NATIVE FORB AND SHRUB TOLERANCE TO AMINOPYRALID

Mary B. Halstvedt* and Byron Sleugh, Dow AgroSciences LLC, Billings, MT and Des Moines, IA; 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.

North American Prairie Conference

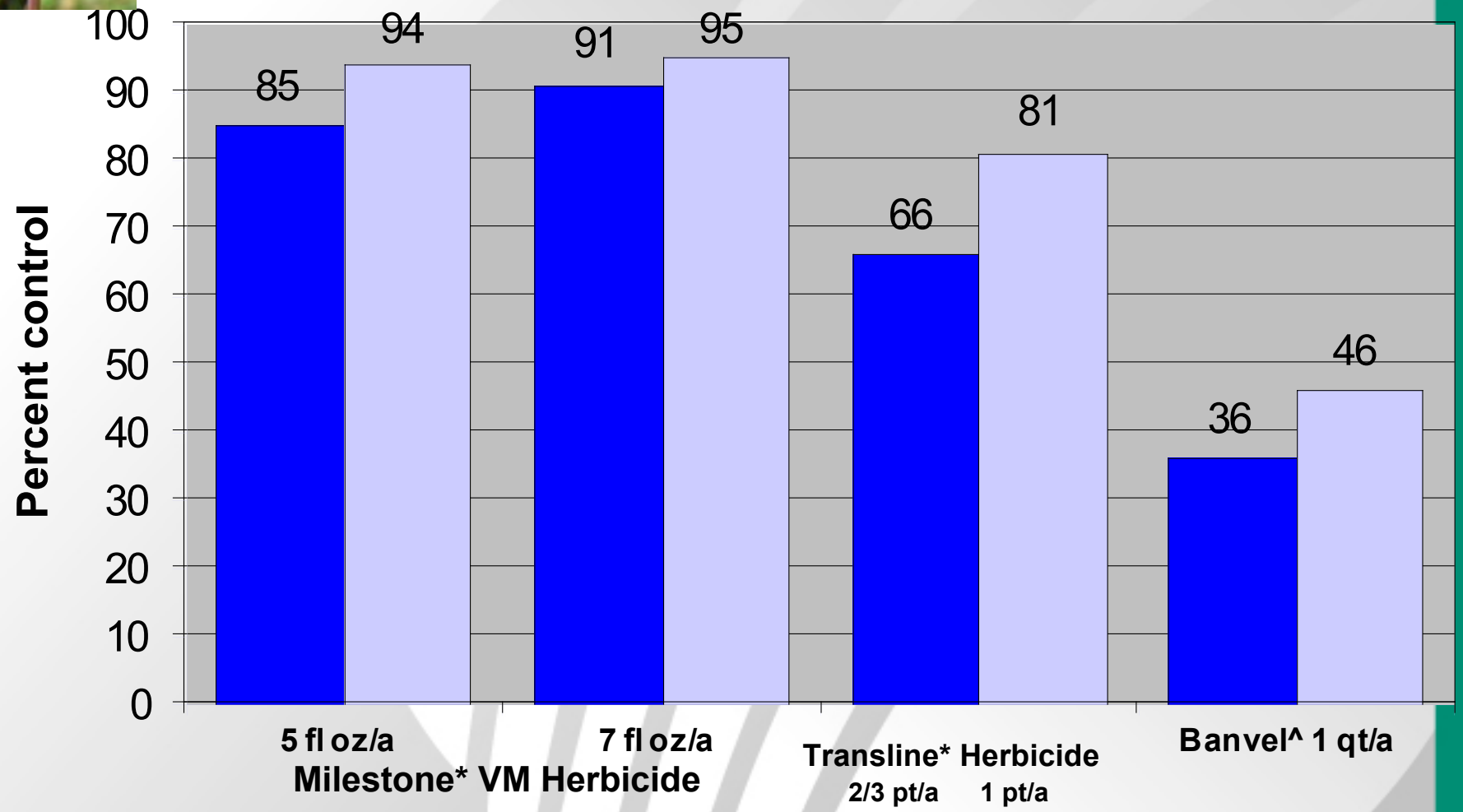
Dow AgroSciences

*Aminopyralid (**Milestone® VM Herbicide**)*

- Provides excellent control of spotted knapweed, Canada thistle and many other invasive species
- 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**

Dow AgroSciences

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

* Trademark of Dow AgroSciences ^Trademark of Micro Flo Company LLC

Dow AgroSciences

Herbicide Treatment

Herbicide Treatment 1 year after application

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 on rangelands and wildland sites.

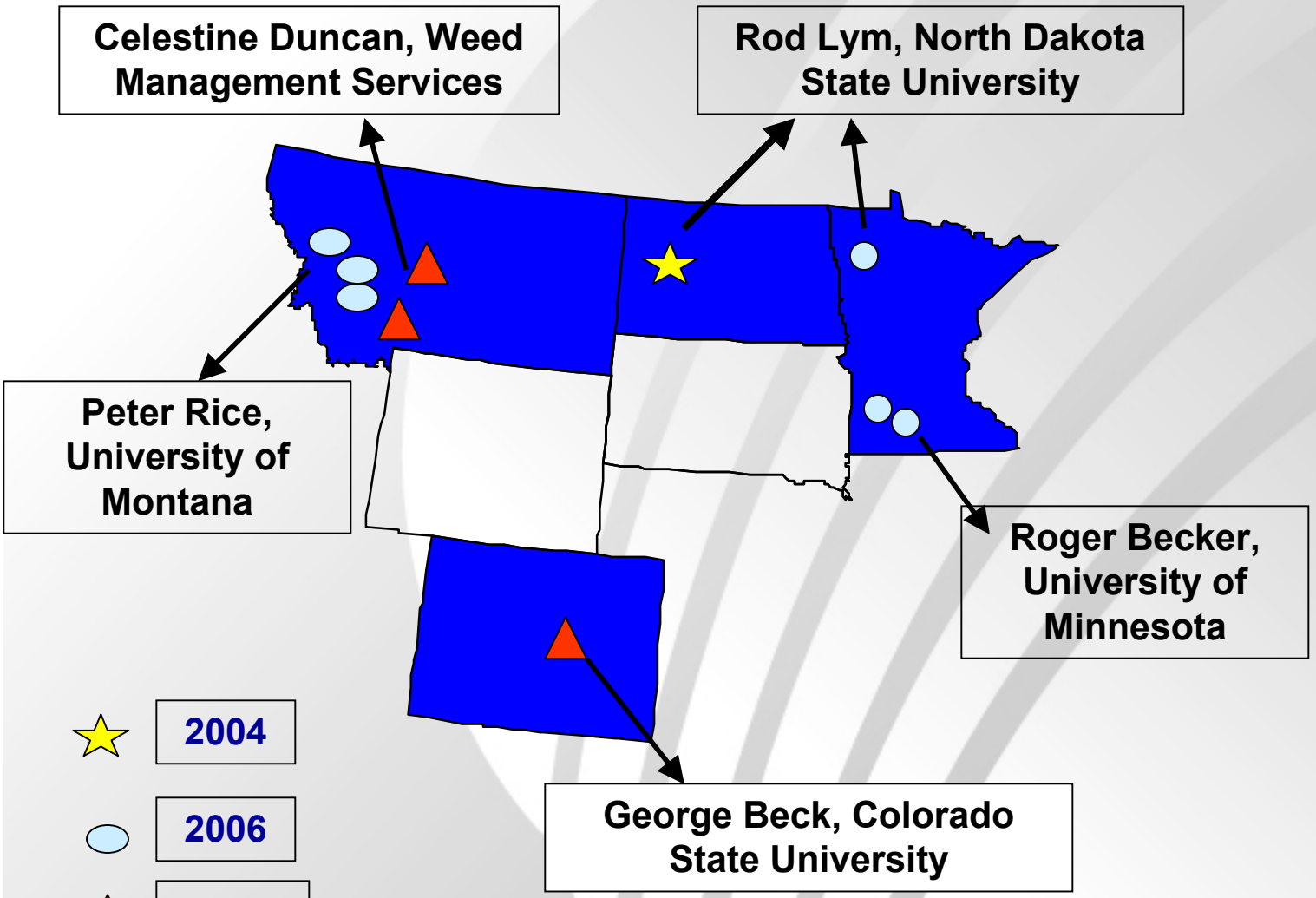
Species diversity is the goal

Research Objectives

- Determine long-term response of native forbs and shrubs to aminopyralid (Milestone® VM) applied in early summer or fall.

- Develop a tolerance/susceptibility ranking for native plants.

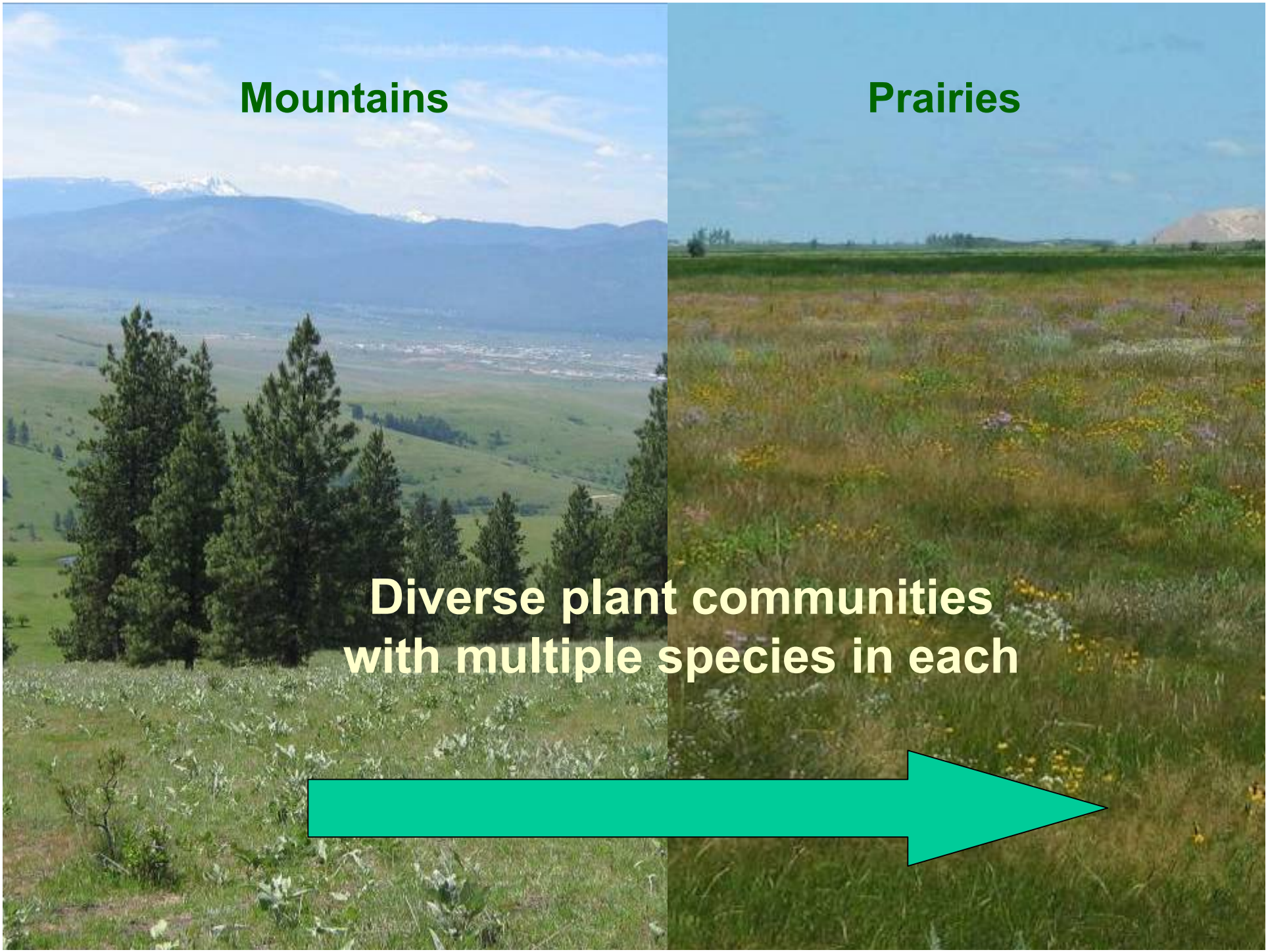
Experiments Established at 10 Locations



Dow AgroSciences

Name	Location	Researcher	Site Type	Treatments	Methods
Theadore Roosevelt National Park	Western ND	Rod Lym and Luke Samuel, North Dakota State University	Canada thistle/arid grassland	Milestone® at 7 f oz/A applied in October 2004	Pre and Post: 30 plots - 3 frames/plot - 90 frames per treatment
Two Rivers - MN Dept of Natural Resources(DNR)	Southwest MN	Roger Becker, University of Minnesota	Canada thistle prairie restoration	Milestone® at 5 fluid oz/A applied June and September comparisons -2006	Post only: 20 frames per treatment for counts by species and presence per plot
Hedquist - MN DNR	SW MN 2006	Roger Becker, University of Minnesota	Canada thistle prairie restoration		
Glacier Ridge Nature Conservancy	Northern MN Fall 2006	Rod Lym and Travis Almquist, North Dakota SU	Canada thistle prairie restoration	Milestone® at 7 f oz/A applied in October 2006	Pre and Post: 90 frames per treatment % cover by species
Larry Creek Bitterroot National Forest	Western MT	Peter Rice, University of Montana	Open canopy, commercially thinned Ponderosa pine with spotted knapweed	Milestone® at 5 fluid oz/A applied in October 2006	Pre and Post: 5 reps - 4 transects with 9 frames - 180 frames per treatment (720 per location). Canopy cover and frequency of occurance
Grant Cr. Elk Refuge National Wildlife Federation	Western MT	Peter Rice	Rough fescue grassland with spotted knapweed		
Pattee Canyon Lolo National Forest	Western MT	Peter Rice	Open canopy, Ponderosa pine habitat with spotted knapweed		
Boulder Open Space	Boulder, CO	George Beck, Colorado State University	Diffuse knapweed upland rangeland	Milestone® at 5 fluid oz/A applied in June 2007	Pre and post data - density of each species per plot.
Native rangeland with good forb diversity	Helena, MT	Celestine Duncan, Weed Management Services	Native Rangeland weed free	Milestone® at 5 fluid oz/A applied in June 2007	Pre and post canopy cover by species
Montana USFS Aerial Operational Study	Western MT	Celestine Duncan and Andy Kulla, US Forest Service	Spotted knapweed open canopy forest	Milestone® at 5 fluiduid oz/A applied by helicopter in October 2007	Pre and post canopy cover by species

Dow AgroSciences


Mountains
Prairies
Diverse plant communities
with multiple species in each

Materials and Methods

- Field experiments were designed as randomized complete block with two to five replications
- Herbicide treatments: Milestone VM at 5 or 7 fluid oz product/A
- Broadcast ground applications were made with either a CO2 backpack sprayer or pickup boom sprayer
- A broadcast application was made with a helicopter at one Montana location.
- Treatments were made in September or October at six locations, June at two locations, and either June or September at two Minnesota sites

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**

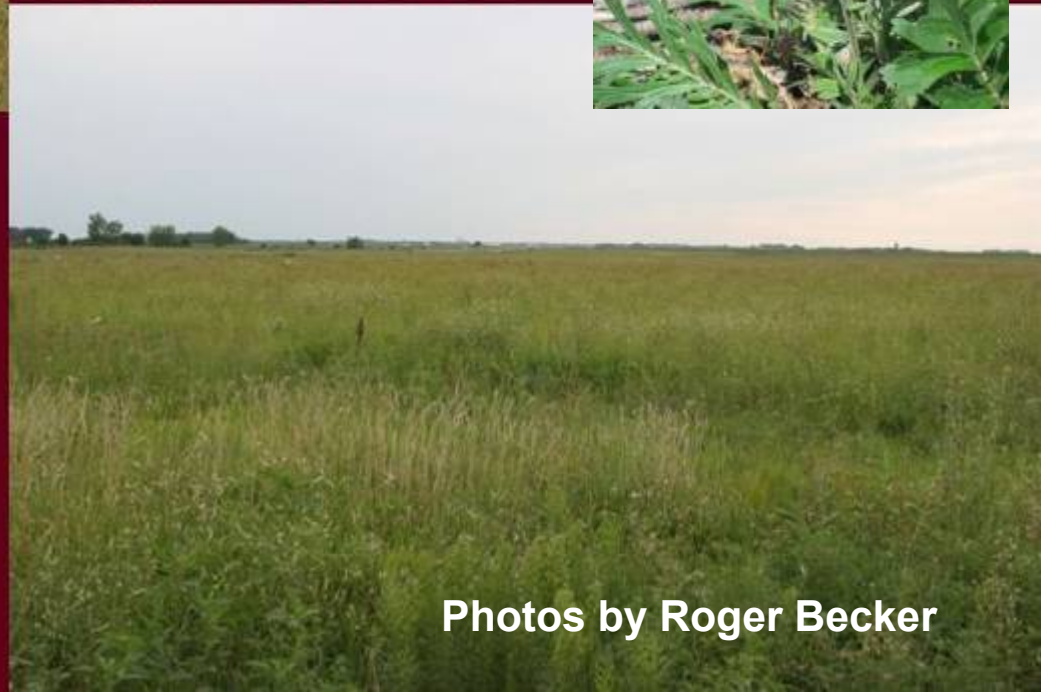
Materials and Methods

- 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 eight study sites.
- In-season injury is not captured in these rankings

Two Rivers Forb Tolerance Site

Year of Treatment – difficult to make conclusions

Hedquist Forb Tolerance Site



Photos by Roger Becker

Species Tolerance

- There were a total of 118 native forbs across sites, with 20 species occurring at more than one location.
- 29 plant families were represented, with the greatest number of species (35%) in the Asteraceae family.
- Individual rankings of tolerance to aminopyralid were established for 98 native forb species and 19 shrubs based on individual species reduction in canopy cover or density compared to non-treated controls or baseline data.

Dow AgroSciences

Four Ranking Categories

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

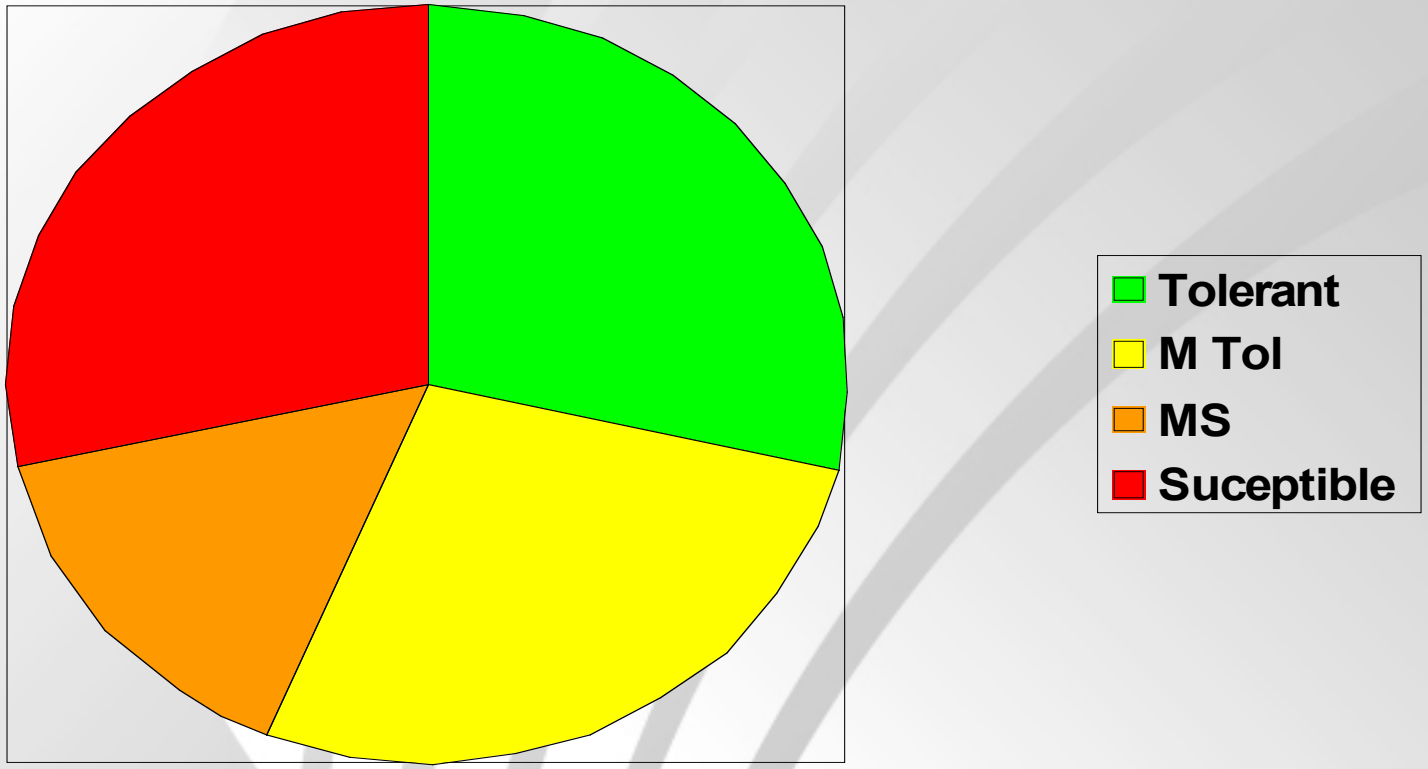
MT = Moderately tolerant: Symptoms include cupping/yellowing and can inhibit flowering, with recovery the first growing season after application – 15-50% stand reduction

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.

Dow AgroSciences

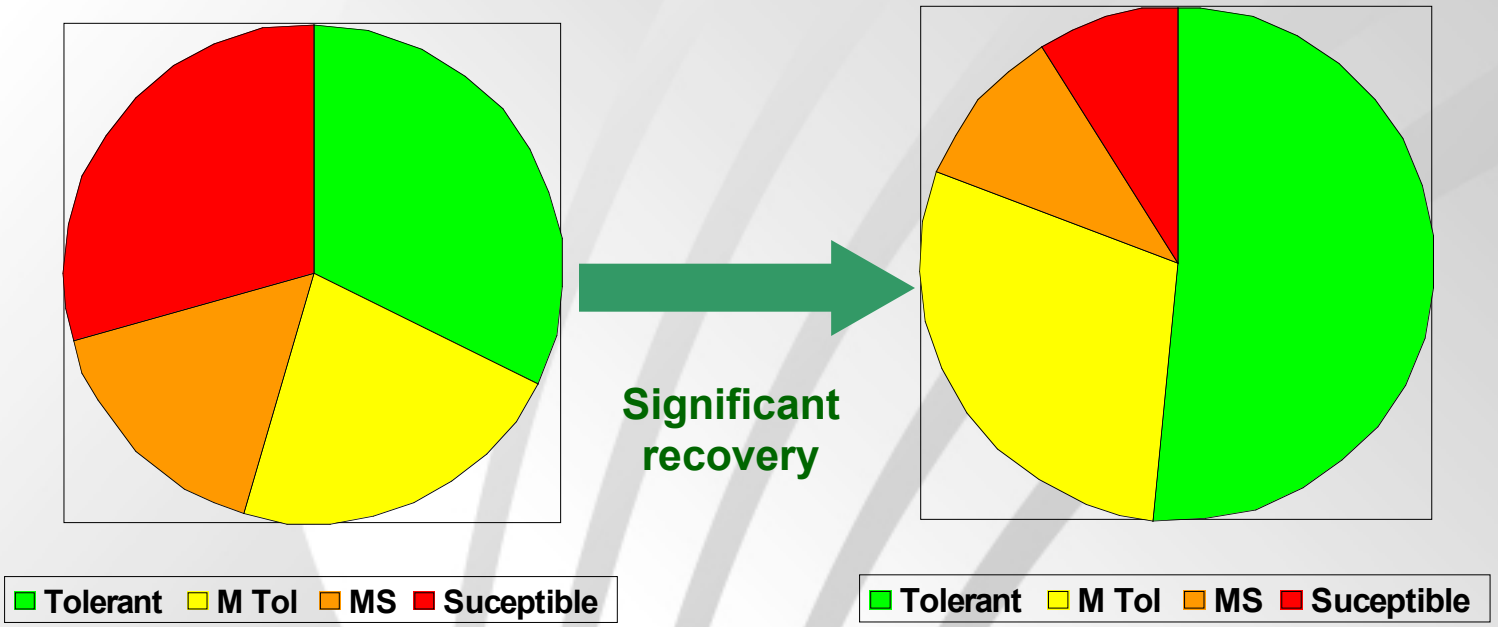
All Forb Species Combined- 1 YAT



Total 98 Species

Dow AgroSciences

Results of 68 Forbs Evaluated 2 YAT



1 YAT

2 YAT

Common Name	Family	Genus	Species	1 YAT	2 YAT	Location
Golden Alexanders	Apiaceae	*Zizia*	*aurea*	T	T	Glacier Ridge Fall
Heart-leaved alexanders	Apiaceae	*Zizia*	*aptera*	T	NA	MN: Summer/Fall
Nine-leaf lomatium	Apiaceae	*Lomatium*	*triternatum*	MT	T	MTRice-Fall
Wyeth's biscuitroot	Apiaceae	*Lomatium*	*ambiguum*	T	T	MTRice-Fall
Spreading dogbane	Apocynaceae	*Apocynum*	*androsaemifolium*	T	T	Glacier Ridge Fall
Common milkweed	Asclepiadaceae	*Asclepias*	*syriaca*	T	T	Glacier Ridge Fall
Arrowleaf balsamroot	Asteraceae	*Balsamorhiza*	*sagittata*	MS	MT	MTRice-Fall
Black-eyed Susan	Asteraceae	*Rudbeckia*	*hirta*	S	NA	MN: Summer/Fall
Blanket flower	Asteraceae	*Gaillardia*	*aristata*	MT	T	MTR-Fall, Glacier Ridg
Canada goldenrod	Asteraceae	*Solidago*	*canadensis*	MS	MS	Glacier Ridge Fall
cudweed sage	Asteraceae	*Artemesia*	*ludoviciana*	T	T	MTDuncan-summer
Cup plant	Asteraceae	*Silphium*	*perfoliatum*	MT	NA	MN: Summer/Fall
Daisy fleabane	Asteraceae	*Erigeron*	*strigosus*	MT	NA	MN: Summer/Fall
Gay feather	Asteraceae	*Liatris*	*punctata*	T	T	CO-summer
Giant goldenrod	Asteraceae	*Solidago*	*gigantea*	MT	NA	MN: Summer/Fall
Giant sunflower	Asteraceae	*Helianthus*	*giganteus*	S	MS	Glacier Ridge Fall
Gumweed	Asteraceae	*Grindelia*	*squarrosa*	MS	MT	MTRice-Fall
Hairy golden aster	Asteraceae	*Chrysopsis*	*villosa*	MT	T	MTR-Fall, MTD summe
Heath aster	Asteraceae	*Aster*	*ericoides*	MT	NA	MN: Summer/Fall
Hound's tongue hawkweed	Asteraceae	*Hieracium*	*cynoglossoides*	MT	MT	MTRice-Fall
Little sunflower	Asteraceae	*Helianthus*	*pumilus*	MT	MT	CO-summer
Maximilian sunflower	Asteraceae	*Helianthus*	*maximiliani*	S	S	Glacier Ridge Fall
Missouri goldenrod	Asteraceae	*Solidago*	*missouriensis*	MT	T	MTRice-Fall
Nuttall's pussy-toes	Asteraceae	*Antennaria*	*parviflora*	MS	MT	MTR-fall, MTD-summe
Orange arnica	Asteraceae	*Arnica*	*fulgens*	S	S	MTRice-Fall
Panicled aster	Asteraceae	*Aster*	*lanceolatum*	MT	NA	MN: Summer/Fall
Prairie blazingstar	Asteraceae	*Liatris*	*aspera*	MT	NA	MN: Summer/Fall
Prairie goldenrod	Asteraceae	*Solidago*	*missouriensis*	MS	MT	Glacier Ridge Fall
Prairie sunflower	Asteraceae	*Helianthus*	*pauciflorus*	MS	NA	Glacier Ridge Fall, MN
Rosy pussy-toes	Asteraceae	*Antennaria*	*microphylla*	MT	T	MTRice-Fall
Shaggy fleabane	Asteraceae	*Erigeron*	*pumulis*	MT	T	MTRice-Fall
Smooth Blue aster	Asteraceae	*Aster*	*laeve*	MT	NA	MN: Summer/Fall
Stiff goldenrod	Asteraceae	*Solidago*	*rigida*	MT	NA	MN: Summer/Fall
Stiff sunflower	Asteraceae	*Helianthus*	*pauciflorus*	MS	MT	Glacier Ridge Fall
Sweet clover	Asteraceae	*Melilotus*	*officinalis*	S	T	Glacier Ridge Fall
Sweet smooth oxeye	Asteraceae	*Heliopsis*	*helianthoides*	MT	NA	MN: Summer/Fall
Tall sunflower	Asteraceae	*Helianthus*	*giganteus*	S	NA	MN: Summer/Fall
White panicle aster	Asteraceae	*Aster*	*simplex*	S	MT	Glacier Ridge Fall
White prairie aster	Asteraceae	*Aster*	*ericoides*	MT	MT	Glacier Ridge Fall
Yarrow	Asteraceae	*Achillea*	*millefolium*	S	S	MTRice-Fall
Yellow prairie coneflower	Asteraceae	*Ratibida*	*pinnata*	S	NA	MN: Summer/Fall

Sciences


Milestone 5 fl oz/A
July 2009

Common Name	Family	Genus	Species	1 YAT	2 YAT	Location
Wayside gromwell	Boraginaceae	*Lithospermum*	*ruderale*	MT	MT	MTRice-Fall
Alyssum	Brassicaceae	*Alyssum*	*alyssoides*	T	T	MTDuncan-summer
Nuttall's rockress	Brassicaceae	*Arabis*	*nuttallii*	T	T	MTRice-Fall
Palespike lobelia	Campanulaceae	*Lobelia*	*spicata*	S	S	Glacier Ridge Fall
Field chickweed	Caryophyllaceae	*Cerastium*	*arvense*	MS	MT	MTRice-Fall
Jagged chickweed	Caryophyllaceae	*Holosteum*	*umbellatum*	S	T	MTRice-Fall
threadleaf sandwort	Caryophyllaceae	*Arenaria*	*capillaris*	S	MT	MTDuncan-summer
Prairie spiderwort	Commelinaceae	*Tradescantia*	*occidentalis*	MS	NA	MN: Summer/Fall
Dwarf morning glory	Convolvulaceae	*Ipomoea*	*tricolor*	MT	T	CO-summer
Equisetum	Equisetaceae	*Equisetum*	*arvense*	T	NA	MN: Summer/Fall
Flowering spurge	Euphorbacae	*Euphorbia*	*corollata*	T	NA	MN: Summer/Fall
Robust spurge	Euphorbia	*Tithymalus*	*brachyceras*	T	T	CO-summer
Lupine	Fabaceae	*Lupinus*	*sericeus*	T	T	MTR-fall, MTD-summer
Purple prairie clover	Fabaceae	*Dalea*	*purpurea*	S	MS	Glacier Ridge Fall
Round-headed bush clover	Fabaceae	*Lespedeza*	*capitata*	MS	NA	MN: Summer/Fall
Showy tickfoil	Fabaceae	*Desmodium*	*canadense*	MS	NA	MN: Summer/Fall
Silky prairie clover	Fabaceae	*Petalostemum*	*villosum*	MS	NA	MN: Summer/Fall
Slimflower scurfpea	Fabaceae	*Psoralea*	*lanceolata*	S	MT	CO-summer
Trailing wild bean	Fabaceae	*Strophostyles*	*helvola*	T	NA	MN: Summer/Fall
Weedy milkvetch	Fabaceae	*Astragalus*	*miser*	S	MS	MTRice-Fall
White prairie clover	Fabaceae	*Dalea*	*candida*	S	S	Glacier Ridge Fall
White wild indigo	Fabaceae	*Baptisia*	*alba*	MT	NA	MN: Summer/Fall
American water horehound	Lamiaceae	*Lycopus*	*americanus*	T	T	Glacier Ridge Fall
Hedgenettle	Lamiaceae	*Stachys*	*palustris*	T	T	Glacier Ridge Fall
Horsemint	Lamiaceae	*Monarda*	*fistula*	T	T	MTRice-Fall
Wild bergamot	Lamiaceae	*Monarda*	*fistulosa*	T	T	Glacier Ridge Fall
Wild mint	Lamiaceae	*Mentha*	*arvensis*	T	T	Glacier Ridge Fall
Death camas	Lilaceae	*Zigadenus*	*venenosus*	T	T	MTRice-Fall
Yellow bell	Lilaceae	*Fritillaria*	*pudica*	T	T	MTRice-Fall
Prairie onion	Liliaceae	*Allium*	*stellatum*	T	NA	MN: Summer/Fall
Sand lilly	Lillaceae	*Leucocrinum*	*montanum*	MS	MT	CO-summer

Common Name	Family	Genus	Species	1 YAT	2 YAT	Location
Blue flax	Linaceae	*Linum*	*lewisii*	S	MS	CO-summer
Common primrose	Onagraceae	*Oenothera*	*biennis*	S	NA	MN: Summer/Fall
Evening Primrose	Onagraceae	*Oenothera*	*howardii*	MS	MT	CO-summer
Scarlet beeblossum	Onagraceae	*Gaura*	*coccinea*	S	MT	CO-summer
Tall annual willow-herb	Onagraceae	*Epilobium*	*paniculatum*	S	MS	MTRice-Fall
Common yellow woodsorel	Oxalidaceae	*Oxalis*	*stricta*	T	T	Glacier Ridge Fall
Narrow-leaf collomia	Polemoniaceae	*Collomia*	*linearis*	S	MS	MTRice-Fall
Pink microsteris	Polemoniaceae	*Microsteris*	*gracilis*	T	T	MTRice-Fall
Douglas's knotweed	Polygonaceae	*Polygonun*	*douglasii*	T	T	MTRice-Fall
Pale dock	Polygonaceae	*Rumex*	*altissimus*	S	NA	MN: Summer/Fall
Water smartweed	Polygonaceae	*Polygonum*	*amphibium*	MS	T	Glacier Ridge Fall
Winged buckwheat	Polygonaceae	*Pterogonum*	*alatum*	S	S	CO-summer
Western androsace	Primulaceae	*Androsace*	*occidentalis*	MS	T	MTRice-Fall
Purple meadow-rue	Ranunculaceae	*Thalictrum*	*dasycarpum*	MT	MT	Glacier Ridge Fall
Prairie cinquefoil	Rosaceae	*Potentila*	*arguta*	S	NA	MN: Summer/Fall
Prairie smoke	Rosaceae	*Geum*	*triflorum*	MT	T	MTRice-Fall
Soft cinquefoil	Rosaceae	*Potentilla*	*gracilis*	S	MT	MTRice-Fall
Virginia strawberry	Rosaceae	*Fragaria*	*virginiana*	T	T	MTRice-Fall
wild rose	Rosaceae	*Rosa sp.*		S	NA	MTDuncan-summer
Small-flowered fringecup	Saxifragaceae	*Lithophragma*	*parviflora*	S	MS	MTRice-Fall
Blue-eyed Mary	Scrophulariaceae	*Collinsia*	*parviflora*	T	T	MTRice-Fall
One-sided penstemon	Scrophulariaceae	*Penstemon*	*secundiflorus*	MT	MT	CO-summer
Clammy groundcherry	Solanaceae	*Physalis*	*heterophylla*	S	NA	MN: Summer/Fall
Stinging nettle	Urticaceae	*Urtica*	*dioica*	MT	NA	MN: Summer/Fall
Blue vervain	Verbenaceae	*Verbena*	*hastata*	T	NA	MN: Summer/Fall
Hoary vervain	Verbenaceae	*Verbena*	*stricta*	T	NA	MN: Summer/Fall
Nuttalls violet	Violaceae	*Viola*	*nuttallii*	MS	T	CO-summer

Shrub Tolerance to Aminopyralid

- Shrubs were more tolerant than forbs to aminopyralid. There were 19 shrub species, and 74% were either MT or T. Shrubs in the Rosaceae family were generally the most susceptible to aminopyralid.

Dow AgroSciences

Shrub Tolerance to Aminopyralid

Common Name	Family	Genus	Species	1 YAT
Fringe sage	Asteraceae	*Artemesia*	*frigida*	**MS**
Louisiana sage	Asteraceae	*Artemesia*	*ludovicia*	**MS**
Nine-bark	Rosaceae	*Physorcarpus*	*mon*	**S**
Chokecherry	Rosaceae	*Prunus*	*virginiana*	**MT**
Dogbane	Apocynaceae	*Apocynum*	*andro*	**MT**
Buffaloberry	Elaeagnaceae	*Shepherdia*	*canadensis*	**MT**
Wood's rose	Rosaceae	*Rosa*	*woodsii*	**S**
Serviceberry	Rosaceae	*Amelancheir*	*alnifolia*	**S**
Golden current	Saxifragaceae	*Ribes*	*aureum*	**T**
Silver sagebrush	Asteraceae	*Artemisia*	*cana*	**T**
Silver Buffaloberry	Elaeagnaceae	*Shepherdia*	*argentea*	**T**
Western snowberry	Caprifoliaceae	*Symphoricarpos*	*occidentalis*	**T**
White sagebrush	Asteraceae	*Artemisia*	*ludoviciana*	**T**
Big Sagebrush	Asteraceae	*Artemisia*	*tridentata*	**T**
Yucca	Agavaceae	*Yucca*	*glauca*	**T**
Elderberry	Caprifoliaceae	*Sambucus*	*racemosa*	**T**
Kinnikinnick	Ericaceae	*Arctostaphalos*	*uvaursi*	**T**
Oregon Grape	Berberidaceae	*Berberis*	*repens*	**T**
Buckbrush	Rhamnaceae	*Ceanothus*	*velutinus*	**T**

Dow AgroSciences

Conclusion

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

Dow AgroSciences

Wild Bergamot

Aminopyralid 1.25 oz ae/A

July 30, 2007

Untreated

July 30, 2007

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

Dow AgroSciences

Conclusion

- Most native forb species and shrubs were moderately tolerant to tolerant, or quickly recovered following treatment with aminopyralid.
- Land managers can use these data as a guideline to evaluate risk and benefits to native plant communities when using Milestone VM to control invasive species.
  - Just one small part of developing an invasive weed strategy

Develop a Long Term Plan

- Prevention, detection, and control are key components of integrated management strategies.
- Reasons for the arrival, establishment, and spread of invasive plants must be understood before invasive plant-infested rangeland ecosystems can be improved.
- Removing an invasive plant species without attention to plant community dynamics often only opens niches for other undesirable species to occupy.
- Restoration of desirable plant communities that resist invasion is an appropriate goal for invasive plant management.

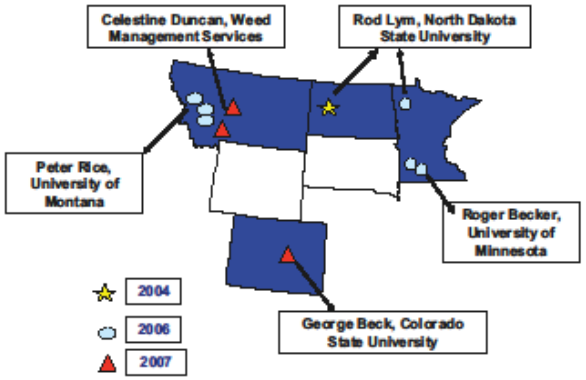

Aminopyralid (Milestone® VM Herbicide) can be used as a catalyst to manage invasive plants and to facilitate recovery of desirable forbs and shrubs.
Selective weed control gives desirable vegetation a competitive advantage.
® Trademark of Dow AgroSciences LLC
Photo by Debbie Morton

NATIVE FORB AND SHRUB TOLERANCE TO MILESTONE® HERBICIDE

Mary B. Halstvedt and Daniel C. Cummings, Dow AgroSciences LLC, Billings, MT and Perry, OK; 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.

Milestone® herbicide (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, and Glacial Ridge Preserve and restored prairies in Minnesota.

Experiments Established at 10 Locations



Field experiments were designed as randomized complete block with two to five replications 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 CO2 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 from either canopy cover or plant counts along a permanent transect, or plant density within each plot.

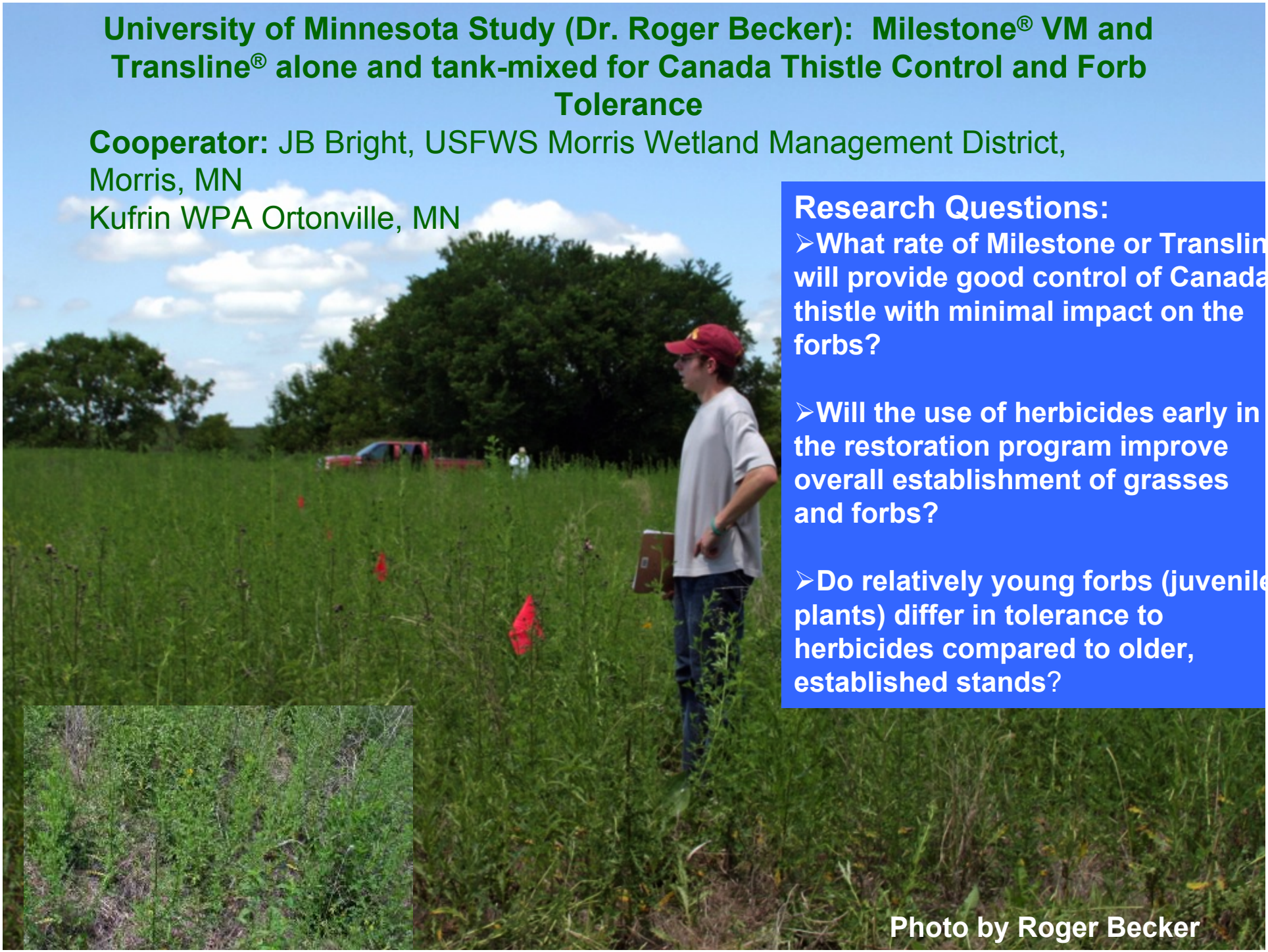
- This summary should serve as a guideline and is just the first step.
- Information will be added as more field work is done.

Summary Handout at booth

Dow AgroSciences

University of Minnesota Study (Dr. Roger Becker): Milestone® VM and Transline® alone and tank-mixed for Canada Thistle Control and Forb Tolerance

Cooperator: JB Bright, USFWS Morris Wetland Management District, Morris, MN
Kufrin WPA Ortonville, MN



Research Questions:

- **What rate of Milestone or Transline will provide good control of Canada thistle with minimal impact on the forbs?**
- **Will the use of herbicides early in the restoration program improve overall establishment of grasses and forbs?**
- **Do relatively young forbs (juvenile plants) differ in tolerance to herbicides compared to older, established stands?**

Photo by Roger Becker

Future Projects

- Discuss current research projects and relevance to field experiences
- Understand natural resource manager needs for invasive weed management
- Develop ideas for future research needs
- Expand to more research/demonstration partnership projects

Dow AgroSciences Goal

Continue to work together with land managers to develop invasive weed control strategies that fit within the prairie and grassland systems

- **Invasive Weed Control**
  - **Site prep for restorations**
  - **In establishment years**
  - **Established restorations**
- **Integrating Herbicides and other practices**
  - **Prescribed burns**
  - **Mowing**
- **Brush Management**

Dow AgroSciences