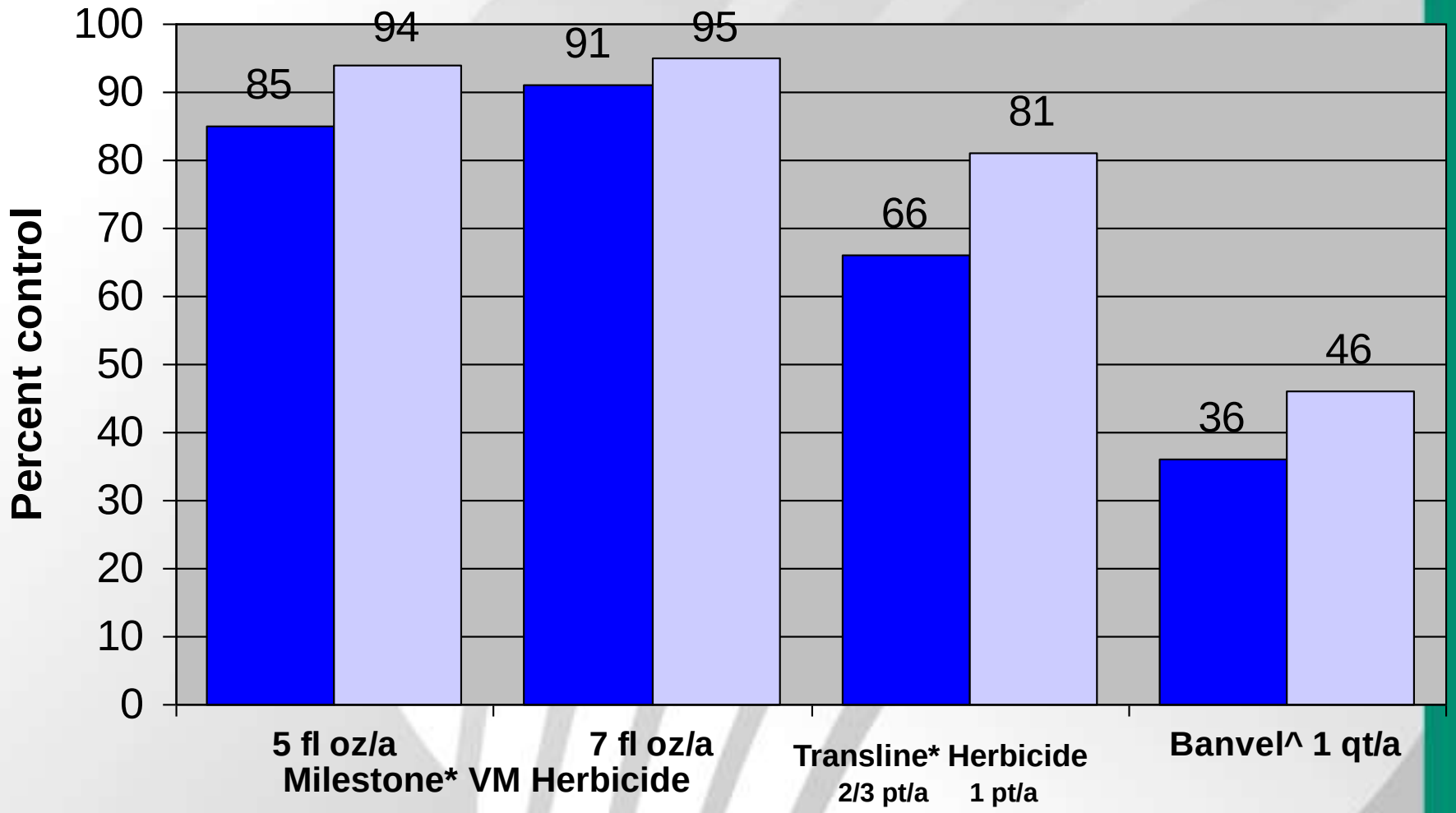
Control of Canada Thistle with Milestone® VM Applied at Pre-bud and Fall (Evaluated 1 Year After Treatment)



Pre-bud: Average of 36 trials (CO, MN, MT, ND, SD, NE, OR, VA, SD, OR, WA, and WY)

Fall: Average of 22 sites VA, ND (2), SD, NE, WY, CO, and WA

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Information Need

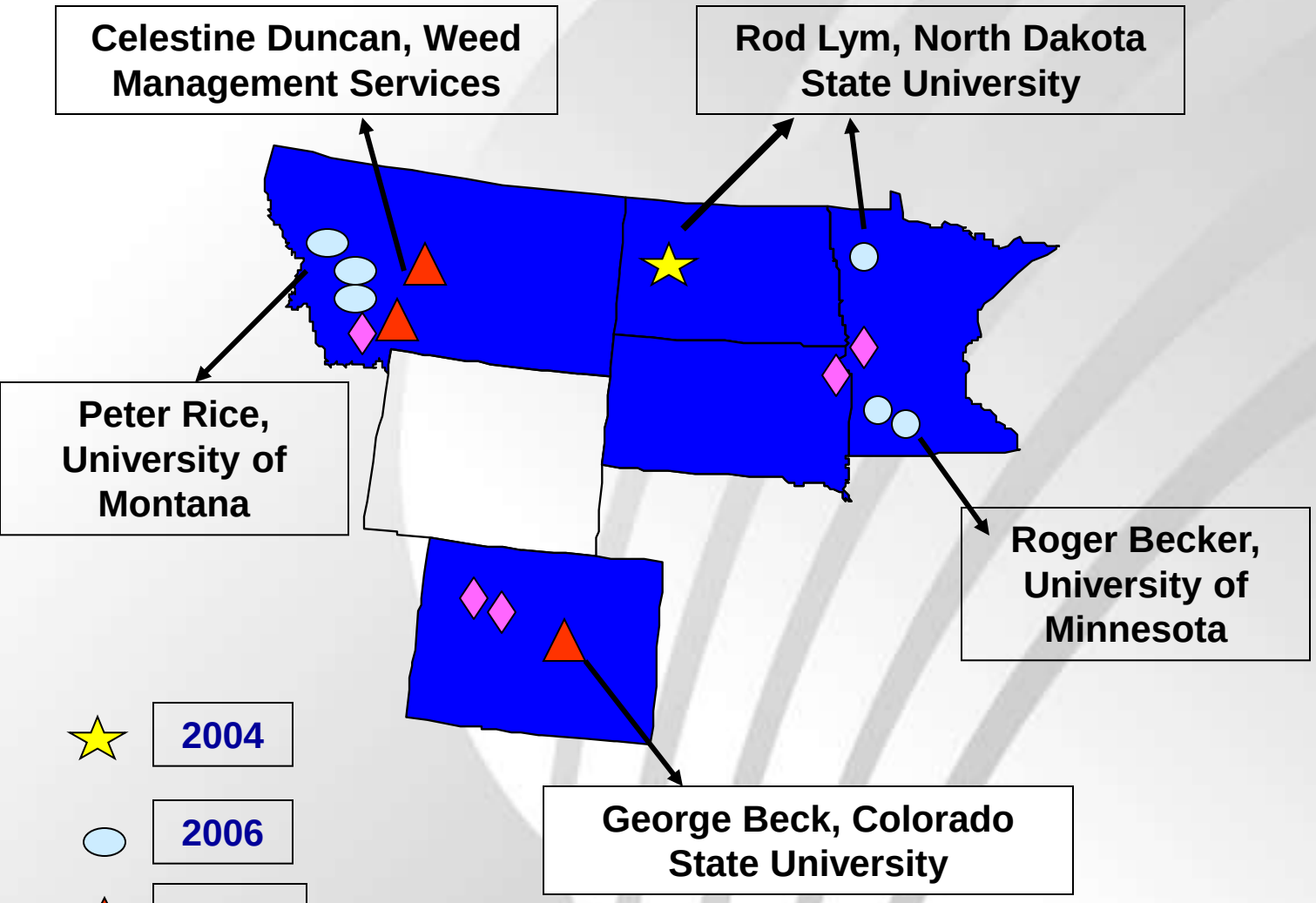
Effect of herbicide treatments on desirable forbs and shrubs is a consideration for land managers when making decisions about controlling invasive, non-native weeds in grasslands or prairie restorations.

Species diversity is the goal

Research Objectives

- **Determine long-term response of native forbs and shrubs to aminopyralid applied in early summer or fall.**
- **Develop a tolerance/susceptibility ranking for native plants.**

Experiments Established at 15 Locations



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Materials and Methods

- **Field experiments were designed as randomized complete block with two to five replications**
- Herbicide treatments: Aminopyralid at 1.25 oz ae/A or 1.75 (5 or 7 fluid oz product/A Milestone® Herbicide)
- **Broadcast ground applications were made with either a CO2 backpack sprayer or pickup boom sprayer**
- Treatments were made in June and September

Materials and Methods

- **Data collection across sites varied from either canopy cover or plant counts along a permanent transect, or plant density within each plot**

Materials and Methods

- First year post-application vegetation sampling was conducted in June and July the summer after treatment at all locations.
- Second year sampling was completed at 13 study sites.
- In-season injury was observed but not quantified.

Wild Bergamot – 45 DAA

Aminopyralid 1.25 oz ae/A

July 30

Untreated

July 30

Results are taken **1 YAT** – there may be plant symptoms the year of application, even on tolerant species


1 Year After Treatment

Results

Species Tolerance

- Individual rankings of tolerance to aminopyralid were established for 90 native forb species based on individual species reduction in canopy cover or density compared to non-treated controls or baseline data.

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Four Ranking Categories

T=Tolerant: Minimal symptoms - may be slight cupping but less than 15%

MT = Moderately tolerant: Symptoms include cupping/yellowing and can inhibit flowering, with recovery the first growing season after application – 15-50% stand reduction

MS = Moderately Susceptible: Injury could be significant the first year may reduce stand by 50-75%

S = Susceptible: Severe Injury the season of application and stand reduction the year after greater than 75% - and may kill established plants. However, certain plants may regenerate from the seed bank.

Species Tolerance

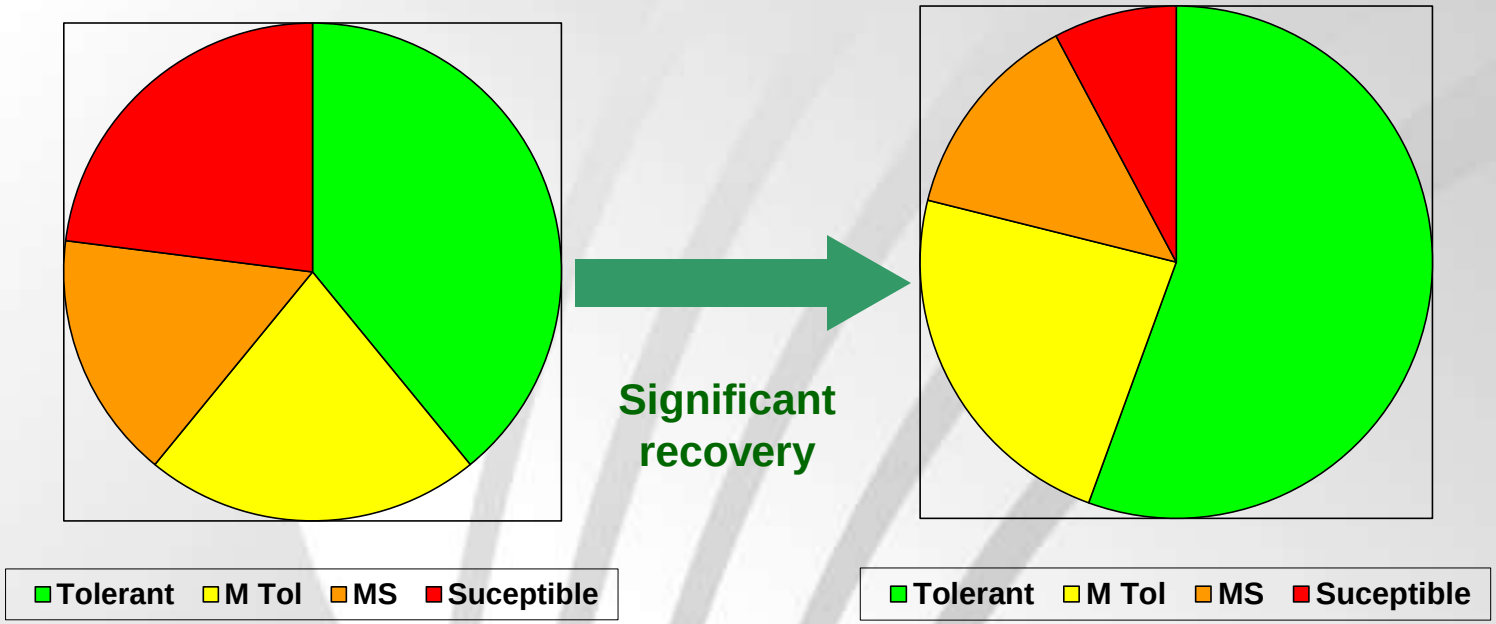
- Individual rankings of tolerance to aminopyralid were established for 90 native forb species based on individual species reduction in canopy cover or density compared to non-treated controls or baseline data.
- 29 plant families were represented, with the greatest number of species (35%) in the Asteraceae family.

Common Name	Family	Genus	Species	1 YAT	2 YAT	Appl Time	Location
Golden Alexanders	Apiaceae	*Zizia*	*aurea*	T	T	Both	Glacial Ridge,MNKufrin
Heart-leaved alexanders	Apiaceae	*Zizia*	*aptera*	T	T	Both	MN2008
Nine-leaf biscuitroot	Apiaceae	*Lomatium*	*triternatum*	MT	T	Fall	MTRice, ID Green
Wyeth's biscuitroot	Apiaceae	*Lomatium*	*ambiguum*	T	T	Fall	MTRice
Spreading dogbane	Apocynaceae	*Apocynum*	*androsaemifolium*	T	T	Fall	Glacial Ridge
Common milkweed	Asclepiadaceae	*Asclepias*	*syriaca*	T	T	Fall	Glacial Ridge
Arrowleaf balsamroot	Asteraceae	*Balsamorhiza*	*sagittata*	MS	MT	Both	MTRice
Black-eyed Susan	Asteraceae	*Rudbeckia*	*hirta*	S	MS	Both	MN2008
Blanket flower	Asteraceae	*Gaillardia*	*aristata*	MT	T	Both	MT Rice/Glacial/MTRice0
Canada goldenrod	Asteraceae	*Solidago*	*canadensis*	MT+	T	Summer	SD/MN Kufrin
Canada goldenrod	Asteraceae	*Solidago*	*canadensis*	MS	MS	Fall	Glacial Ridge,MNKufrin
cudweed sage	Asteraceae	*Artemesia*	*ludoviciana*	T	T	Summer	MTDuncan
Cup plant	Asteraceae	*Silphium*	*perfoliatum*	MT	NA	Both	MN2008
Gay feather	Asteraceae	*Liatris*	*punctata*	T	T	Summer	CO2007
Giant goldenrod	Asteraceae	*Solidago*	*gigantea*	MT	NA	Both	MN2008
Giant sunflower	Asteraceae	*Helianthus*	*giganteus*	S	MS	Fall	Glacial Ridge
Gumweed	Asteraceae	*Grindelia*	*squarrosa*	MS	MT	Fall	MTRice
Hairy golden aster	Asteraceae	*Chrysopsis*	*villosa*	MT	T	Both	MT Rice/MT Duncan
Heath aster	Asteraceae	*Aster*	*ericoides*	MT	T	Both	MN2008
Hound's tongue hawkweed	Asteraceae	*Hieracium*	*cynoglossoides*	MT	MT	Fall	MTRice
Little sunflower	Asteraceae	*Helianthus*	*pumilus*	MS	MT	Summer	CO07/CO09
Little sunflower	Asteraceae	*Helianthus*	*pumilus*	T	T	Fall	CO09
Maximilian sunflower	Asteraceae	*Helianthus*	*maximiliani*	S	S	Fall	Glacial Ridge
Missouri goldenrod	Asteraceae	*Solidago*	*missouriensis*	MT	T	Fall	MTRice
Nuttall's pussy-toes	Asteraceae	*Antennaria*	*parviflora*	MS	MT	Fall	MT Rice
Nuttall's pussy-toes	Asteraceae	*Antennaria*	*parviflora*	S	MS	Summer	MT Duncan
Orange arnica	Asteraceae	*Arnica*	*fulgens*	S	S	Fall	MTRice
Panicled aster	Asteraceae	*Aster*	*lanceolatum*	MT	NA	Both	MN2008
Prairie blazingstar	Asteraceae	*Liatris*	*aspera*	MT	NA	Both	MN2008
Prairie goldenrod	Asteraceae	*Solidago*	*missouriensis*	MS	MT	Fall	Glacial Ridge
Rosy pussy-toes	Asteraceae	*Antennaria*	*microphylla*	MT	T	Fall	MTRice
Shaggy fleabane	Asteraceae	*Erigeron*	*pumulis*	MT	T	Fall	MTRice
Smooth Blue aster	Asteraceae	*Aster*	*laeve*	MT	NA	Both	MN2008
Stiff goldenrod	Asteraceae	*Solidago*	*rigida*	MT	MT	Summer	MN2008
Stiff goldenrod	Asteraceae	*Solidago*	*rigida*	S	MS	Fall	MNKufrin
Stiff sunflower	Asteraceae	*Helianthus*	*pauciflorus*	MT	NA	Summer	SD2009
Stiff sunflower	Asteraceae	*Helianthus*	*pauciflorus*	MS	MT	Fall	Glacial Ridge
Sweet smooth oxeye	Asteraceae	*Heliopsis*	*helianthoides*	MT	NA	Both	MN2008
Tall sunflower	Asteraceae	*Helianthus*	*giganteus*	S	NA	Both	MN2008
White panicle aster	Asteraceae	*Aster*	*simplex*	S	MT	Fall	Glacial Ridge
White prairie aster	Asteraceae	*Aster*	*ericoides*	MS	MT	Summer	SD2009
White prairie aster	Asteraceae	*Aster*	*ericoides*	MT	MT	Fall	Glacial Ridge/SD
Yarrow	Asteraceae	*Achillea*	*millefolium*	S	S	Both	MTRice/MTRice08
Yellow prairie coneflower	Asteraceae	*Ratibida*	*pinnata*	S	NA	Both	MN2008
Wayside gromwell	Boraginaceae	*Lithospermum*	*ruderale*	MT	MT	Fall	MTRice
Alyssum	Brassicaceae	*Alyssum*	*alyssoides*	T	T	Summer	MTDuncan
Nuttall's rockress	Brassicaceae	*Arabis*	*nuttallii*	T	T	Fall	MTRice
Palespike lobelia	Campanulaceae	*Lobelia*	*spicata*	S	S	Fall	Glacial Ridge
Field chickweed	Caryophyllaceae	*Cerastium*	*arvense*	MS	MT	Fall	MTRice
Jagged chickweed	Caryophyllaceae	*Holosteum*	*umbellatum*	S	T	Fall	MTRice
threadleaf sandwort	Caryophyllaceae	*Arenaria*	*capillaris*	S	MT	Summer	MTDuncan
Prairie spiderwort	Commelinaceae	*Tradescantia*	*occidentalis*	MS	NA	Both	MN2008
Dwarf morning glory	Convolvulaceae	*Ipomoea*	*tricolor*	MT	T	Summer	CO2007


Untreated
Milestone® 5 fl oz/A July 2009
Picture August 2010

Common Name	Family	Genus	Species	1 YAT	2 YAT	Appl Time	Location
Equisetum	Equisetaceae	*Equisetum*	*arvense*	T	T	Both	MN2008
Flowering spurge	Euphorbacae	*Euphorbia*	*corollata*	T	T	Both	MN2008
Robust spurge	Euphorbia	*Tithymalus*	*brachyceras*	T	T	Summer	CO2007
Lupine	Fabaceae	*Lupinus*	*sericeus*	T	T	Fall	MT Rice, IDGreen
Lupine	Fabaceae	*Lupinus*	*sericeus*	MT	T	Summer	CO2009/MTRice08
Purple prairie clover	Fabaceae	*Dalea*	*purpurea*	S	MS	Fall	Glacial Ridge, MNKufrin
Purple prairie clover	Fabaceae	*Dalea*	*purpurea*	T	T	Summer	MNKufrin
Round-headed bush clover	Fabaceae	*Lespedeza*	*capitata*	MS	NA	Both	MN2008
Sheldon's milkvetch	Fabaceae	*Astragalus*	*sheldonii*	T	T	Fall	IDGreen
Showy tickfoil	Fabaceae	*Desmodium*	*canadense*	MS	NA	Both	MN2008
Silky prairie clover	Fabaceae	*Petalostemum*	*villosum*	MS	NA	Both	MN2008
Slimflower scurfpea	Fabaceae	*Psoralea*	*lanceolata*	S	MT	Summer	CO2007
Trailing wild bean	Fabaceae	*Strophostyles*	*helvola*	T	T	Both	MN2008
Weedy milkvetch	Fabaceae	*Astragalus*	*miser*	S	MS	Fall	MTRice
White prairie clover	Fabaceae	*Dalea*	*candida*	S	S	Fall	Glacial Ridge
White wild indigo	Fabaceae	*Baptisia*	*alba*	MT	NA	Both	MN2008
American water horehound	Lamiaceae	*Lycopus*	*americanus*	T	T	Fall	Glacial Ridge
Hedgenettle	Lamiaceae	*Stachys*	*palustris*	T	T	Both	Glacial Ridge
Horsemint	Lamiaceae	*Monarda*	*fistula*	T	T	Fall	MTRice
Spearmint	Lamiaceae	*Mentha*	*spicata*	MT	T	Summer	CO2009
Spearmint	Lamiaceae	*Mentha*	*spicata*	S	MS	Fall	CO2010
Wild bergamot	Lamiaceae	*Monarda*	*fistulosa*	T	T	Both	Glacial Ridge/MNKufrin
Wild mint	Lamiaceae	*Mentha*	*arvensis*	T	T	Fall	Glacial Ridge
Death camas	Lilaceae	*Zigadenus*	*venenosus*	T	T	Both	MTRice/MTRice08
Yellow bell	Lilaceae	*Fritillaria*	*pudica*	T	T	Both	MTRice/MTRice08
Prairie onion	Liliaceae	*Allium*	*stellatum*	T	NA	Both	MN2008
Sand lilly	Lillaceae	*Leucocrinum*	*montanum*	MS	MT	Summer	CO2007
Blue flax	Linaceae	*Linum*	*lewisii*	S	MS	Summer	CO2007
Common primrose	Onagraceae	*Oenothera*	*biennis*	S	NA	Both	MN2008
Evening Primrose	Onagraceae	*Oenothera*	*howardii*	MS	MT	Summer	CO2007
Scarlet beeblossum	Onagraceae	*Gaura*	*coccinea*	S	MT	Summer	CO2007
Tall annual willow-herb	Onagraceae	*Epilobium*	*paniculatum*	S	MS	Fall	MTRice
Common yellow woodsorel	Oxalidaceae	*Oxalis*	*stricta*	T	T	Fall	Glacial Ridge
Narrow-leaf collomia	Polemoniaceae	*Collomia*	*linearis*	S	MS	Fall	MTRice
Pink microsteris	Polemoniaceae	*Microsteris*	*gracilis*	T	T	Fall	MTRice
Douglas's knotweed	Polygonaceae	*Polygonun*	*douglasii*	T	T	Fall	MTRice, ID Green
Pale dock	Polygonaceae	*Rumex*	*altissimus*	S	NA	Both	MN2008
Subalpine buckwheat	Polygonaceae	*Eriogonum*	*subalpinum*	S	S	Summer	CO2009
Subalpine buckwheat	Polygonaceae	*Eriogonum*	*subalpinum*	MT	MT	Fall	CO2010
Water smartweed	Polygonaceae	*Polygonum*	*amphibium*	MS	T	Fall	Glacial Ridge
Winged buckwheat	Polygonaceae	*Pterogonum*	*alatum*	S	S	Summer	CO2007
Western androsace	Primulaceae	*Androsace*	*occidentalis*	MS	T	Fall	MTRice
Purple meadow-rue	Ranunculaceae	*Thalictrum*	*dasycarpum*	MT	MT	Fall	Glacial Ridge
Prairie cinquefoil	Rosaceae	*Potentila*	*arguta*	S	NA	Both	MN2008
Prairie smoke	Rosaceae	*Geum*	*triflorum*	MT	T	Fall	MTRice
Soft cinquefoil	Rosaceae	*Potentilla*	*gracilis*	T	T	Both	CO2009
Virginia strawberry	Rosaceae	*Fragaria*	*virginiana*	T	T	Fall	MTRice
wild rose	Rosaceae	*Rosa sp.*		S	NA	Summer	MTDuncan
Small-flowered fringecup	Saxifragaceae	*Lithophragma*	*parviflora*	S	MS	Both	MTRice/MTRice08
Yellow Paintbursh	Scorphulariaceae	*Castilleja*	*occidentallis*	T	T	Both	CO2009
Blue-eyed Mary	Scrophulariaceae	*Collinsia*	*parviflora*	T	T	Both	MTRice/MTRice08
One-sided penstemon	Scrophulariaceae	*Penstemon*	*secundiflorus*	MT	MT	Summer	CO2007
Clammy groundcherry	Solanaceae	*Physalis*	*heterophylla*	S	NA	Both	MN2008
Stinging nettle	Urticaceae	*Urtica*	*dioica*	MT	NA	Both	MN2008
Blue vervain	Verbenaceae	*Verbena*	*hastata*	T	T	Both	MN2008
Hoary vervain	Verbenaceae	*Verbena*	*stricta*	T	T	Both	MN2008
Nuttalls violet	Violaceae	*Viola*	*nuttallii*	MS	T	Summer	CO2007

Results of 90 Forbs Evaluated 2 YAT



1 YAT

2 YAT

Conclusion

- **Most native forb species were moderately tolerant to tolerant, or quickly recovered following treatment with aminopyralid.**

- **Many land managers assume that applications in the fall to dormant forbs would provide better tolerance than summer applications**
- **<u>Study 2 Objective: Determine if there is an application timing difference on key forbs</u>**

Native Forb and Shrub Tolerance to Milestone® Herbicide

Milestone® (aminopyralid) is a broadleaf herbicide that has reduced risk to the environment compared with other commercially available herbicides, making it a desirable alternative for invasive weed control on rangeland and wildland sites. Effect of Milestone® on desirable native forbs and shrubs is a consideration for land managers when making decisions about controlling invasive plants. Experiments were established at ten locations in four states to determine long- term response of native forbs and shrubs to Milestone® applied in early summer or fall, and to develop a tolerance/susceptibility ranking for native plants. Studies were established within diverse native plant communities in western Montana; Boulder, Colorado, Theodore Roosevelt National Park (TRNP), North Dakota; Glacial Ridge Preserve and restored prairies in Minnesota.

This is a summary of multiple research locations completed by Mary B. Halstvedt, Dow AgroSciences Field Scientist. The following researchers conducted the field experiments. Travis Almquist, Luke Samuel, Rodney G Lym, North Dakota State University, Fargo; K. George Beck, Colorado State University, Ft. Collins; Roger L. Becker, University of Minnesota, St. Paul; Celestine A. Duncan, Weed Management Services, Helena, MT; Peter M. Rice, University of Montana, Missoula.

Materials and Methods:
Plant communities with high levels of diversity were selected as research sites. Some locations had light to moderate infestations of invasive species such as Canada thistle or spotted knapweed. Field experiments were designed as randomized complete block with two to five replications per treatment and initiated from 2004 to 2007. Herbicide treatments were Milestone® at 5 or 7 fluid ounces/A. Broadcast ground applications were made with either a CO_2 backpack sprayer, or pickup boom sprayer. At one Montana location a broadcast application was made with a helicopter. Treatments were made in September or October at six locations, June at two locations, and June and September comparisons at two Minnesota sites. Data collection across sites varied and included either canopy cover or plant counts along a permanent transect, or plant density within each plot.

Herbicide Application Dates

Treatments applied:

- **South Dakota:**
  - ✓ **July 1 and October 8, 2009**
- **Colorado Site One:**
  - ✓ **July 10 and October 16, 2009**
- **Colorado Site Two:**
  - ✓ **July 10 and October 16, 2009**
- **Minnesota:**
  - ✓ **June 25th and September 23rd, 2009**
- **Montana:**
  - ✓ **October 2006 and June 5, 2008**

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Materials and Methods:
RCB Design – 3-4 reps
Applications with plot equipment
Data collected along a transect or whole plot
Photo by Roger Becker

20 Forbs Included Across Locations

Common Name	Family	Genus	Species	Location
Arrowleaf balsamroot	Asteraceae	*Balsamorhiza*	*sagittata*	Montana
Blanket flower	Asteraceae	*Gaillardia*	*aristata*	Montana
Blue-eyed Mary	Scrophulariaceae	*Collinsia*	*parviflora*	Montana
Canada goldenrod	Asteraceae	*Solidago*	*canadensis*	South Dakota and Minnesota
death camas	Liliaceae	*Zigadenus*	*paniculatus*	Montana
Golden alexander	Apiaceae	*Zizia*	*aurea*	Minnesota
Little sunflower	Asteraceae	*Helianthus*	*pumilus*	Colorado
Purple praire clover	Fabaceae	*Dalea*	*purpurea*	Minnesota
Silky lupine	Fabaceae	*Lupinus*	*sericeus*	Montana
Small-flowered fringecup	Saxifragaceae	*Lithophragma*	*parviflora*	Montana
Soft cinquefoil	Rosaceae	*Potentila*	*gracilis*	Colorado
Spearmint	Lamiaceae	*Mentha*	*spicata*	Colorado
Stiff Goldenrod	Asteraceae	*Solidago*	*rigida*	Minnesota
Stiff sunflower	Asteraceae	*Helianthus*	*grosseserratus*	South Dakota
Subalpine buckwheat	Polygonaceae	*Eriogonum*	*subalpinum*	Colorado
white prairie aster	Asteraceae	*Aster*	*ericoides*	South Dakota
Wild bergamot	Lamiaceae	*Monarda*	*fistulosa*	Minnesota
Yarrow	Asteraceae	*Achillea*	*millefolium*	Montana
Yellow bell	Lilaceae	*Fritillaria*	*pudica*	Montana
Yellow Paintbursh	Scorphulariaceae	*Castilleja*	*occidentallis*	Colorado

11 Plant Species with no Difference in Tolerance

Common Name	Family	Genus	Species	Location	Summer	October
Arrowleaf balsamroot	Asteraceae	*Balsamorhiza*	*sagittata*	Montana	MS+	MS
Blanket flower	Asteraceae	*Gaillardia*	*aristata*	Montana	MT	MT
Blue-eyed Mary	Scrophulariaceae	*Collinsia*	*parviflora*	Montana	T	T
death camas	Liliaceae	*Zigadenus*	*paniculatus*	Montana	T	T
Golden alexander	Apiaceae	*Zizia*	*aurea*	Minnesota	T	T
Small-flowered fringecup	Saxifragaceae	*Lithophragma*	*parviflora*	Montana	S	S
Soft cinquefoil	Rosaceae	*Potentila*	*gracilis*	Colorado	T	T
Wild bergamot	Lamiaceae	*Monarda*	*fistulosa*	Minnesota	T	T
Yarrow	Asteraceae	*Achillea*	*millefolium*	Montana	S	S
Yellow bell	Lilaceae	*Fritillaria*	*pudica*	Montana	T	T
Yellow Paintbrush	Scorphulariaceae	*Castilleja*	*occidentallis*	Colorado	T	T

New plants to add to list – yellow paintbrush and soft cinquefoil

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4 Plant Species more Tolerant with Late Autumn Application

Common Name	Family	Genus	Species	Location	Summer	October
Little sunflower	Asteraceae	*Helianthus*	*pumilus*	Colorado	**MS**	**T**
Silky lupine	Fabaceae	*Lupinus*	*sericeus*	Montana	**MT**	**T**
Silky lupine	Fabaceae	*Lupinus*	*sericeus*	Colorado	**MT**	**T**
Subalpine buckwheat	Polygonaceae	*Eriogonum*	*subalpinum*	Colorado	**S**	**MT**
white prairie aster	Asteraceae	*Aster*	*ericoides*	South Dakota	**MS**	**MT**

Subalpine buckwheat and spearmint are new to the list

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5 Plant Species more Tolerant with Summer Application

Common Name	Family	Genus	Species	Location	Summer	October
Canada goldenrod	Asteraceae	*Solidago*	*canadensis*	South Dakota	**T**	**MT+**
Canada goldenrod	Asteraceae	*Solidago*	*canadensis*	Minnesota	**MS+**	**S**
Purple praire clover	Fabaceae	*Dalea*	*purpurea*	UMN Fall	**T**	**S**
Spearmint	Lamiaceae	*Mentha*	*spicata*	Colorado	**MT**	**S**
Stiff Goldenrod	Asteraceae	*Solidago*	*rigida*	Minnesota	**MT+**	**S**
Stiff sunflower	Asteraceae	*Helianthus*	*grosseserratus*	South Dakota	**MT**	**S**

Purple prairie clover is an important native perennial prairie forb – this difference needs further investigation

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Conclusions

- **Of the 20 forb species categorized, tolerance ratings of 11 species were not different regardless of application date.**
- **Species with greater tolerance to aminopyralid following a summer application compared to autumn application were stiff sunflower, Canada goldenrod, spearmint, stiff goldenrod, and purple prairie clover.**
- **Species more tolerant to an October application of aminopyralid were subalpine buckwheat, lupine, little sunflower, and white prairie aster.**

Summary

- **Most native forb species were moderately tolerant to tolerant, or quickly recovered following treatment with aminopyralid.**
- Historical data suggests that by the third or fourth year post-application there would be little difference in non-target forb tolerance with only a few very sensitive forbs being adversely impacted in the long term
- **Based on timing study, tolerance of certain forb species to aminopyralid may vary depending on application date.**
- Land managers can use these data to evaluate risk to native plant communities when using aminopyralid to control invasive species.

Aminopyralid (*Milestone® Herbicide*) can be used to control invasive plants and facilitate recovery of desirable forbs.

Selective weed control gives desirable vegetation a competitive advantage.

Research Ongoing
1 Year Old Established Prairie

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Questions?
Photo by Debbie Morton